The rumen degradability of Mongolian pastures measured by *in sacco* and *in vitro* gas production techniques

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Abstract *Grass samples from nine pastures in Mongolia were collected and analysed for various chemical components. Three pasture types from the desert-steppe zone, one from steppe, two from forest-steppe, and two from high mountain were analysed. Desert steppe and steppe zones had significantly higher (P>0.01) hemicellulose values compared to high mountain and forest steppe. There were no differences between pastures types within climatic zones. The nutritive value of these grasses was assessed using the in vitro gas production and the in sacco technique. There were no significant differences between zones or pastures in in vitro gas production parameters or in sacco parameters. There was a significant effect of season on CG70 (P>0.003), DMD70(P>0.0001), protein (P>0.0001), ADF (P>0.0001) and NDF (P>0.0001). Data from the in vitro gas production and in sacco techniques were also compared. The correlations in the extent of degradation were generally good for several measures for the two techniques (in sacco DM disappearance at 96 hours and in vitro DM disappearance at 70 hours* $R^2=0.72$*). Both techniques detected similar trends in pasture degradabilities over time.*

Keywords: Mongolia, pastures, *in sacco degradability*, *in vitro* gas production

Introduction

In Mongolia livestock production is very important, contributing 40% to the GNP, and will continue to be in the future as the human population of this country continues to increase. It is important that research concentrates on increasing livestock numbers and improving the productive capacity of the national herd to ensure a food supply for the population of Mongolia in the future.

In Mongolia animal performance is very much dependant on the quality and quantity of the native grasslands available, since certain pastoral animals may obtain as much as 97% of their annual intake from pasture. Over the years these grasslands have degenerated due to overgrazing. Geography as well as climate plays a major factor in affecting the condition of the pasture for grazing. Most of the livestock in Mongolia are now privately owned having been state owned previously. The lifestyle is nomadic, with herds been moved frequently to make best use of the pasture available. Sheep are the most common type of livestock in terms of numbers (13.8m), although the productive capacity of the sheep flock is declining. Goats are one of the few livestock species which are on the increase (7.2m), due to the demand for cashmere. The other main livestock species are cattle (3m), horses (2.4m) and camels (0.4m). Cattle numbers have been steadily increasing over the past decade while there is a long term decline in camel numbers due to a reduction in their use as draft animals.

Although the native pastures are very important resource, little detailed information has been published on Mongolian pastures and little or no research has been conducted to evaluate these pasture grasses as feeds for grazing animals. Native grassland is distributed over an area of some 125.8 million ha and from preliminary studies it is estimated that there are about 2270 grass species and 600 species of other fodder plants. Rangelands occur in five regions in Mongolia; the high mountain, forest-steppe, steppe, desert-steppe and desert. Forty five percent of rangeland belongs to desert-steppe and desert, 28% to steppe, and the remaining 27 % belongs to forest-steppe and high mountain. In the northern rangelands, where the rainfall is 250 mm to 300 mm, the main pastures occur in forest-steppe and high mountain. In the high mountain areas the average altitude is 2000-2400 m above sea level and the average temperature is -1.4°C. In the south, where the rainfall is 50-100 mm per annum, steppe and desert steppe are the most common. In these areas the average altitude is 1000-2000 m above sea level and the average temperature is 3.9°C.

In Mongolia the growing season is short and is very dependent on climate, particularly rainfall. New growth in drier forest-steppe and dry steppe zones begins in the middle of April whereas in wet meadows growth is later and may not begin until the middle of May. Growth is often very slow, and the grazing of young grass may only be possible 30-35 days after the beginning of a new stage of pasture. Livestock, therefore, consume small amounts of fresh grass in April/May along with larger amounts of senescent material. During June to September, nearly all of the intake is from fresh grass. Some grass species reach their final growth stage in August and show signs of senescence, although other grass species may continue till the middle of September. Some species remain green until the middle of October. The nutritive value of senescent grass is significantly lower than fresh grass. Mongolian native livestock may rely on senescent grass as a main feed source for about 200 days. During the growing season some areas remain ungrazed to be harvested and conserved as hay or, alternatively, the pasture is left to provide a standing forage during the winter period.

This paper considers the seasonal changes in chemical composition of various native Mongolian grasses; three pasture types from the desert-steppe zone, one from steppe, two from forest-steppe, and two from high mountain. Also the nutritive value of these grasses was assessed using the *in vitro* gas production and *in sacco* technique. The aim of this research was to gain a better understanding of the differences in nutritive value between pasture types and to study changes in nutritive value over time. A further aim of the study was to compare the *in vitro* gas production technique with the *in sacco* technique and to consider to what extent they correlate.

Experimental

Sampling procedure

Pasture samples were collected at the end of February, April, May, June, July, August, September and October or November from desert steppe, steppe, forest steppe and high mountain areas. Samples were harvested from 5cm above ground level from a 1 m square quadrat. This procedure was repeated four times for each pasture. The samples were then air dried before being milled to pass through a 1 mm sieve. In total 90 samples were collected.

