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Perennial ryegrass cultivar effects on intake of grazing sheep and feeding value

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Abstract – The use of animal trials in routine evaluation of grass cultivars under grazing is expensive and space- and time-consuming. Therefore, there is a need to find cultivar morphological traits enhancing animal production under grazing which could be used to evaluate and breed grass cultivars. The morphogenesis of four cultivars of perennial ryegrass (*Lolium perenne* L.) was compared in relation to their intake by grazing sheep. Sheep intakes were estimated by following the consumption of marked tillers over 4 days of grazing, after 3, 4 and 5 weeks of growth and at the same allowance of 1.7 kg DM day^{-1} $sheep^{-1}$. Significant differences in intake were found between cultivars but the order was management-dependent. Intake under grazing was positively correlated with the green lamina mass above 10 cm. The same cultivars were fed to sheep in individual crates. Ingestibility, in vivo digestibility and palatability were assessed and significant differences were found between cultivars. Ingestibility was positively correlated with the lamina to pseudostem ratio, while digestibility was negatively correlated with the quantity of dead leaves in the fresh forage. No correlations were found between the intake under grazing and ingestibility, in vivo digestibility and palatability measured with the housed animals. The potential value of perennial ryegrass cultivars under grazing can not be drawn from the feeding value assessment with housed animals. Green lamina mass could be a good trait to assess in an evaluation process of grass cultivars and to select for since it seems to be related to the potential intake by grazing sheep at a given management. (© Elsevier / Inra)

feeding value / grazing / *Lolium perenne* / morphogenesis / plant breeding

Résumé – Effet variétal sur l'ingestion au pâturage des ovins et valeur alimentaire du ray-grass anglais. Le coût et la lourdeur des essais conduits avec des animaux au pâturage rend leur utilisation peu compatible avec une évaluation en routine des variétés de graminées fourragères. Il conviendrait donc de déterminer les caractéristiques variétales à l'origine d'une meilleure pro-

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duction animale au pâturage afin de les prendre en compte pour l'évaluation et la sélection des variétés. Nous avons comparé la morphogénèse de quatre variétés de ray-grass anglais (*Lolium perenne* L.) en relation avec les quantités ingérées par des moutons au pâturage. Les quantités ingérées ont été estimées par le suivi de talles baguées durant 4 j de pâturage, après une repousse de 3, 4 et 5 semaines et à une quantité offerte de 1,7 kg MS.jour^{-1}.mouton^{-1}. Des différences significatives de quantités ingérées au pâturage ont été mises en évidence, cependant le classement des variétés dépendait de la durée de la repousse. Ces quantités ingérées au pâturage sont toutefois positivement corrélées à la quantité de limbe vert des variétés. La valeur alimentaire des quatre variétés a été parallèlement étudiée au moyen de moutons maintenus en cage. L'ingestibilité, la digestibilité in vivo et l'appétibilité des quatre variétés ont été déterminées. Des différences significatives existent entre variétés pour ces variables en condition de distribution à l'auge. L'ingestibilité est positivement corrélée au rapport limbe sur gaine. La digestibilité est négativement corrélée à la quantité de matériel mort dans les strates supérieures du couvert. Aucune corrélation n'a été mise en évidence entre l'ingestibilité et la digestibilité mesurées à l'auge et les quantités ingérées au pâturage. La valeur en condition de pâturage d'une variété ne peut pas être déduite des résultats obtenus en condition de distribution à l'auge puisque la préhensibilité de l'herbe est très différente entre ces deux modes d'exploitation. La quantité de limbes verts semble être un caractère à retenir afin d'évaluer et de sélectionner les variétés de graminées. En effet, pour un rythme d'exploitation donné, la quantité de limbes verts d'une variété semble traduire la quantité potentiellement ingérée par des moutons au pâturage. (© Elsevier / Inra)

amélioration des plantes / *Lolium perenne* / morphogenèse / pâturage / valeur alimentaire

1. INTRODUCTION

Animal production costs could be reduced by maximizing individual production from grazing animals through increasing their daily intake of grass. Herbage intake limits milk production under grazing [12]. It can be maximized by increasing herbage allowance and sward height, thus reducing the difficulties animals may have in prehending herbage [3, 9, 14]. However, this results in decreasing the animal output per unit area and an under-utilization of the grass production, which can spoil the forage quality and complicate pasture management. In this context, any significant genetic improvement in intake of grass cultivars by grazing animal is of interest to farmers, both to maximize animal production and to increase the flexibility of pasture management.

