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THE EFFECTS OF SITE AND VARIETY ON THE 'IN VITRO' DIGESTIBILITY AND 'IN VIVO' DEGRADABILITY OF SPRING BARLEY STRAW

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RESEARCH REPORT - FINAL

THE EFFECTS OF SITE AND VARIETY ON THE IN VIVO DEGRADABILITY, IN VITRO DIGESTIBILITY AND FIBRE FRACTIONS OF SPRING BARLEY STRAW

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INTRODUCTION

The purpose of this project was to determine the effects of site and variety on the feeding quality of spring barley straw. In order to have samples of straw produced under similar agronomic conditions, samples were obtained from the fungicide treated plots of the N.I.A.B. Recommended List Trials. Samples of straw were collected from eight sites (Bridgets', Wye, Harper Adams, Morley, Cockle Park, Headley Hall, Trawscoed, Seale-Hayne) in 1987. At each site the trial tested 12 varieties and two fungicide treatments in a split plot randomised block design with fungicide treatments on main plots and varieties on sub-plots. In each trial there were three blocks. Samples were collected from fungicide treated plots only except at Trawscoed, where samples were collected from treated and untreated plots. A random sample of approximately 50g of dry straw was collected from each individual plot as soon as possible after harvest. After removing all weed material the straw samples were dried and milled to pass through a 2mm screen. In vitro digestibility of the dry matter was determined using a cellulase preparation

(derived from Trichoderma reesei) following the method of Jones and Hayward (1975). In vivo degradability was determined by measuring the loss of dry matter from samples in dacron bags placed in the rumen of fistulated bullocks. This analysis was carried out in duplicate, i.e. each sample from an individual plot was tested in two bullocks. The percentage of individual fibre fractions in the undegraded straw was determined using sequential cell fractionation. This involved progressive removal of each fibre component using a modification of a method developed by Van Soest (1966). From a known dry weight of straw cell contents were removed by digestion with neutral detergent, hemicellulose by digestion with acid detergent and cellulose by digestion with 72% sulphuric acid. After each digestion the sample was dried and re-weighed. The contents of individual fibre fractions were expressed as percentages of the dry matter. The percentage of lignin was calculated as the percentage of material remaining. Protein content was calculated as nitrogen content x 6.25. Nitrogen content was determined using the Kjeldahl method.

The results for in vitro digestibility have been compared with results obtained in a similar experiment carried out in the previous year. These results have been accepted for publication in the "Varieties and Seeds" (see attached photocopy) and hence are not presented again here.

RESULTS

Tables 1 and 2 show the main effects of variety and site on the measured parameters of straw quality. The site x variety interaction was not significant, except for in vitro digestibility, where it just attained significance at the 5%

probability level.

Effects of variety on straw quality

There were significant differences between varieties in in vivo degradability, in vitro digestibility, cell contents and hemicellulose (Table 1). The range of degradability values varied between sites. At four sites the difference in in vivo degradability between the highest and lowest ranked variety was greater than 15%. At two of the remaining sites it was greater than 10%.

To study the performance of individual varieties at different sites the range of in vivo degradability values for each site was split up into three equal groups termed, high, medium and low. Individual varieties were then allocated to these groups.

Table 3 shows the number of sites at which individual varieties were ranked as either high, medium or low in vivo degradability. The variety Digger had the highest degradability at five out of the eight sites from which straw was obtained. The varieties Doublet, Regatta and Vista also produced straw of medium to high in vivo degradability. The varieties Blenheim, Ilka, Triumph and Klaxon consistently produced straw of low in vivo degradability.

These results suggest that there are differences between spring barley varieties in straw quality. These differences appear to be consistent over a number of sites, and to be of sufficient magnitude so as to be of practical importance to farmers using straw as a feed for livestock or animal feed

compounders.

Effects of site on straw quality

There were significant differences between sites in all the measured parameters of straw quality (Table 2). Differences between sites were larger than differences between varieties, and always accounted for a greater percentage of the total variability in any one parameter. The in vivo degradability of the straw from Seale-Hayne was nearly twice as high as that of the straw from Trawscoed. Sites in the south and east of England (Seale-Hayne, Bridgets', Morley, Wye) produced straw of higher in vivo degradability than sites in the north and west of England (Headley Hall, Harper Adams, Cockle Park) and Wales (Trawscoed). However the reasons for these differences are not clear.