Ecology and climatic conditions of the sample collecting area

Desert-steppe

Representative pasture samples were collected in the Bulgan somon Omnogov aimak territory which lies 530 km north of th e capital Ulaanbaatar. The average annual rainfall is about 114 mm and 74 % of this falls between June and August. The annual mean temperature averaged 5.1°C. Desert steppe pastures are used as standing forage during the winter-spring period.

Pasture 1
Bunch grass-forb dominated pasture. Species which predominate are *Stipa gobica, S. glareosa, Cleistogenes squarrosa, Artemisia frigida, A. xerophytica, Anabasis salsa, Reamura soongaricum, Carex duriuscula, Caragana bungei and Allium polyrrhizum*. Utilized mainly by camels, sheep and goats.

Pasture 2
Allium polyrrhizum-Stipa gobicum dominated pasture. Common species are *Allium pollyrhizum* and *Stipa gobicum* also *Caragane bungie, Cleistogenes soongaricum, Convolvulus ammanii* and *Iris tenifolia*. Generally used as a pasture for sheep and goats.

Pasture 3
Haloxylon ammodendron-Artemisia xerophytica-Reamura soongaricum dominated pasture. The predominating plants are xerophilous and saline shrubs. This pasture is mostly grazed by camels.

Steppe

The sample collecting area was located in the Dornod aimak territory, 350-400 km east of Ulaanbaatar, and has an average altitude of 600-750 m above sea level. The principal pasture species are *Stipa caphillata* and *Cleistogenes squarrosa,* with also *Agropyron cristatum, Koeleria macrantha, Poa botryodes* and *Leymus chinensis.*

Forest-steppe

The sample collecting field was sited 67 km north of Ulaanbaatar.

Pasture 1
Grass forb dominated pasture. The main grass species were *Stipa krylovii, Agropyron cristatum, Poa botryoides, Leymus chinensis, Artemisia frigida and Arenaria capillaris.* The most common sedge species were *Carex duriuscula, C. korshinskyi* and *C. pediformis.* New growth in these sites can occur form 10 April onwards and tillering occurs around the 15 - 30 May.

Pasture 2
Meadow Community. This pasture contains mesophyte grasses which require comparatively high moisture. Also the bunch grasses *Leymus chinensis, Bromus inermis, Agrostis mongolica* and *Poa attenuatta* predominate. The main types of forbs are *Valerina officinalis, Thalictrum simplex, Geranium pratense* and *Sanguisorba officinalis.*
New growth occurs at the beginning of May and grazing of young grass becomes possible after about 30 days. Tillering by loose bunch and rhizomatous grasses in the meadow community occurs around the 15-30 of June. In September most of the pasture species have senesced and by October the plants completely dry. What remains is referred to as "khagd" which is used as a standing crop to provide fodder for animals during the winter-spring period.

High mountain

These two pastures are mostly used as grazing for horses and yaks. They are located in Tshuluut somon Arkhangai aimak which is 300 km south west of Ulaanbaatar. At this altitude, livestock derive 97-98 % of their intake from pasture.

Pasture 1
Festuca lenensis dominated pasture which lies 2100-2200 m above sea level and is south facing. Ground coverage is about 60 to 70 % in late July or mid-August and the height of the grass layer is about 4 to 6 cm. Other species found are *Helictotrichon schellianum (Hack), Koeleria cristata(Z), Agropyron cristatum (Z), Artemisia commutate, Arenaria capillaris, Artemisia glauca* and *Pulsatilla turzaninovii.* This pasture is heavily over grazed by large and small livestock.

Pasture 2

Kobresia bellardii dominated alpine meadow. The experimental site was located 2500-2600 m above sea level, lying on the north slope of the mountain. The degree of ground coverage is about 65 to 75 % in the middle of summer and the height of the grass layer is 20-22 cm. The main forage plants are *Kobresia bellardii* which dominates, *Polygonum viviparum, Helictotrichon mongolicum, Oxytropis kuznecovii, Conpenula turzaninovii, Sanqusorba officinalis, Vicia multicaulis, Aster alpinus, Scorzonera radiata, Pedicularis oederi, P. rubens, Thalictrum alpinum, Carex melanantha, Crepis chrysantha and Androsance chamajasme*. Regardless of envirnomental conditions, the growth of alpine meadow species is less than 70 days. *Kobresia bellardii* is a very good standing forage and is maintained in the form of "khagd" to provided winter forage for livestock.

Chemical analysis

Chemical Composition

Samples were analysed for dry matter (DM), organic matter (OM) crude protein (CP), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF) according to AOAC (1980) methods. Hemicellulose was defined as NDF-ADF.

In Sacco Degradability

In sacco rumen degradability was determined on 51 samples from high mountain and forest steppe pastures and was determined by the method of Orskov and McDonald (1979). Degradation of pasture samples was assessed at 0,6,12,24,48,72 and 96 hours using duplicated bags for each incubation time. Dry matter disappearance at 96 hours (DMD96) was a measure of the extent of degradation.