Herbage allowance and sward height are not the only sward traits involved in the variation of intake under grazing, since, at a same allowance or at a same height, intake varies considerably according to the sward structure [9]. Intake rate has been related to sward traits such as bulk density of material in the grazed zone [19, 22] or green leaf mass [13, 15, 16]. When done at an intraspecific level, these studies report the relationship between intake and sward structure affected by management [13] or maturity stage [15, 16]. However, very few references exist on the effects of cultivar and intraspecific variability of sward structure on animal intake [17].

At the intraspecific level, sward structure has been shown to be the major factor influencing net herbage production [2]. The genetic variability of ryegrass morphogenesis has been used successfully in a breeding program to match its productivity to defoliation frequency [7, 8]. However, there is no evidence that intraspecific genetic differences in sward structure could be large enough to modify the intake of grazing animals since perennial ryegrass is already well adapted to grazing and of a high feeding value [5, 23].

In order to establish cultivar effects on intake and differences between indoors and grazing conditions, ingestibility, digestibility and palatability using fresh forage fed indoors and intake by grazing sheep were compared among four perennial ryegrass cultivars. Different durations of regrowth were studied to take into account possible differences in cultivar growth rates [2, 10]. Differences in cultivar sward structures were related to differences in intake and feeding value to identify sward traits to be used in grass breeding and cultivar evaluations.

2. MATERIALS AND METHODS

The seeds of four diploid cultivars of perennial ryegrass, registered in France, intermediate (referred to as cv 1 and cv 2) and late flowering (referred to as cv 3 and cv 4), were treated with Benomyl to prevent any endophyte contamination of the forage. In October 1995, a paddock of 5000 m^2 per cultivar was sown in rows, 20 cm apart, at the rate of 40 kg/ha. The four paddocks were cut on April 4, 1996. The experiment was carried out from April 22 to May 10, 1996.

One half of each paddock was devoted to rotational grazing and the other half to mechanical harvesting of fresh grass fed to sheep in crates. Both grazing and indoors experiments were conducted with Texel castrated sheep weighing on average 80 kg.

2.1. Grazing management

In order to study the effect of regrowth duration on intake under grazing (GI), the four paddocks were divided into strips and grazed successively after 3, 4 and 5 weeks of regrowth. Grazing was managed at a constant herbage allowance of 1.7 kg of DM per sheep and per day. Consequently, the surface of the strips was independently adjusted each week according to each cultivar DM yield. The first strip was grazed from April 22–26 by eight sheep after 3 weeks of regrowth (week 3). Another strip was grazed after 4 weeks of regrowth (week 4), from April 29 to May 3 by 11 sheep, and the last one, after 5 weeks of regrowth (week 5), from May 6 to May 10 by 11 sheep.

2.2. Indoor feeding management

Four weeks of feeding value measurements with sheep were taken during week 3, week 4, week 5 and after 6 weeks of regrowth (week 6). The four cultivars were cut every day and fed twice a day to six sheep housed individually in metabolism crates for 5 days, after a preliminary ad libitum feeding period of 7 days. The level of feeding had been adjusted to leave approximately 15% refusal to estimate the ingestibility and the in vivo digestibility of organic matter (DOM) with ad libitum feeding. Palatability was estimated according to the cafeteria method developed by Gillet et al. [6]. On April 30, a cafeteria trial was carried out with 20 troughs and 12 sheep. The four cultivars, five replications of 2 kg fresh herbage, were randomized in the troughs. The sheep were allowed to choose and eat during 1 h 30. The fresh herbage remaining in each trough was weighed and the result was expressed as the percentage of forage eaten for each cultivar.