Relationships between in vivo degradability, in vitro digestibility, fibre fractions and protein content

Table 7 shows the values of the linear correlation coefficient between in vivo degradability and in vitro digestibility, the percentage of the various fibre fractions and protein content. For the data for all sites and varieties, in vivo degradability was positively correlated with percentage cell contents and negatively correlated lignin and protein content. However, variation in cell contents, lignin and protein accounted for only 27%, 11% and 9% of the variation in in vivo degradability respectively. There was also a significant linear relationship between in vivo degradability and in vitro digestibility. However, variations in in vitro digestibility accounted for only 30% of the variation in in vivo degradability.

DISCUSSION

In earlier work (see enclosed paper) we found that there are significant differences between varieties of spring barley in *in vitro* straw digestibility. These differences were broadly maintained over a wide range of contrasting sites in two seasons. These experiments have shown that there are similar differences in *in vivo* degradability in ruminant animals. Differences in degradability between varieties and sites might be related to differences in the content of various botanical fractions (mainly leaf and stem) in the straw, or to differences in the degradability of these fractions. Cell contents represent the most and lignin the least degradable fractions of straw and in these experiments there were significant linear relationships between the % content of these fractions and *in vivo* degradability. Although there was a significant linear relationship between *in vivo* degradability and *in vitro* digestibility the latter was not a good guide to the former. The varieties Digger and Doublet produced straw of high *in vivo* degradability and high *in vitro* digestibility. However several varieties, notably Blenheim, Ilka and Triumph, produced straw of low *in vivo* degradability but high *in vitro* digestibility. A method of rapidly and accurately assessing straw degradability would be of considerable use to purchasers of straw wishing to identify high degradability samples.

Table 1 Effects of variety on *in vivo* degradability, *in vitro* digestibility and fibre fractions of spring barley straw. Data are means of eight sites and are all expressed as % of the dry matter.

	in vivo degradability	*in vitro* digestibility	cell contents	hemi-cellulose	cellulose	lignin	protein
Digger	40.9	36.8	22.0	35.4	35.0	8.1	3.3
Doublet	36.6	38.2	20.3	35.7	32.6	11.4	3.1
Regatta	36.1	33.0	21.3	35.0	33.2	10.3	3.1
Vista	35.9	33.0	20.2	36.4	33.5	9.8	3.0
Prisma	35.9	35.0	19.3	35.6	33.4	11.7	2.9
Cameo	35.0	32.9	20.6	35.1	33.9	10.8	3.2
Joline	34.4	32.4	19.7	37.0	35.6	8.7	3.2
Corniche	33.2	34.0	19.2	35.2	33.3	12.3	3.0
Klaxon	32.6	33.2	19.8	36.6	34.2	9.5	3.1
Triumph	32.2	35.2	20.0	35.2	35.2	9.6	3.0
Ilka	30.8	34.3	20.5	34.1	34.6	10.8	3.0
Blenheim	29.4	34.6	22.1	33.8	33.5	10.6	3.1
S.E. of Means	0.90	0.56	0.58	0.51	1.08	1.10	0.09

Table 2 Effects of site on *in vivo* degradability, *in vitro* digestibility and fibre fractions of spring barley straw. Data are means of 12 varieties and are all expressed as % of the dry matter

	in vivo degradability	*in vitro* digestibility	cell content	hemi-cellulose	cellulose	lignin	protein
Seale Hayne	42.2	44.6	23.5	37.4	30.8	8.3	2.9
Bridgets'	40.1	38.9	20.5	35.7	35.3	8.6	2.6
Morley	38.0	29.3	21.9	35.5	32.9	10.1	2.4
Wye	37.6	34.5	21.4	34.5	34.1	10.1	4.2
Headley Hall	37.0	36.0	20.3	34.5	36.2	9.5	2.5
Harper Adams	29.7	29.8	19.8	34.2	33.1	13.0	3.6
Cockle Park	29.1	33.0	18.1	36.7	33.7	11.9	2.4
Trawscoed	24.1	31.0	18.9	35.6	34.7	10.2	3.9
S.E. of Means	0.88	0.54	0.57	0.50	1.06	1.08	0.09

Table 3 Total number of sites at which individual varieties produced straw of high, medium or low *in vivo* degradability.

