GRASS-LEGUME MIXTURES UNDER GRAZING

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ABSTRACT
Nine grass-legume mixtures were evaluated during their first year. A factorial experiment was carried out using a complete block design. Herbage on offer and residual herbage were estimated allowing calculation of net herbage production, herbage accumulation rate and grazing efficiency. The mixture of alfalfa (*Medicago sativa* L.) and orchard grass (*Dactylis glomerata* L.) with a net herbage production of 22 407 kg dry matter (DM) per ha outyielded white clover (*Trifolium repens* L.) mixtures. Substitution of alfalfa by white clover in the mixtures resulted in reduction of herbage accumulation rate by 19 kg DM ha^{-1} day^{-1} . Net herbage production of mixtures including orchard grass was 2800 kg DM higher than that of mixtures including perennial ryegrass (*Lolium perenne* L.). Net herbage production of mixtures including tall fescue (*Festuca arundinacea* Schreb) was similar to that of mixtures including orchard grass or perennial ryegrass.

KEYWORDS
Medicago sativa, *Dactylis glomerata*, *Trifolium repens*, *Lolium perenne*, *Festuca arundinacea*, *Lotus corniculatus*, grazing, net herbage production

INTRODUCTION
Dairy systems based on grazing of perennial grass-legume pastures appear to offer a more sustainable option than cut-and-carry dairy systems in Mexico (Muñoz and Odermatt, 1992). Even though some evaluations of grass-legume mixtures have been carried out under cutting (Jimenez *et al.*, 1986), there are no comparative studies of such mixtures under grazing. Results of cutting evaluations might seem a reliable method of testing relative differences in herbage production (Scheneiter *et al.*, 1995); but in terms of feed planning on pastures, data on the absolute values of herbage production under the influence of grazing management are indispensable (Milligan *et al.*, 1987). A grazing experiment was conducted to evaluate nine grass-legume mixtures during their first year.

METHODS
The experiment was carried out at the experimental station of Chapingo University, located at 19°29' N, 98°53' W. and 2250 m above sea level. Climate is temperate and sub-humid with summer rains, average annual rainfall is 636 mm, while mean temperature is 15.2 °C. Soils are clay-loam of volcanic origin, deep, neutral and fertile.

Treatments resulted from the factorial combination of three grasses with three legume-components. Grasses were orchard grass (*Dactylis glomerata* L.) cv. Potomac, perennial ryegrass (*Lolium perenne* L.) cv. Linn and tall fescue (*Festuca arundinacea* Schreb). Legume-components were alfalfa (*Medicago sativa* L.) cv. Valenciana, white clover (*Trifolium repens* L.) cv. Zapic·n and a mixture of the same white clover with birdsfoot trefoil (*Lotus corniculatus* L.) cv. Ganador. A complete block design with four replicates was used; experimental units were plots of 26.25 m^2 each.

The experiment was sown on April 5, 1991 with a basal dressing of 40 N and 60 P_2O_5 per ha. Sprinkling irrigation took place every 15 days between October and June. Blocks were rotationally grazed by replacement heifers using a daily herbage allowance of 7 kg DM (100 kg live weight)$^{-1}$ day^{-1}, grazing period was on average 1.5 day per block. Eight grazing cycles took place between sowing and April 10, 1992. The first grazing took place 75 days after sowing, then grazing took place at 56.6-days intervals (on average) until May 1, 1992, and afterwards with 35.5-days intervals.

Herbage mass on offer and residual herbage mass were estimated using the comparative yield method of Haydock and Shaw (1975). According to Hodgson (1990) differences of herbage mass on offer and residual herbage mass were used to calculate net herbage production, herbage accumulation rates and efficiency of grazing.

Data were submitted to conventional analysis of variance, means comparison by Tukey and orthogonal contrasts (Steel and Torrie, 1988).

RESULTS AND DISCUSSION
Means presented are from averages or totals of the experimental period (April, 1991-June, 1992). Results of means comparisons are presented in Table 1, while results from orthogonal contrasts are presented in Table 2.

