Near infrared determination of the morphological structure of rye grass swards

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Introduction

The grass biomass produced in grazing swards does not have a uniform feeding value. Phenological stage, time of year and botanical composition modify the energy and protein value of the forage, as well as its rumen filling value and hence the intake capacity of the ruminants. In grazing pastures the structure of grass cover plays an important part in determining the extent to which the grass is grazed by animals.[1] The daily intake by ruminants is influenced, not only by the quality of the grass, but also by morphological characteristics, such as the exposed surface of leaves.

The height and volume of grazed horizons modify the speed of intake,[2] During growth, the proportion of a plants accounted for by the stem and leaves vary according to a gradient that operates between the low and high parts of the plant.[3] The role of leaf sheaths in restricting intake has been highlighted in several studies.[4] In a grazed pasture the presence of a high quantity of easily accessible leaf blades and a low quantity of sheaths clearly results in increased intake and a reduction in the residual height of the grass.[5]

Optimal grazing of a pasture will depend on the presence of a raised and easily accessible biomass of green leaves and a limited amount of sheaths or senescent organs.[3] To this end, good leaf blade production and the efficient use of nitrogen for leaf blade growth have been introduced into grass cultivar selection.[6] Nevertheless, rapidly determining the morphological characteristics of grass cover is difficult and involves slow and tedious manual sorting. It seemed appropriate, having a database on the proportions of blade stems and senescent organs evaluated by manual sorting, to investigate the use of near infrared (NIR) for rapidly determining the proportions of these plant parts in the whole plant.

Material and methods

A calibration to estimate the proportion of the main vegetative parts of a graminae was established, based on the proportions of the different plant parts—leaves/stem and sheaths/senescent organs—estimated during 250 sortings of rye grass (Lolium perenne) cultivars. The cultivars had different heading dates and had received different fertilisation regimes.

Sampling rye grass varieties

From November 1996 to October 1997, 16 varieties of rye grass (11 diploid and 5 tetraploid) representing a wide range of earliness (index 53 to 63) and of fertiliser use were sampled at regrowth, the duration of which varied from two to nine weeks. The samples were collected by mowing the grass close to the ground, using a micromower on a surface of 0.12 sq. m (1.2 m × 0.1 m).

Fresh or defrosted samples of about 100 g of green matter were morphologically sorted. Each sorted subsample was weighed green, then dried at 65°C (48 h) and weighed again when dry. The sheath/leaf separation was done by cutting close to the auricle (ligule). The green blade part was separated from the dried or ageing parts; these senescent blades were added to dead sheaths to constitute the "senescent organs" fraction of the plant. After calculating the different organs, on a DM basis, the sorted dry samples were remixed in the corresponding proportions and then ground using a Gondard mill (1 mm mesh). The results of the sortings were expressed as a percentage of the dry matter and the

Table 1. General description of the rye grass sample series.

Date	min. N kg ha^{-1}	Cycle year	Stage	Head Index	Prod. t.DM ha^{-1}	Blades % DM	Sheaths % DM	Sen. organs % DM	Blade prod. t.DM h^{-1}
11/96	50	3-AO	leaf	62	1.65	89.0	11.0	0.0	1.47
11/96	0	5-A2	leaf	62	3.03	52.8	10.2	37.0	1.60
04/97	0–40	1-Al	leaf	53–62	2.61	85.2	12.1	2.7	2.22
05/97	50	1-Al	leaf	61–63	2.85	69.1	30.2	0.7	1.97
05/97	50	1-Al	head	61–63	3.95	57.7	38.7	3.6	2.28
05/97	50	1-Al	head	61–63	5.56	48.3	45.5	6.2	2.69
06/97	0	1-Al	head	53	2.79	28.8	60.1	11.1	0.80
06/97	0	1-Al	head	62	3.01	60.4	27.7	11.9	1.82
06/97	30	1-Al	head	62	3.11	42.8	46.1	11.1	1.33
06/97	0	2-Al	head	53	1.95	54.7	46.7	8.6	1.07
06/97	0	2-Al	head	62	1.81	68.8	23.8	7.4	1.25
06/97	30	2-Al	head	62	2.52	52.5	43.0	4.5	1.32
06/97	50	2-Al	leaf	61–63	0.92	79.3	20.7	0.0	0.73
06/97	50	2-Al	leaf	61–63	1.31	68.2	31.8	0.0	0.83
06/97	50	2-Al	leaf	61–63	1.92	61.6	38.4	0.0	1.18
06/97	40	3-Al	leaf	53	0.77	76.8	19.9	3.3	0.59
07/97	50	3-Al	leaf	61–63	2.86	70.6	24.1	5.3	2.02
09/97	50	4-Al	leaf	61–63	2.15	58.8	15.6	25.6	1.26
09/97	0	5-Al	leaf	53–62	1.50	51.0	6.1	42.9	0.76
09/97	45	5-Al	leaf	53-62	2.15	57.0	13.4	29.6	1.23
10/97	50	3-AO	leaf	54	0.83	55.3	44.7	0.0	0.46

quantity of leaves (t.DM h^{-1}) arising from the harvested biomass was multiplied by the green leaves percentage.