In Vitro Gas Production

In vitro gas production and dry matter dissappearance was determined by the method developed by Theodorou *et al* (1994). Cumulative gas production was measured using 125 ml serum bottles containing 1g of pasture sample, 90 mls of nitrogen rich medium and 5 ml of inoculum prepared from strained rumen liquor. Gas volumes were measured at 3,6,8,12,16,20,24,28,33,39,45,52, 60 and 70 hours. At the end of the incubation period the residues were recovered by filtration and the dry matter disappearance calculated. Cumulative gas production at 70 hours (CG70) and *in vitro* dry matter disappearance at 70 hours (DMD70) were measured values of the extent of degradation.

Computation of Data and Statistical Analysis

In sacco dry matter (DM) degradation and gas production kinetics (from 12 hours incubation) were described using the exponential equation $p=a+b(1 - e^{-ct})$ (McDonald 1981), where p was defined as the DM degradation or gas production at time t, (a+b) was the potential DM degradation or gas production, c was the rate of DM degradation or gas production. a, b and c are constants in the exponential equation.

Statistical analysis was carried out on gas production data, *in sacco* data and chemical parameters using the REML technique. Each variable was analyzed for the effect of zone and season.

Results

Differences between zones and pasture types

Table 1 shows the differences in chemical composition, *in vitro* gas production and *in sacco* degradability between the four zones.

There were no significant differences between the four zones in protein content, organic matter (OM) or neutral detergent fibre (NDF). For hemicellulose there was strong evidence ($P>0.01$) that desert steppe and steppe pastures had significantly higher values than high mountain and forest steppe pastures.

There were no significant differences between the four zones in *in vitro* gas parameters or *in sacco* parameters.

There were no significant differences in chemical composition, *in vitro* gas production and *in sacco* degradability between between pasture types within climatic zones.

Trends with time for different zones

Figure 1 shows the differences in certain *in vitro* gas production parameters and chemical components between seasons for the four zones. There was a significant effect of season on CG70 ($P>0.003$) and DMD70 ($P>0.0001$). There was a dramatic reduction in CG70 and DMD70 in the forest steppe zone during the winter period. Season had a significant effect ($P>0.0001$) on protein content. The content of protein was highest for all zones in the summer months and declined in autumn and winter. The levels of neutral detergent fibre and acid detergent fibre were also significantly affected by season ($P>0.0001$), with levels tending to be at their lowest in the summer and highest in the winter months for all four zones.

Comparisons between *in vitro* gas production and *in sacco* degradability

The different indicators of the extent of degradation obtained from the gas production were highly correlated (CG70 vs DMD70, R^2=0.76; CG70 vs gas pool, R^2=0.67), but indicators from the *in sacco* technique were less highly correlated (a+b vs DMD96, R^2=0.60). Table 2 shows the between technique correlations of the indicators of the extent of degradation for the two techniques, which were generally highly correlated (for example *in sacco* DM disappearance at 96 hours and *in vitro* DM disappearance at 70 hours, R^2=0.72). *In sacco* (a+b) and gas production CG70, probably the most reliable measures of the extent of degradation from the two techniques, were correlated with R^2=0.59; closely similar to the (a+b) and DMD96 correlation of the two *in sacco* parameters. The correlation between DM disappearance at 96 hours *in sacco* and gas pool size (constant b for gas production) was particularly poor (R^2=0.12), possibly reflecting experimental errors in measuring DMD96 and errors in gas pool size arising from systematic mis-fitting between the exponential equation and the experimental data. Rate constants (c) were poorly correlated (R^2=0.26).

There was a very strong correlation between the two gas production runs for cumulative gas production at 70 hours (R^2=0.92) demonstrating the high degree of reproducability achieved.

Trends with time were equivalent for cumulative gas production at 70 hours and *in sacco* DM disappearance at 96 hours for both pastures (Figure 2). Degradabilities were highest in the month of June and declined through July and August for high mountain pasture samples collected in 1994. With forest steppe samples the peak was in May. High mountain pastures had a marginally higher degradability in the summer months compared to forest steppe. There were no significant differences (P>0.05) between the two pastures in the indicators of the extent of degradation.

Discussion and conclusion

There were no significant differences in chemical composition between the pastures from the four zones apart from the levels of hemicellulose. High mountain and forest steppe pastures had a lower hemicellulose compared to steppe and desert steppe. When the pasture samples were analysed *in vitro* and *in sacco* there were no significant differences between the four zones.

As would be expected, season had an effect on various gas production parameters and chemical parameters such as protein, ADF and NDF. Levels of protein were highest in the summer months whilst levels of ADF and NDF were at their lowest. This trend is well documented and requires no further discussion.

The correlations in the extent of degradation were generally good with several measures for the two techniques agreeing with the findings of Blummel and Orskov (1993) on work will cereal straws. Both techniques detected similar trends in pasture degradabilities over time.

We conclude, therefore, that there are no apparent overall major differences between pastures sampled in the four climatic zones, nor between different pasture types within zones. These conclusions are, however, tentative due to the very limited nature of the samples collected. Seasonal effects on degradability were observed and such variations may have implications for the optimal use of grazed and conserved pastures in Mongolia.

