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Tame Italian ryegrass (*Lolium multiflorum* L.) enhancement in the argentine flooding Pampa. Assessing winter forage production under grazing conditions

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Promoción de raigrás anual naturalizado (*Lolium multiflorum* L.) en la cuenca del río Salado. Evaluación de la producción invernal de forraje en pastoreo

ABSTRACT. Effective operation of grazing production systems needs control the production of forage at farm level. A nine year old stand of enhanced tame native ryegrass (*Lolium multiflorum* L.) (RGE) and an annual crop of Italian ryegrass (*Lolium multiflorum* L. cv Tama) (RGT) were monitored to test the hypothesis that: (i) herbage biomass in such pastures can be assessed by Ration Calculation methodology as accurately as by more exhaustive procedures, and (ii) enhancement increases amount and quality of forage winter supply. Enhancement includes fertilization with NH_4NO_3 and $(NH_4)_2HPO_4$ and weed control with Glyphosate (N-(phosphonomethyl glycine)). The Ration Calculation method estimates available herbage dry matter assuming that «one herbage ration» equal to one cow equivalent (CE), consisting of 10 kg DM day^{-1} with 77.57 MJ of ME. Herbage samples were taken from each paddock, representing harvestable biomass. Grazing harvest efficiency and herbage DM intake (HDMI) were estimated through difference between initial (IHA) and final (FHA) herbage available (kg DM ha^{-1}), before and after grazing, corrected by losses due to grazing. Eight grazing cycles of RGE produced 16 041 kg DM/ha year^{-1}, (2 001 ± 79.3 rations/ha year^{-1}) while ration calculation estimates 9 775 kg DM/ha year^{-1}. The RGT allowed seven grazing cycles, yielded 12 269 kg DM/ha year^{-1} or 1 144 ± 87.1 rations/ha year^{-1} compared to 8 688 kg DM/ha year^{-1} estimated by calculating ration. The ration calculation method did not accurately assess the enhanced cumulative herbage DM produced. Enhancement technology improved production and quality of tame ryegrass in winter time.

Key words: Rangelands enhancement, Ryegrass enhancement, Ration calculation, Cow equivalent.

RESUMEN. El manejo de sistemas ganaderos de producción requiere controlar la producción de forraje a nivel de unidad de pastoreo. Con una pastura naturalizada y promocionada durante nueve años de raigras (*Lolium multiflorum* L.) (RGE) y un cultivo de raigras anual (*Lolium multiflorum* L. cv. Tama) (RGT) se probaron las hipótesis de que la biomasa forrajera aerea puede ser estimada correctamente por el método del cálculo de raciones como mediante los atributos del forraje, y que la promoción permite aumentar la producción invernal de forraje. La promoción involucra fertilizaciones con NH_4NO_3 y $(NH_4)_2HPO_4$ y control de malezas con Glifosato (N- (phosphonomethyl glycine). La estimación de materia seca disponible mediante el calculo de raciones asume que «una ración de forraje» son 10 kg MS día^{-1} que contienen 77.57 MJ de EM que representan un equivalente vaca (CE). La eficiencia de cosecha y consumo en pastoreo (HDMI) fueron estimados por diferencia entre disponibilidad forrajera inicial (IHA) y final (FHA) antes y después del pastoreo, corregido por pérdidas debidas al pastoreo. El período de crecimiento de la RGE permitió ocho pastoreos produciendo 16 041 kg MS/ha año^{-1} ó 2 001± 79.3 raciones/ha año^{-1} comparado con 9 775 kg MS/ha año^{-1} estimados por cálculo de raciones. En siete pastoreos el RGT produjo 12 269 kg MS/ha año^{-1} ó 1 144 raciones/ha año^{-1}, comparado con 8 688 kg MS/ha año^{-1} estimados por el cálculo de raciones. Se concluye que el cálculo de

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raciones no estima correctamente la biomasa producida por una promoción y que, efectivamente, la tecnología de promoción aumenta la producción y calidad invernal del pastizal natural.

