Breeding Morphogenetic Traits to Match Genotypes to Their Utilization

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ABSTRACT
A divergent selection for lamina length was done from natural populations of perennial ryegrass. Tested in a multi-site experiment in France, the short-leaved perennial ryegrass was more productive under simulated grazing and less productive under infrequent cutting than the long-leaved perennial ryegrass. Matching cultivars to their management is possible by selecting for morphogenetic traits. However, our results suggest the range of adaptation to different managements of perennial ryegrass cultivars could be extended by increasing their phenotypic plasticity.

KEYWORDS
adaptation, cutting frequency, DM yield, *Lolium perenne*, management, morphogenesis, perennial ryegrass.

INTRODUCTION
In France, selection and evaluation process of new cultivars of forage grasses are done under infrequent cutting and intensive management. Grazing and extensive management are promoted to reduce the production costs, but not used, until now, to screen the forage grasses. There is a need of cultivars adaptated to stressful environments and managements.

The performance of perennial ryegrass under infrequent cutting appeared to be negatively correlated to that under simulated grazing (Hazard *et al.*, 1994). Adaptation to infrequent cutting involves a high leaf elongation and a high ceiling yield (Horst *et al.*, 1978) while adaptation to grazing depends on the maintainance of an optimal leaf area index by short leaves and a high tiller density. According to these two ideotypes, we succeed in creating short- and long-leaved perennial ryegrass. Their DM yields were checked to match the hypothesis done when defining the ideotypes: the long-leaved ideotype performing well under infrequent cutting and the short-leaved ideotype performing well under simulated grazing.

MATERIALS AND METHODS
One cycle of divergent selection was done for lamina length from late flowering populations collected from the wild in France. Twenty half-sib families were obtained for both short- and long-leaved perennial ryegrass.

In 1992, the leaf morphogenesis of these families was studied in spaced plant conditions and compared to that of turf and forage cultivars used as controls. The design consisted of 20 blocks with one replicate of each family per block. The plants were not vernalized and remained vegetative throughout the experiment (Hazard *et al.*, 1995).

In 1993, DM yields of these families were evaluated in 7 different sites in France, under infrequent cutting (a cut every 5 weeks using a motorscythe) and under simulated grazing (a cut every week using a lawn-mower). After each cut under infrequent cutting, 60 kg of N was applied. Every 2 cut, under simulated grazing, 20 kg of N was applied (Hazard *et al.*, submitted).

RESULTS AND DISCUSSION
Significant genetic progress was achieved after one cycle of divergent selection on lamina length (Table 1) (Hazard *et al.*, 1995). This progress was correlated to a significant change in the leaf elongation rate and in the tiller DM. The leaf appearance rate, the leaf elongation duration and the sheath length remained relatively unchanged.

Manipulating leaf morphogenesis through selection led to a significant effect on DM yield despite the important genotype x environment interaction (Hazard *et al.*, submitted). Moreover, the long-leaved ryegrass was more productive under infrequent cutting, and less productive under simulated grazing, than the short-leaved ryegrass. The best long-leaved family under infrequent cutting yielded 14.9 t DM per year, the best short-leaved family under simulated grazing yielded 8.6 t DM per year. Thus, its seems possible to release new cultivars well adapted to a specific utilization such as infrequent cutting or continous grazing. However, some long-leaved families showed both a high yield under infrequent cutting and an important capacity of adaptation to grazing. This capacity of adaptation to grazing of long-leaved perennial ryegrass involves phenotypic plasticity of the plant size and of tillering. The genetic variability and the heritability of that phenotypic plasticity in response to frequent cutting is now investigated in perennial ryegrass.

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Table 1
Interaction between leaf morphogenesis and management for the dry matter yield.

	Cultivars		Experimental selection	
	Turf	Forage	Short leaves	Long leaves
Lamina length (mm)	82 (3.3)	102 (1.6)	96 (1.6)	110 (1.6)
Leaf elongation rate (μm DD^{-1*})	480 (2)	680 (1)	580 (1)	620 (1)
Tiller DM (mg)	422 (40)	766 (21)	773 (21)	897 (22)
Sheath length (mm)	28 (2.2)	38 (1.2)	32 (1.2)	38 (1.2)
Leaf elongation duration (DD)	104 (3)	109 (1.6)	111 (1.6)	115 (1.6)
Leaf appearance rate (DD)	182 (7.7)	182 (4)	201 (4)	207 (4.2)
DM Yield (t ha^{-1} $year^{-1}$)				
Infrequent cutting	12.1 (0.2)	14.3 (0.2)	13.46 (0.07)	14.25 (0.07)
Simulated grazing	7.4 (0.2)	7.8 (0.2)	7.82 (0.05)	7.06 (0.05)

[*] DD: Growing Degree Day