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Table 1
The effect of climatic zone on chemical components, *in vitro* gas production and *in sacco* degradability of native pastures

	Desert Steppe	Steppe	Forest Steppe	High Mountain	EMS	Sig
OM(%)	85.6	94.8	90.4	90.7	38.62	NS
CP(%)	12.05	9.19	11.51	10.88	1.152	NS
NDF(%)	62.5	63.9	59.4	60.1	9.349	NS
ADF(%)	38.05	38.11	43.92	42.06	4.099	NS
HEM(%)	24.41	25.81	15.51	18.05	4.053	0.011
In Vitro Gas Production						
CG70ml/g	221	262	229	243	1516	NS
DMD70(%)	66.8	68.4	63.4	69.4	0.221	NS
OMD70(%)	65.9	68	63.8	70.3	0.432	NS
(a+b)	271	328	287	309	2616	NS
c	0.0396	0.0309	0.0379	0.0388	0.00004	NS
In Sacco Degradation						
a			23.3	20.3	7.305	NS
b			50.9	57.4	11.54	NS
(a+b)			74.1	77.7	16.08	NS
c			0.0395	0.0378	0.00003	NS
DMD 96(%)			72.4	74.8	11.64	NS

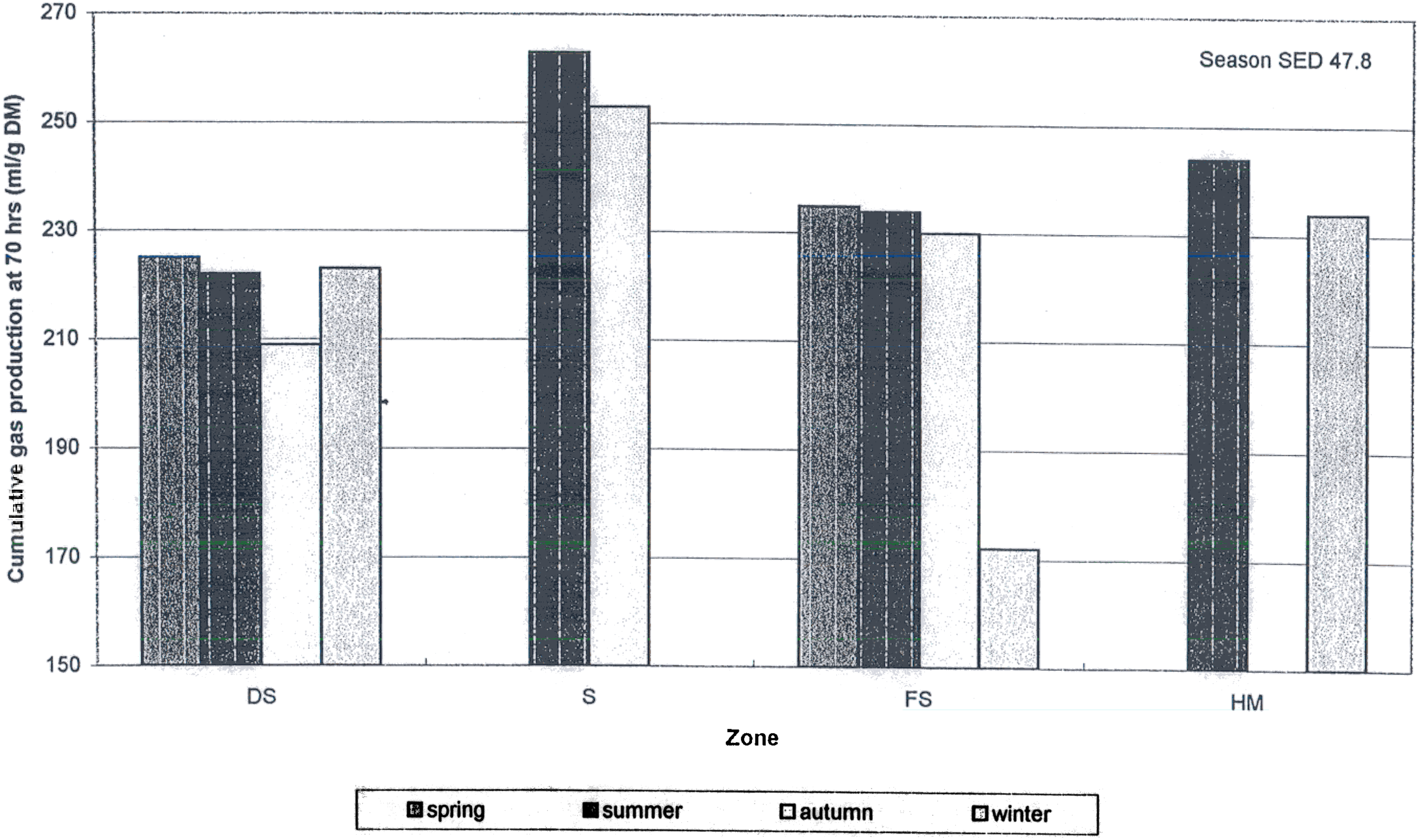
Table 2 Correlations (R^2) between *in sacco* and *in vitro* gas production indicators of the extent and rate of degradation.