2.3. Sward measurements

Every week, the DM content, the DM yield, the vertical distribution of biomass and the sward structure of each cultivar were described before beginning the grazing. DM content and DM yield were estimated from 10 randomized quadrats (0.50 m x 0.20 m) cut to ground level. Vertical distribution of biomass and sward structure were assessed from three randomized quadrats (0.12 m x 0.20 m) cut into layers of 5 cm height from the top to the bottom of the sward. Green lamina, green pseudostems and dead materials in each layer were separated and oven-dried to calculate the total DM per square meter, the DM of lamina, pseudostem and dead material and their vertical distribution within the sward. The in vitro dry matter digestibility of each fraction (IVDMD) was investigated through enzymatic solubility (adapted from Libramont-Limagrain protocol: bags replaced crucibles, and 0.1 N HCl was used [11]). Moreover, four 0.2 m x 0.4 m samples of aerial biomass were randomly taken from each paddock in order to estimate the tiller density.

Before each grazing period, 100 individual tillers spaced 20 cm apart were marked per paddock with rings of telephone wire within 10 transects. These were randomly distributed on the plot. The heights to the ligule (sheath length) and tip of the highest leaf (extended tiller length) of each marked tiller were measured before, on each day during and after grazing [21]. The DM of grazed grass was calculated, using each transect as a replication, from the tiller length remaining after grazing and from the vertical distribution of the biomass. The average of daily intake per sheep under grazing (GI) was the DM of grazed sward divided by the 4 days of grazing and by the number of sheep.

Statistical analyses were carried out following the GLM procedure of the SAS software [18]. Cultivar, maturity group (group), and week effects on feeding value and sward parameters were tested according to the model: cultivar(group) + group + week + cultivar (group) * week + group * week. When testing the vertical distribution, the factor of variation due to layers was added to the model, as well as its interaction with the other factors.

3. RESULTS

On average, the values of intake under grazing were lower than those measured with housed sheep (40 vs. 62 g DM kg^{-1} MW per day). We can not conclude that the lack of prehensibility of the grass under grazing decreases intake compared to the same herbage fed indoors since GI could be systematically underestimated. However, cultivar comparisons are still relevant within the grazing treatment and within the indoors feeding treatment.

Under grazing, GI was found to be significantly different between cultivars of a same maturity group (*tables I, II*). The cultivar rank depended on the regrowth duration. These differences were due to differences both in the depth of defoliation and in the density of dry matter in the grazed layers.

Table I. Means of intake under grazing, and ingestibility, in vivo digestibility and palatability of the same herbage fed indoors of four cultivars of perennial ryegrass after 3, 4, 5 and 6 weeks of regrowth using 'Texel' castrated sheep.

			Weeks of regrowth			
		Cultivar	3	4	5	6
Grazing	Intake (GI) (g DM kg^{-1} MW per day)	1	49	51	29	–
		2	42	32	33	–
		3	38	45	38	–
		4	27	43	57	–
Indoors	Ingestibility (g DM kg^{-1} MW per day)	1	59	61	56	54
		2	58	64	60	57
		3	63	66	60	58
		4	67	68	63	64
	In vivo DMO (%)	1	80	80	80	77
		2	79	78	76	75
		3	81	79	78	77
		4	78	78	79	78
	Palatability (%)	1	–	59	–	–
		2	–	35	–	–
		3	–	15	–	–
		4	–	30	–	–

Table II. ANOVA of intake under grazing, and ingestibility, in vivo digestibility and palatibility of the same herbage fed indoors of four cultivars of perennial ryegrass after 3, 4, 5 and 6 weeks of regrowth using 'Texel' castrated sheep.

	Grazing		Foddering				
	df	Mean square	df	Mean square		df	Mean square
Source of variation		intake		intake	digestibility		palatability
Cultivar (preco.)	2	531 ***	2	126.3 *	30.3 ***	2	1242 **
Precocity	1	208 *	1	596.5 ***	4.0	1	3624 ***
Week	2	167 *	3	196.7 **	36.5 ***	–	–
Week*preco.	2	1940 ***	3	10.7	5.3 *	–	–
Week*cultivar (preco.)	4	771 ***	6	11.0	6.2 **	–	–
Error	108	55	80	40.7	1.9	20	147

*,**,*** Significant at 0.05, 0.01, and 0.001 levels, respectively.

The sward structure was different between cultivars. While DM content and tiller densities (7600 tillers/m^2) were the same, the four cultivars were significantly different ($P < 0.05$) for their biomass per square meter, their vertical distributions of biomass, and the distributions of their lamina, pseudostem and dead material. Among the morphological traits of the cultivars, the green lamina mass per square meter above 10 cm gave the best correlation with GI (*figure 1*).