Variety	High	Medium	Low
Digger	7	1	0
Doublet	3	4	1
Regatta	3	4	1
Vista	3	4	1
Prisma	2	4	2
Cameo	1	6	1
Joline	1	3	4
Corniche	1	2	5
Klaxon	1	1	6
Triumph	1	1	6
Ilka	0	0	8
Blenheim	0	0	8

Table 4 Values of the linear correlation coefficient between *in vivo* degradability and other measured parameters of straw quality

in vivo degradability (%)	*in vitro* digestibility (%)	cell contents (%)	hemi-cellulose (%)	cellulose (%)	lignin (%)	protein (%)
	0.55***	0.52***	0.13	-0.08	-0.33***	-0.27***

*** : P 0.001

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The effects of site and variety on the *in vitro* digestibility of spring barley straw

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Two series of investigations were carried out to study the effects of site and variety on the in vitro *digestibility of spring barley straw. In the first, samples of straw were obtained from the fungicide-treated plots of the Recommended List Trials carried out by the NIAB at nine sites in 1986 and eight sites in 1987. These trials tested 18 and 12 varieties respectively. Digestibility was determined using a cellulase preparation. There were significant differences in digestibility between sites and varieties* in vitro; *the variety × site interaction was not significant in 1986 and just attained significance in 1987. Differences between varieties were greater in 1986 than in 1987 but in both years were of sufficient magnitude to be of practical importance to livestock farmers and animal feed compounders. Differences in* in vitro *digestibility between sites were greater than differences between varieties. Fungicide treatments applied to the growing crop significantly increased digestibility* in vitro. *Differences in digestibility between varieties, sites and fungicide treatments could be due to differences in the content or digestibility of various botanical fractions in the straw.*

Changes in digestibility in vitro *between ear emergence and harvest were monitored in two experiments at Bangor in 1986 and 1987. Digestibility declined during ripening but a late maturing variety (Digger) had higher digestibility* in vitro *than early maturing varieties (Corniche and Atem) at almost all sampling dates, including the final harvest.*

Further research is necessary to determine whether the differences in in vitro *digestibility observed here influence voluntary food intake and* in vivo *straw degradability in ruminant animals. A more rapid method of assessing straw digestibility would be of considerable use to purchasers of straw who wish to identify high digestibility samples.*

INTRODUCTION

Cereal straw is an important food frequently included in the diets of ruminant animals (O'Donovan 1983). There are marked differences in *in vitro* digestibility of the straw from the main cereal crops (Eriksson 1981). The digestibility of barley straw *in vitro* is usually higher than that of wheat straw (Morrison 1983), and oat straw usually has a higher digestibility than barley straw (Mullholland *et al.* 1974; Kernan *et al.* 1979). Differences in *in vitro* digestibility between cereal varieties have also been reported in experiments carried out in Canada (Kernan *et al.* 1979), America (White *et al.* 1981; Erickson *et al.* 1982) and the United Kingdom (Jewell *et al.* 1986). Varietal differences in *in vivo* straw degradability have been related to differences in the content of various botanical fractions (leaves, nodes, internodes, chaff) in the straw

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(Ramanzin *et al.* 1986) and can influence voluntary food intake and milk yield (Orskov *et al.* 1988). Differences in *in vitro* digestibility between environments have also been reported Kernan *et al.* 1979; Erickson *et al.* 1982). However, there is little information on the effects of site and variety on straw digestibility in the UK. In this paper we present the results from several series of experiments carried out to determine the effects of site, variety and fungicide treatment on the *in vitro* digestibility of spring barley straw. In order to make comparisons between sites and varieties by having straw produced under similar agronomic conditions, samples of straw were obtained from the fungicide-treated plots of the Recommended List Trials carried out by the National Institute of Agricultural Botany (NIAB) in 1986 and 1987. Changes in *in vitro* digestibility during ripening were measured in two trials carried out at the University Farm.