Gas Production	***In Sacco* Technique**		
	Extent of degradation	***Rate of degradation***	
Technique	DMD96	a+b	c
Extent of degradation			
CG70	0.47	0.59	
DMD70	0.72	0.60	
Gas pool	0.12	0.45	
Rate of degradation			
Rate Constant			0.26

Figure 1 Seasonal changes in a)CG70 (ml/g) , b) DMD70 (%), c) Protein (%), d) ADF(%) and e) NDF (%) for pastures from four climatic zones in Mongolia.

gas70

Fig 1a



Season SED 47.8
Cumulative gas production at 70 hrs (ml/g DM)
270
250
230
210
190
170
150
DS
S
FS
HM
Zone
spring
summer
autumn
winter

dmd70

Fig 16

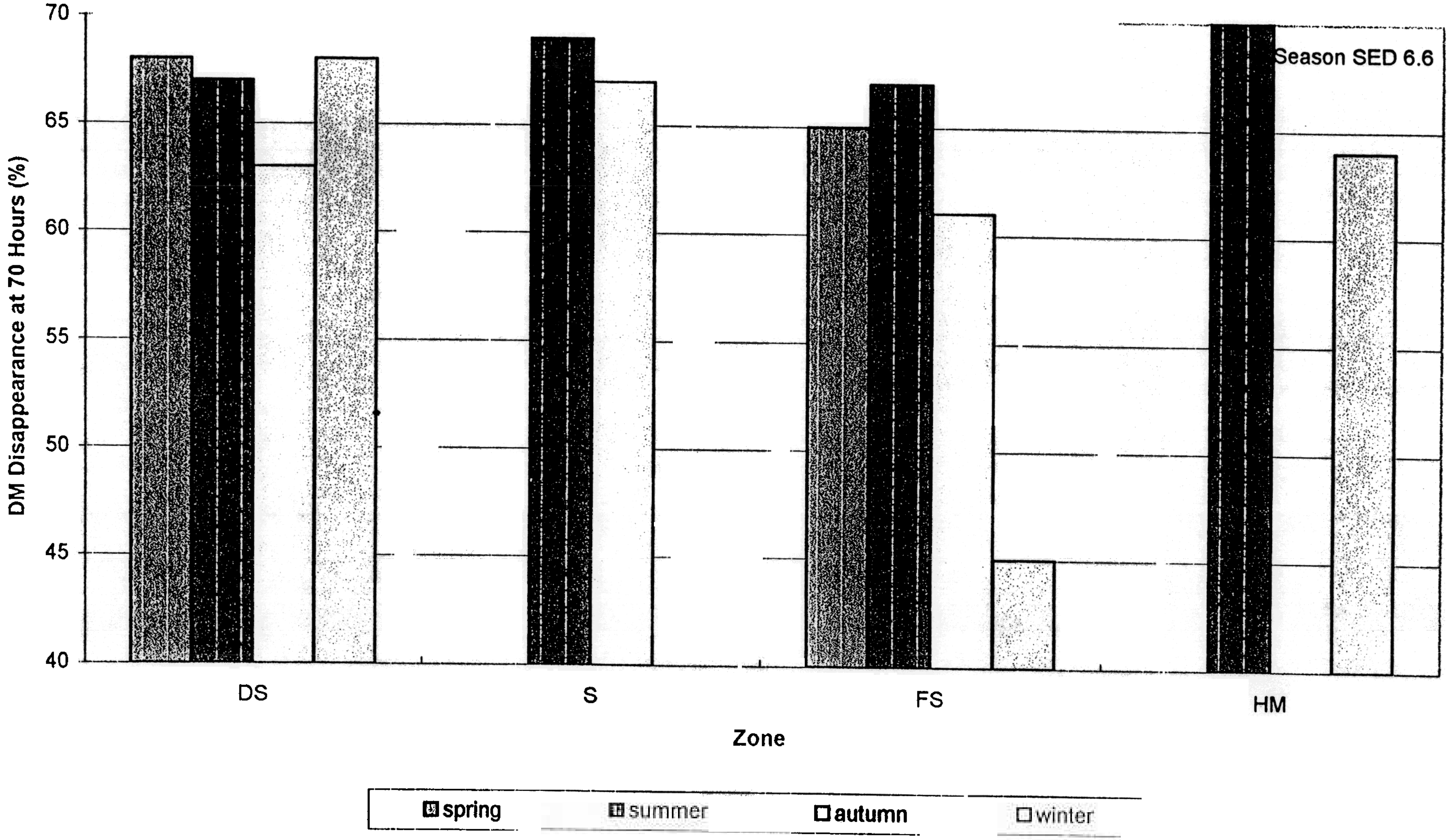

70
65
60
55
50
45
40
DM Disappearance at 70 Hours (%)
Season SED 6.6
DS
S
FS
HM
Zone
spring
summer
autumn
winter