NIR treatment

For each of the dried and ground samples the NIR reflection was measured, twice, between 1100 and 2500 nm (in 2 nm steps), using an NIRSystem 5000 monochromator and placing 10 g of the powder of the whole plant sample in a quartz window cup (diameter 35 mm, height 10 mm).[7] This method is used routinely by the laboratory of Libramont.[8]

The data were processed using the Partial Least Square (PLS) regression technique, with the help of InfraSoft International (ISI) software.[9]

Results and discussion

The main characteristics of the rye grass samples are described in Table 1. The statistical parameters of the PLS models are given in Table 2. Figures 1, 2 and 3 compare the NIR predicted with the reference value for the blades, sheaths and senescent parts of the plants.

The description of the rye grass samples (Table 1) shows the important variability of the morphological composition evident from manual sortings. These characteristics have been previously described.[10] Starting from the leafy stage to the heading the diminution of the blades proportion varied on average from 89.0 to 42.0% DM, while the stems and sheaths progressed from 6.1 to 60.1% DM. With delayed cutting rhythms, due mainly to heavy rust (Puccinia graminis) infestation, the senescent organs exceeded 40% DM. The morphological description would complete the height measurements, which are not sufficient to characterise the grass cover.[11]

The NIR technique enables one to predict proportions of green blades, stems and sheaths and dying organs with cross-validation errors of 4.18, 3.85 and 2.88, respectively. For vegetation conditions as varied as those described in Table

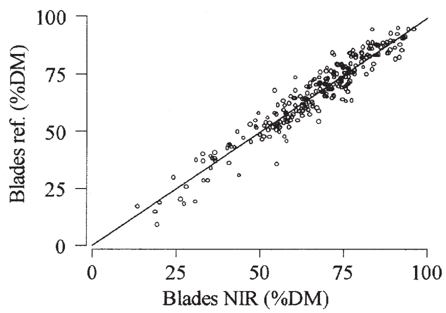

Figure 1. NIR predicted v. reference value for blades percentages.

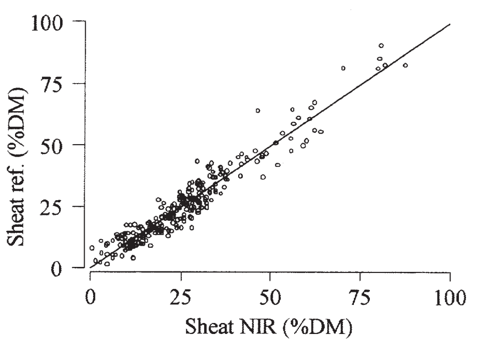

Figure 2. NIR predicted v. reference value for sheath percentages.

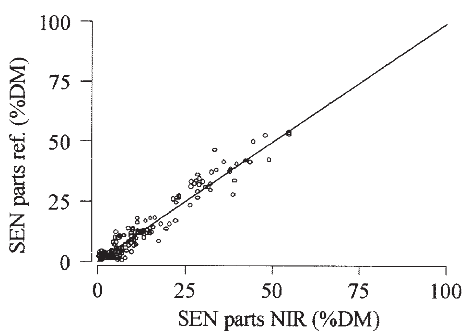

Figure 3. NIR predicted v. Reference value for senescent percentages.

Table 2. Statistical parameters of the calibrations of morphological traits.

Variable	Nb	Min.	Max.	Mean	*SEC*	R^2c	*SECV*	R^2cv
Green blades	243	9.4	94.9	66.4	3.47	0.96	4.18	0.94
Green sheaths and stems	243	1.5	90.6	25.9	3.06	0.97	3.85	0.95
Senescent parts	243	0.4	54.1	7.7	2.35	0.97	2.88	0.95

1, this degree of precision is entirely satisfactory. Furthermore, the determination coefficients in calibration reached 0.96 to 0.97 and stabilised between 0.94 and 0.95 in validation. There appears to be a negative relationship between blades and residual sheaths ($r = -0.62$) that does not occur with senescent organs.

Conclusion

Because of it's quickness and low cost the NIR technique could be a very interesting tool to study the morphological traits of a sward vegetation. It could allow dynamic studies of the evolution of the structure of the sward under grazing. Development should be undertaken to extend the database with pure or mixed samples of other species, particularly with dicotyledons like clover, a main component of mixed swards.

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