MATERIALS AND METHODS

Samples of straw were obtained from the Recommended List Trials carried out at nine sites (Bridgets', Cockle Park, Cambridge, Rosemaund, High Mowthorpe, Preston, Sutton Bonington, Trawsgoed and Wye) in 1986 and at eight sites (Bridgets', Cockle Park, Morley, Harper Adams, Headley Hall, Seale-Hayne, Trawsgoed and Wye) in 1987. In each trial cultivations, manuring and herbicide treatments were carried out according to local conditions and the requirements of good crop husbandry. Details of trials procedures and the methods used to assess non-yield characters have been described by Fiddian (1964, 1979). Each trial tested a number of varieties (18 in 1986, 12 in 1987) and two fungicide treatments in a split plot randomized block design with fungicide treatments on main plots and varieties on sub-plots. In each trial there were three blocks. The fungicide treatments tested were: untreated, no fungicide applied; treated, broad-spectrum fungicides applied at growth stages (Zadoks *et al.* 1974) 31 (fenpropimorph plus carbendazim) and 39 (propiconazole plus tridemorph) with the aim of controlling all diseases.

Straw samples were collected from fungicide-treated plots only except at Trawsgoed, where samples were collected from treated and untreated plots. A random sample of approximately 50 g of dry straw was collected from each individual plot as soon as possible after harvest. Samples were collected from all three blocks in all trials except at Trawsgoed and Seale-Hayne in 1987, where samples from fungicide-treated plots were collected from two blocks only. After removing all weed material the straw samples were dried and milled to pass through a 2-mm screen. Digestibility of the dry matter was determined using a cellulase preparation (derived from *Trichoderma reesei*) following the method of Jones & Hayward (1975).

To prepare the cellulase solution, 10 ml of liquid celluclast 1.5 l (Novo Enzyme Products Limited, Windsor, England) were made up to 1 litre with citrate phosphate buffer pH 4.6. First, 200 mg of dried milled straw were incubated in 20 ml of acid pepsin (prepared by dissolving 2 g pepsin in 1 litre of 0.1 M HCl) in a screw cap bottle at 40°C for 24 h. The acid pepsin was then removed by suction using a filter stick which was subsequently washed with the cellulase solution. Further cellulase solution was then added to make up to 20 ml. The straw plus cellulase was then incubated for a further 24 h at 40°C. The contents of the bottle were then filtered through previously dried and weighed filter paper. The residue was washed with water and acetone. After drying at 105°C for 12 h the filter paper and residue were cooled in a desiccator and reweighed. The *in vitro* digestibility of the dry matter was calculated as the percentage loss of dry matter. All determinations were standardized against the same sample of straw of known *in vivo* digestibility which was included in each run of determinations. For each run the values of *in vitro* digestibility for each sample were multiplied by the ratio

Table 1. Analyses of variance of straw digestibility in 1986 and 1987

	1986			*1987*		
Source of variation	*Degrees of freedom*	*Mean square*	*Variance ratio*	*Degrees of freedom*	*Mean square*	*Variance ratio*
Sites	8	2351.3	179.2	7	764.0	109.1
Varieties	17	127.5	9.7	11	66.6	9.5
Sites × varieties	136	15.4	1.2	77	10.6	1.5
Error	320	13.1		164	7.0	

in vivo/in vitro digestibility of the known standard. Each run took 4 days to complete.

Changes in digestibility of straw during ripening were monitored in two experiments carried out in 1986 and 1987 at the University College of North Wales Farm, Aber, Gwynedd. In each experiment the previous crop was intensively managed grass and cultivations and weed control were carried out according to normal farm practice. Maintenance dressings of phosphorus and potassium were applied during seed bed preparation and nitrogen fertilizer (75 kg N/ha) was applied by hand immediately after crop emergence. A seeding density of 300 seeds/m^2 was used and each plot was 11 × 1.2 m. Triadimefon was applied at the recommended rate during early booting to control mildew. Each experiment was carried out in a randomized blocks design (two blocks in 1986, four blocks in 1987) and tested a number of varieties (12 in 1986, 10 in 1987) although only selected varieties (Atem, Corniche, Digger in 1986; Atem, Corniche, Digger, Doublet in 1987) were used in these studies. Samples of straw were harvested by clipping with shears at approximately 3 cm above the soil surface. Sampling commenced shortly after ear emergence and continued on a weekly basis until harvest. On each occasion a random sample of approximately 50 g of straw was obtained from each of the selected plots. The ears were removed and *in vitro* digestibility of the dry matter was determined as described above.