Fig 1c

protein

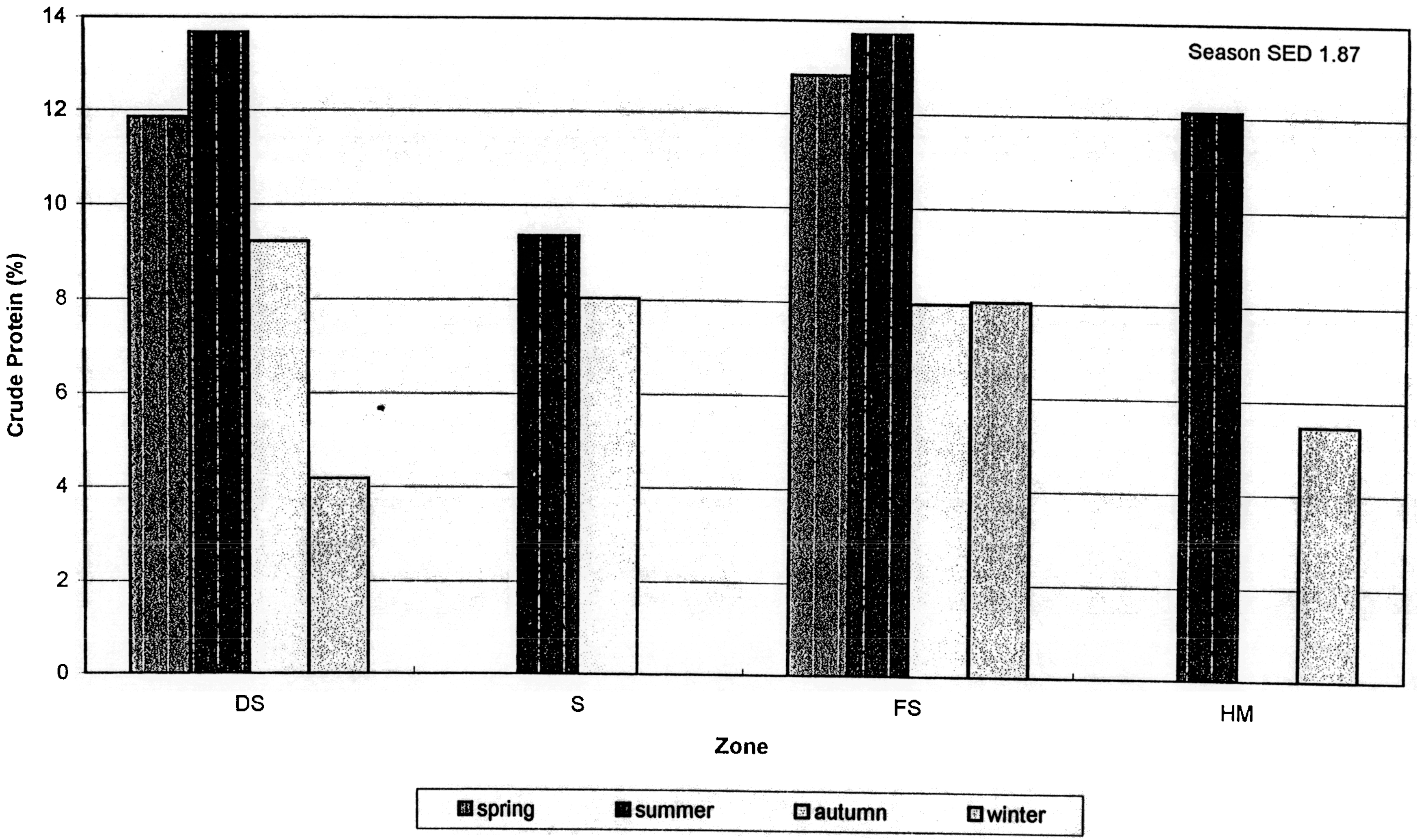