Intakes of fresh grass fed indoors, for each cultivar, and their respective rankings were different from these obtained under grazing (*table I*). Significant differences in ingestibility existed between cultivars but, contrary to the observations of the intake levels done under grazing, no significant interaction occurred between the cultivar effect and the duration of regrowth (*table II*). Cultivar 4 showed the best ingestibility regardless of its duration of regrowth (*table I*). Ingestibility appeared to be well correlated to the lamina/pseudostem ratio (*figure 2*). Cultivar 4 had the highest value for this ratio throughout the experiment.

The in vivo digestibility of cultivar 2 was significantly lower than that of the others and this difference increased with the duration of the regrowth (*table I, II*). However, the IVDMD of the green material was not significantly different between the cultivars nor its vertical distribution in the sward. The upper layers, which had been grazed, remained of a similar digestibility regardless of the regrowth duration for the four cultivars (*figure 3*). Therefore, differences in in vivo DOM between cultivar 2 and the others could be due to the higher percentage of dead material found in its layers above 5 cm (9% vs. 5%).

Differences in cultivar palatability, tested in a cafeteria on week 4, were highly significant (*table I*). Cultivar 1 was found to be more palatable than the others (*table II*).

No relationship was found between GI, ingestibility and in vivo DOM among the four cultivars. As a matter of fact, their best predictors, quantity per square meter of green lamina above 10 cm, lamina/pseudostem ratio and percentage of dead tissues above 10 cm, were not correlated.

4. DISCUSSION

At a non-limiting allowance, significant differences between cultivars were

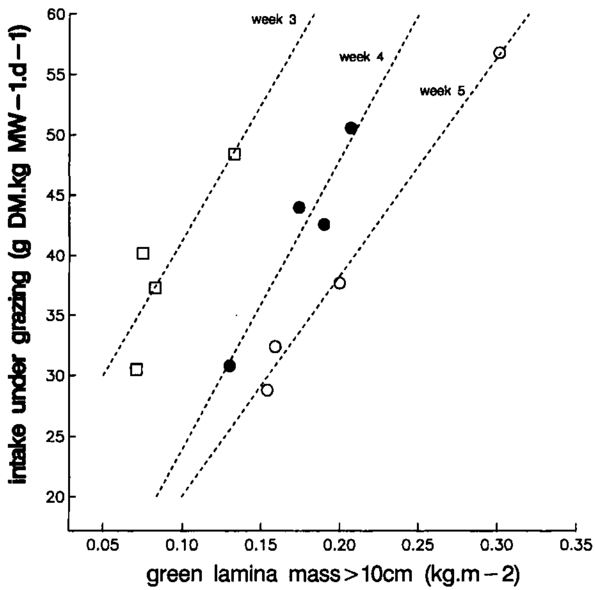

Figure 1. Relationships between green lamina mass above 10 cm and intake of grazing sheep in weeks 3, 4 and 5.

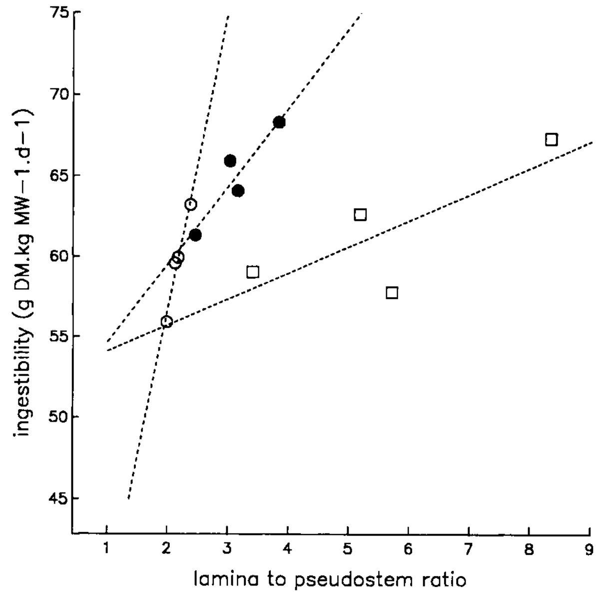

Figure 2. Relationships between lamina to pseudostem ratio and intake of housed sheep in weeks 3, 4 and 5.