The mixture of alfalfa and orchard grass outyielded all white clover mixtures (Table 1). Ranking of mixtures is approximately the same as in a previous cutting experiment (Jiménez *et al.*, 1986), but net herbage production was in this grazing experiment about 40% higher than yield under cutting. In both components of net herbage production (herbage accumulation rate and efficiency of grazing), the mixture of alfalfa and orchard grass showed good performance. Herbage accumulation rate of alfalfa-orchard grass was higher than those of white clover mixtures, and efficiency of grazing of this mixture was particularly high, exceeding most other mixtures.

The analysis of results from orthogonal contrasts allows some statements about grass and legume components of the mixtures (Table 2). The effects of legume component were stronger than those of grass component. Alfalfa mixtures outyielded clover mixtures by 5 and 6 t DM/ha (a difference of about 40%). The advantage came from higher herbage accumulation rate (about 24%) and higher efficiency of grazing (about 12%). The inclusion of birdsfoot trefoil in white clover mixtures had no effect on production, growth or utilization of these mixtures.

Mixtures with orchard grass outyielded ryegrass mixtures (about 15%) showing higher herbage accumulation rates (about 14%) and efficiencies of grazing (about 11%). Mixtures with tall fescue presented higher efficiency of grazing than ryegrass mixtures which might be associated with higher legume content (unpublished data) in tall fescue mixtures in the first year.

The higher grazing efficiencies of alfalfa mixtures and of orchard grass mixtures compared with ryegrass mixtures contradict what is usually reported (e.g. Langer, 1990). Ranking of visits of animals to individual paddocks and of time spent on those paddocks (unpublished results), show clear preferences of animals associated with grazing efficiencies. These unexpected results might be linked with previous grazing experiences of the heifers (Provenza and Balph, 1988), which were weaned on alfalfa-orchard grass pastures, and grazed for 90% of their time on these pastures.

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Table 1

Means of net herbage production, herbage accumulation rate and efficiency of grazing of nine grass-legume mixtures at Chapingo, México.

Mixture	Net herbage production (kg DM ha^{-1} day^{-1})	Herbage accumulation rate (kg DM ha^{-1})	Efficiency of grazing (%)
alfalfa-orchard	22407 a	91 a	71.0 a
alfalfa-tall fescue	21350 ab	86 ab	68.9 abc
alfalfa-ryegrass	17374 abc	75 abc	59.7 bcd
white clover- orchard	15673 c	70 bc	61.5 abc
white clover+birsdfoot trefoil -orchard	15260 c	67 bc	60.0 bcd
white clover+birsdfoot trefoil - tall fescue	15204 c	63 c	61.5 abcd
white clover+birsdfoot trefoil-ryegrass	14868 c	61 c	56.3 d
white clover-ryegrass	13269 c	60 c	55.8 d
white clover-tall fescue	12936 c	61 c	58.2 cd

Note; means with the same letter within each column are not significantly different (pž0.05)

Table 2

Estimates and level of significance of orthogonal contrasts of net herbage production, herbage accumulation rate and efficiency of grazing of nine grass-legume mixtures at Chapingo, México.

Contrast	Net herbage production (kg DM ha^{-1})	Herbage accumulation rate (kg DM ha^{-1} day^{-1})	Efficiency of grazing (%)
alfalfa-white clover	5936 (p=0.0001)	19 (p=0.0001)	8.1 (p=0.0004)
alfalfa- white clover +birdsfoot trefoil	5103 (p=0.0001)	19 (p=0.0001)	7.7 (p=0.0011)
white clover-white clover + birdsfoot trefoil	-840 (p=0.4447)	1 (p=0.8112)	-0.5 (p=0.8415)
orchard-tall fescue	1400 (p=0.1897)	5 (p=0.2541)	2.2 (p=0.3329)
orchard-ryegrass	2800 (p=0.0112)	10 (p=0.0217)	8.6 (p=0.0003)
tall fescue-ryegrass	1400 (p=0.2012)	5 (p=0.2311)	6.4 (p=0.0060)