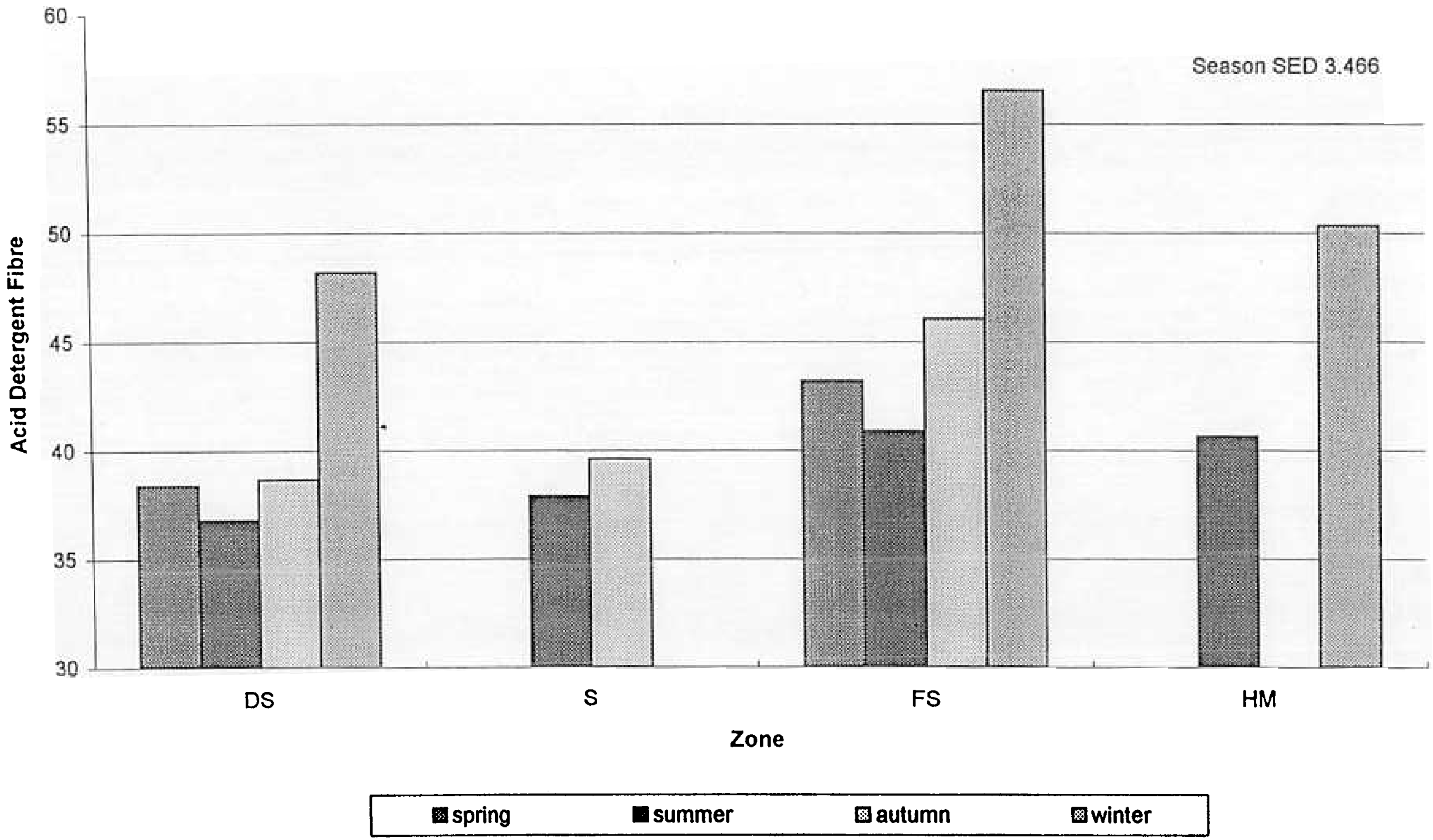
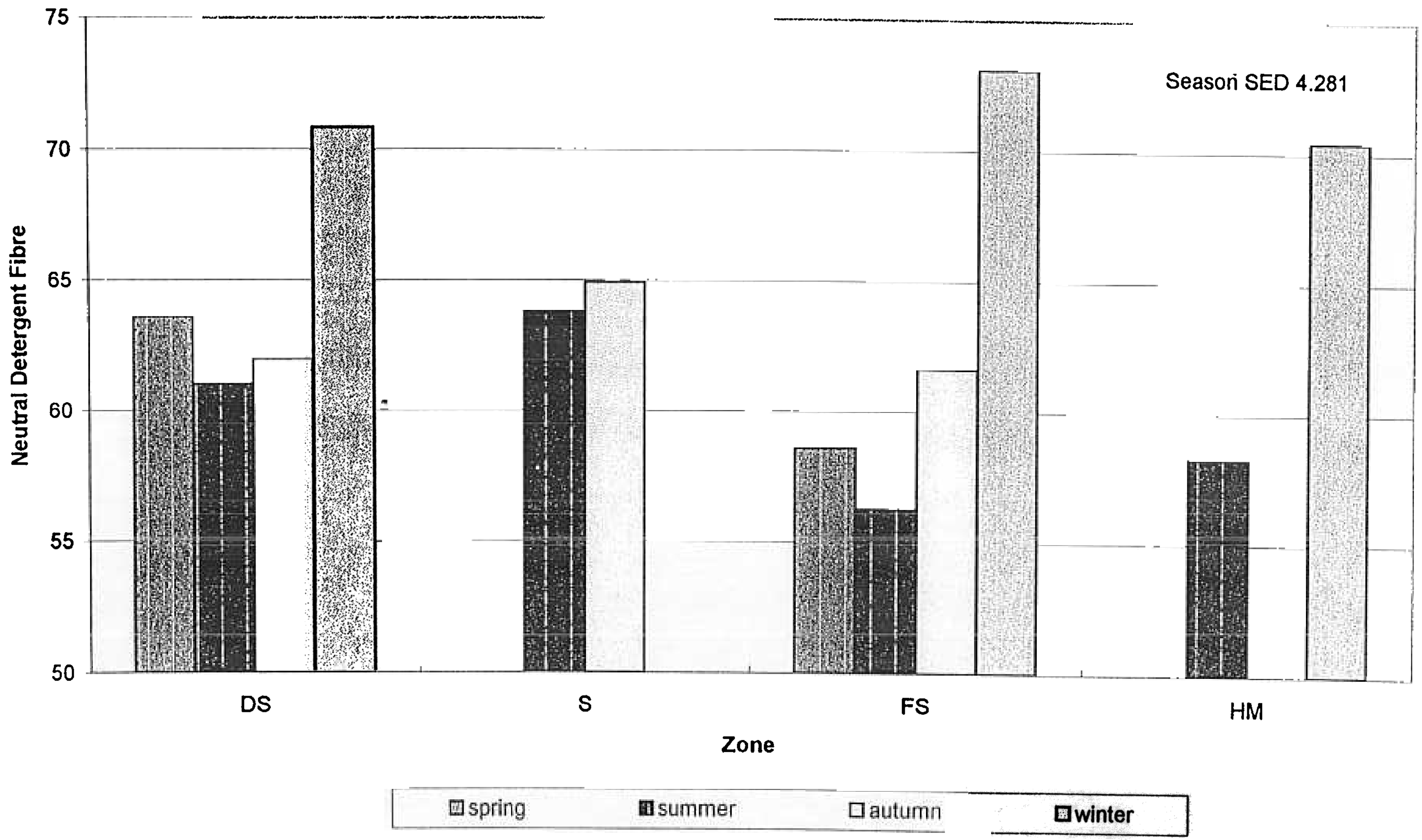