Table 2. Effects of site on straw digestibility (%) in 1986 and 1987

Site	*1986*	*1987*
Cockle Park	38.1	33.0
Headley Hall	—	36.0
Harper Adams	—	29.8
High Mowthorpe	36.6	—
Rosemaund	42.0	—
Myerscough	39.9	—
Cambridge	48.4	—
Morley	—	29.3
Sutton Bonington	29.7	—
Bridgets'	52.5	38.9
Wye	40.0	34.5
Seale-Hayne	—	44.6
Trawsgoed	39.8	31.0
SE of means	0.49	0.54

Data are means of all varieties.

RESULTS

Effects of site and variety on *in vitro* digestibility

In both years there were significant effects of site and variety on *in vitro* digestibility. The site × variety interaction also attained significance in 1987 but not in 1986 (Table 1). Differences between sites accounted for more of the total variation in *in vitro* digestibility than differences between varieties and the site × variety interaction. Samples were collected from only four specific sites in both years (Table 2). For these sites *in vitro* digestibility was lower in 1987 than in 1986, and the straw from Bridgets' had the highest *in vitro*

Table 3. Effects of variety on straw digestibility (%) in 1986 and 1987

	Means of all sites	
Variety	*1986*	*1987*
Doublet	45.1	38.2
Digger	44.9	36.8
Kingpin	42.5	—
Everest	42.1	—
Blenheim	41.8	34.6
Triumph	41.8	35.2
Regatta	41.7	33.0
Auto	41.4	—
Natasha	41.2	—
Klaxon	40.4	33.2
Atem	40.1	—
Vista	39.7	33.0
Corniche	39.7	34.0
Dandy	39.6	—
Cameo	38.9	32.9
Apex	38.4	—
Ayr	38.0	—
Kym	36.9	—
Ilka	—	34.3
Joline	—	32.4
Prisma	—	35.0
SE of means	0.70	0.56

digestibility in both years. Differences in *in vitro* digestibility between varieties were smaller in 1987 than in 1986 (Table 3). In 1986, at seven out of the nine sites, the difference in *in vitro* digestibility between the highest and lowest variety was greater than 10%. In 1987, at seven out of the eight sites, the difference in *in vitro* digestibility between the highest and lowest variety was greater than 5%. To study the performance of individual varieties at different sites the range of *in vitro* digestibility values for each site was split into three equal groups termed high, medium and low *in vitro* digestibility and individual varieties were then allocated to these groups. Table 4 shows the number of sites at which individual varieties were ranked at either high, medium or low *in vitro* digestibility in the 2 years. Some varieties produced straw of consistently high *in vitro* digestibility (e.g. Doublet, Digger) and others of consistently low *in vitro* digestibility (e.g. Vista, Cameo). Some varieties tended to be more variable (e.g. Triumph) producing straw of high *in vitro* digestibility at some sites and low *in vitro* digestibility at others.

In 1986 the variety Doublet had the highest *in vitro* digestibility at seven out of nine sites from which straw was obtained. In 1987 Doublet had the highest *in vitro* digestibility at six out of the eight sites from which straw was obtained. Straw was obtained from nine specific varieties in both years. For these varieties there was a significant linear relationship between the *in vitro* digestibility values obtained in the 2 years ($r=0.91$, $P<0.001$). Thus these results suggest that there are consistent differences in *in vitro* digestibility between varieties of spring barley that are maintained over different sites and seasons.

Effects of fungicide treatment on *in vitro* digestibility

The effects of fungicide treatment on *in vitro* digestibility of the straw collected from the Recommended List Trials at Trawsgoed are shown in Table 5. In both years fungicide treatment applied to the growing crop significantly increased *in vitro* digestibility.

Changes in *in vitro* digestibility during ripening

The effects of variety on changes in *in vitro* digestibility during ripening in 1986 and 1987 are shown in Figs 1 and 2, respectively. In both years *in vitro* digestibility was high when the first measurements were taken shortly after ear emergence but declined to much lower values at harvest. The NIAB ratings (1–9 scale) for earliness of ripening of the varieties used in these experiments were as follows in 1987: Digger, 4; Doublet, 5; Corniche, 6; Atem, 6 (Anon 1987). It is interesting to note that in 1986, on six out of the seven sampling occasions, the ranking of the varieties for *in vitro* digestibility was the same

Table 4. Total number of sites at which individual varieties produced straw of high, medium or low digestibility in 1986 and 1987