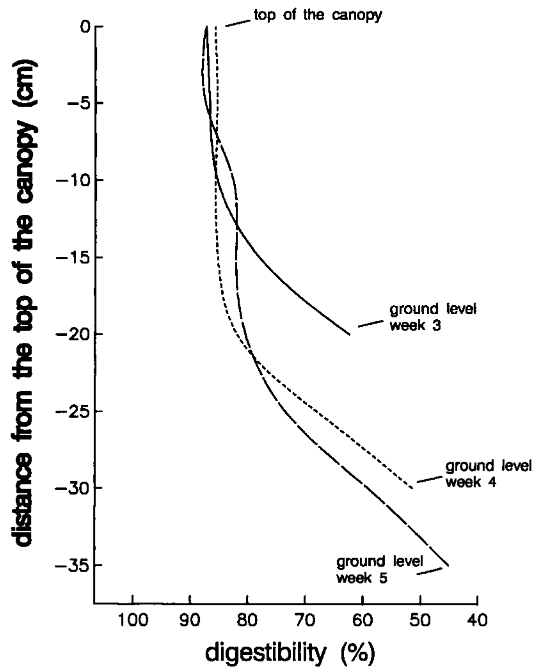

Figure 3. Vertical distribution of the in vitro digestibility of the dry matter within the canopy in weeks 3, 4 and 5.

found in the valorization of perennial ryegrass by sheep under both grazing and feeding indoors. The cultivars differed in their feeding values, and even more in intakes under grazing conditions. Such a large difference could affect animal production.

Ingestibility assessed under the standard conditions of individual crates was not related to intake measured under grazing. As a result, estimating cultivar ingestibility would not provide any valuable information on cultivar performances under grazing. Moreover, the intake of grazing sheep appeared to be more sensitive to cultivar effects and regrowth duration than the measurements done with housed animals.

In vivo digestibility was high, but significantly lower for cultivar 2 than for the others. The decrease in digestibility from week 3 to week 6 is low but significant. Cultivar differences slowly increased with the age of the sward and were likely to be maximized under stockpiling conditions. No relationship existed between cultivar digestibility and ingestibility which can be due to both the low variability in digestibility (Demarquilly, personal communication) and the low DM content of the fresh grass ranging from 16.7 to 19.5% throughout the experiment [1, 20].

The palatability of cultivar 1 was much higher than that of the others but this high palatability did not lead to a higher ingestibility and was not a consequence of a higher in vivo digestibility.

Obviously, an evaluation of cultivar abilities to enhance animal production can not be limited to the characterization of its feeding value or its palatability. Since perennial ryegrass is mainly used under grazing, cultivars should be tested for their value under grazing conditions taking into account differences in prehensibility between cultivars. Several attempts have been made to simplify grazing trials. However, simplification can cause misinterpretations. For instance, testing cultivars displayed in Fisher blocks under common grazing can be confounded by their differences in palatability. An alternative to grazing trials is to assess cultivars for physiological traits associated with a high grazing value.

The top lamina layer, as pointed out by Flores et al. [4], seems to play an important role in determining intake by a grazing animal. Green lamina mass above 10 cm, which is a rough expression of the top lamina layer, was not a good estimator of intake over time since there was no significant regression between this trait and the evolution of intake during the regrowth. Nevertheless, green lamina mass could have an interest for cultivar evaluation and breeding since it allowed to rank the cultivars on their potential intakes by grazing sheep at a given time. As expected, this trait, like cultivar performance, was management-dependent and cultivar ranking changed during the regrowth. When the forage was cut and fed indoors, the housed animals had no choice but to eat a proportion of the bottom layer of pseudostem which has been cut with the top lamina layer. Consequently, ingestibility seemed to be well correlated to the lamina to pseudostem ratio at a given time. Finally, differences in digestibility between cultivars did not result from differences in green material digestibility but from differences in the proportion of dead material in the top lamina layer. These criteria, which could be used in both cultivar selection and evaluation, are likely to be antagonistic with increasing DM yields.

The evidence of cultivar effects upon animal production through their sward morphology and prehensibility has still to be proven. Nevertheless, these first results are promising for grass breeders. Further co-operation is needed between animal scientists and breeders in order to define more accurately the desirable cultivar traits improving intake and digestibility under grazing, as well as between crop physiologist and breeder to determine the relative genetic and environmental effects of such highly management-dependent traits.

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