Fig 1d


Season SED 3.466
Acid Detergent Fibre
60
55
50
45
40
35
30
DS
S
FS
HM
Zone
spring
summer
autumn
winter

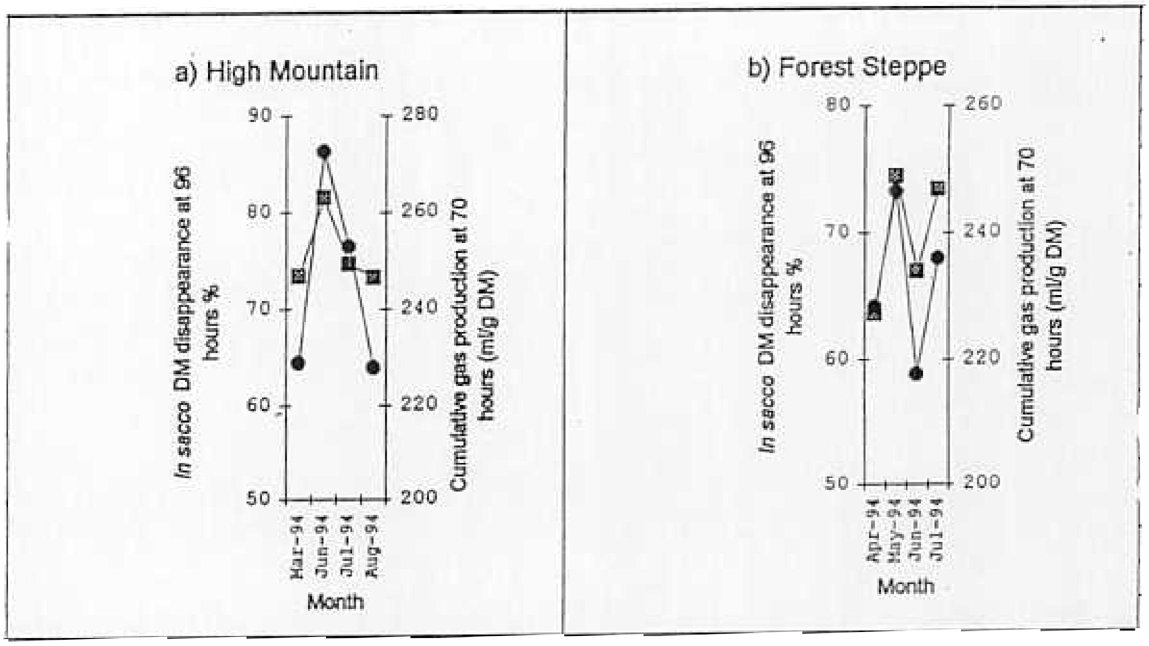
ndf

Fig 1e



75
70
65
60
55
50
Neutral Detergent Fibre
Season SED 4.281
DS
S
FS
HM
Zone
spring
summer
autumn
winter

Figure 2 **Changes over time in cumulative gas production at 70 hours (-●-) and *in sacco* DM disappearance at 96 hours (-■-) in a) high mountain and b) forest steppe pastures.**



a) High Mountain
b) Forest Steppe
In sacco DM disappearance at 96 hours %
Cumulative gas production at 70 hours (ml/g DM)
Mar-94
Jun-94
Jul-94
Aug-94
Apr-94
May-94
Month