	1986			*1987*		
Variety	*High*	*Medium*	*Low*	*High*	*Medium*	*Low*
Doublet	7	2	0	7	1	0
Digger	6	3	0	5	2	1
Kingpin	4	4	1	—	—	—
Everest	2	7	0	—	—	—
Blenheim	2	6	1	1	4	3
Triumph	2	4	3	1	3	4
Regatta	3	4	2	0	3	5
Auto	3	5	1	—	—	—
Natasha	2	4	3	—	—	—
Klaxon	2	4	3	0	4	4
Atem	1	5	3	—	—	—
Vista	1	3	5	0	1	7
Corniche	0	4	5	1	3	4
Dandy	1	3	5	—	—	—
Cameo	0	3	6	1	2	5
Apex	1	1	7	—	—	—
Ayr	0	1	8	—	—	—
Kym	0	2	7	—	—	—
Ilka	—	—	—	1	4	3
Joline	—	—	—	0	4	4
Prisma	—	—	—	1	4	3

Table 5. Effects of fungicide treatment on straw digestibility (%) in 1986 and 1987

	Means of all varieties		
Year	*Untreated*	*Treated*	*SE of means*
1986	34.6	39.9	1.86
1987	28.5	31.0	0.48

(i.e. Digger > Corniche > Atem). In 1987 at most sampling dates the *in vitro* digestibility of the straw from the late variety, Digger, was higher than that of the other varieties. In the final harvest, taken at maturity, the rank order of the varieties for *in vitro* digestibility was the same as the rank order for earliness of ripening. These two sets of results therefore strongly suggest that late maturing varieties have a higher *in vitro* digestibility than early maturing varieties.

DISCUSSION

These results confirm the results of earlier workers (Palmer 1976; Kernan *et al.* 1979; White *et al.* 1981; Erickson *et al.* 1982; Jewell *et al.* 1986) that there are significant differences between cereal varieties in straw digestibility. In these studies varietal differences were broadly maintained over a wide range of contrasting sites in two seasons. As straw digestibility has been shown to influence voluntary food intake and milk yield (Orskov *et al.* 1988) a classification of spring barley varieties on the basis of straw digestibility would be of considerable interest to livestock farmers and animal feed compounders.

Differences in straw digestibility between varieties and sites observed here might be related to differences in the content of various botanical fractions in the straw, or to differences in the digestibility of these various fractions (Ramanzin *et al.* 1986). Leaf material has

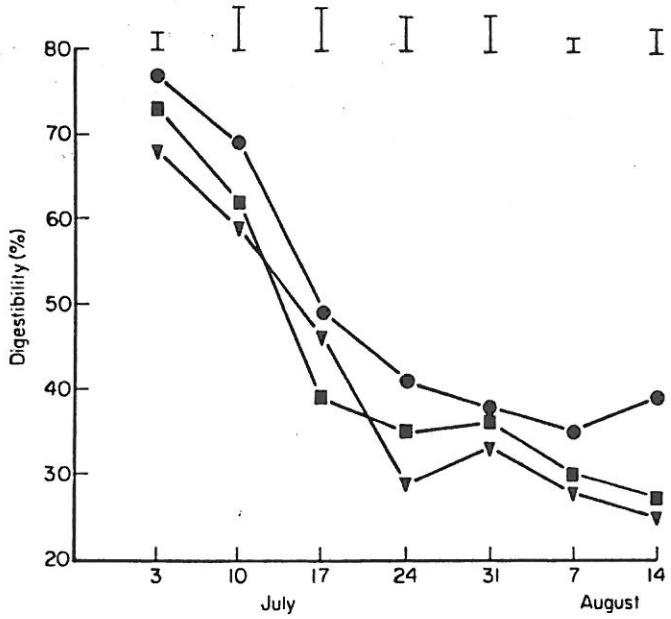

Figure 1. Changes in straw digestibility (%) during ripening of three varieties, (●) Digger; (■) Corniche; (▼) Atem; of spring barley in 1986. The final data values are for samples of straw collected immediately after harvest. Vertical bars indicate standard errors of means.

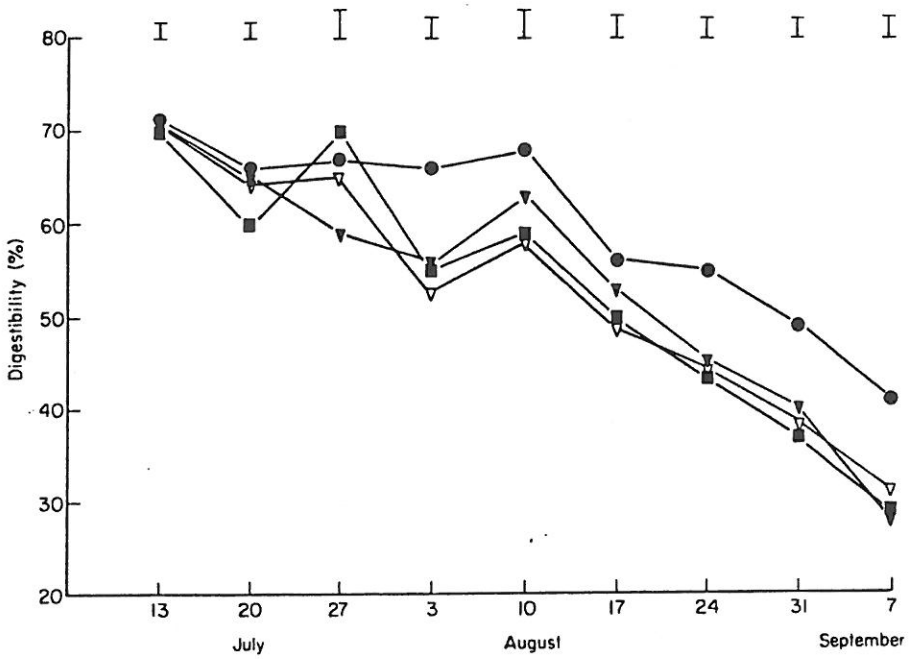

Figure 2. Changes in straw digestibility (%) during ripening of four varieties, (●) Digger; (▽) Doublet; (■) Corniche; (▼) Atem; of spring barley in 1987. The final data values are for samples of straw collected immediately after harvest. Vertical bars indicate standard errors of means.

a higher digestibility than stem (Manley & Wood 1978) so that varieties with a high proportion of leaf would be expected to produce straw of high digestibility (Jewell *et al.* 1986).

Cereal crops and varieties have also been shown to differ in cellulose and fibre content (Kernan *et al.* 1979; Jewell *et al.* 1986). The decline in digestibility as cereal crops mature is associated with increases in these fractions (Manley & Wood 1978; Jewell *et al.* 1986). At any one point in time late maturing varieties might therefore be expected to have a higher straw digestibility than early maturing varieties. However, it is interesting to note that in these experiments differences were maintained right up until maturity.

Using a nylon bag technique, Tuah *et al.* (1986) measured the *in vivo* dry matter degradability of the straw from 19 varieties of spring barley, four of which (Doublet, Triumph, Vista, Klaxon) were included in the experiments here. The *in vivo* degradabilities (grams of dry matter lost/100 g dry matter incubated) of these varieties (68.1, 58.0, 53.0, 52.1, respectively) were closely correlated ($r=0.992$, $P<0.01$) with the *in vitro* digestibilities recorded in the experiments here (41.6, 38.5, 36.3, 36.8 respectively, expressed as the means of all sites and 2 years). Mulholland *et al.* (1974) found that *in vitro* digestibility was positively correlated with straw intake and differences in *in vitro* digestibility between samples were reflected in live weight changes in sheep.

As reported by other workers (Kernan *et al.* 1979; Erickson *et al.* 1982), site and season have large effects on straw digestibility. These differences might be related to differences in soil fertility, particularly the availability of nitrogen. This is known to have large effects on leaf growth (Watson 1974) and might therefore influence digestibility by influencing the botanical composition of straw.

Little is known about which features of the environment influence cellulose and fibre content of straw. Fungicide treatments applied to the growing crop resulted in increased straw digestibility, possibly by delaying senescence or by increasing the proportion of leaf in the harvested straw.

In future work it will be necessary to study the effects of site and varietal differences in straw digestibility on voluntary food intake and *in vivo* degradability in ruminant animals. These topics are the subject of current investigations at Bangor. The procedure used in these studies to determine digestibility took 4 days to complete. A more rapid method of assessing digestibility would be of considerable use to purchasers of straw who wish to identify high digestibility samples.

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