Palabras clave: Pastizales naturales, Promoción de raigrás, Cálculo de raciones, Equivalente vaca.

Introduction

In temperate regions, grazing livestock production systems are primarily constrained, both biophysically and economically, by the amount, seasonality, and interannual variability of forage produced (Oesterheld *et al*., 1992, 1994). In those systems, setting stocking rate is a major managerial decision. The main goal of grazing management is balancing forage supply with livestock requirements.

Tame and native grasslands are a significant source of feed for ruminant livestock, because direct grazing of grasses and legumes are the cheapest source of feed for livestock. In Argentina, the flooding Pampas is a cattle producing area of 8 000 000 ha located in the Humid Pampa, characterized by temperate humid climate, soils with low levels of permeability, organic matter and available phosphorus (Agnusdei *et al.*, 2001). Although an average of 25 frost events occur between May and September, both forage production and grazing can be done year round.

With strong seasonality, the dominant vegetation are C_3 and C_4 type of native winter-spring and summer-autumn grasses of the genus *Stipa, Piptochaetium, Briza, Paspalum,* and *Botriochloa,* and *Lolium multiûorum* and *Trifolium repens* as legume (Sala *et al*., 1981) with growth rates range from 5 kg DM/ha day^{-1} (winter) to 25 kg DM/ha día^{-1}. Over time, the productivity and livestock carrying capacity of these pastures decline, largely as a result of reduced stand vigor, the invasion of unpalatable or less productive species, grazing and poor soil fertility. These grasslands evolved under low grazing pressure (Oesterheld and Sala, 1990), although its continued use led to their degradation (Deregibus and Cahuepé, 1983) and loss of carrying capacity due to the reduction of winter grass population (Jacobo *et al.,* 2000).

Traditionally, sown pastures are grown on low fertility soils where their productivity can be increased markedly by plowing and fertilizing. Rather than breaking the stand, rejuvenation of

forage stands is probably the most economic and practical method to improve production and quality.

Direct seeding is a technological practice originally developed and improved by AAPRESID (Spanish acronym for Argentine Association of Direct Seeding Farmers) for production of soybean and corn crops which was adapted for grass herbage production, relying on fertilizers and herbicides to optimize quantity and quality of winter forage supply in a technological package described as «the enhancement and rejuvenation of grass species from the soil seed bank» (Tommasone and García Oliver, 1999). Such improvement consist of creating conditions of light, temperature and humidity favorable for germination of seeds from the soil bank and establishment of seedlings with minimum weed competition (Casal, 2000; Rodríguez *et al.,* 1998).

Due to the costs involved, enhancement makes sense only if complemented by adequate pasture budgeting to optimize its use by setting the best stocking rate. Budgeting forage implies a systematic comparison of feed oûered and demanded plus eûciency calculations as key diagnostic tools which will allow farmers and advisors to plan and evaluate managerial decisions in a rational way. Such an objective diagnostic require a systematic quantiûcation of herbage productivity (above-ground net primary production, ANPP) (Stuth *et al*.,1993), balancing available herbage and supplements DM intake against the requirements of different classes of cattle throughout the year. The aerial available phytomass in any pasture can be assessed using standard destructive methods, non-destructive methods or by combinations of both (Meijs, 1981; Malossini *et al*., 1996; Danelón *et al*., 2001, Smit *et al*., 2005).

Non-destructive methods assess indirectly by using vegetation variables that can be correlated to the amount of DM (Malossini et al., 1996; Smit et al., 2005) or to the quantity of rations produced (Cocimano *et al.*, 1975). For simplicity, at farmer level the budgeting pasture method mostly used in Argentina´s humid pampas is the indirect called «*ration calculation*». In this procedure the unit of measure is the «*ration*», which assume that to build «one ration» requires 10 kg herbage DM containing 77.59 MJ ME (Cocimano *et al.,* 1975), or 88.41 MJ ME (Rosso *et al*., 1995), an amount known as a *«cow unit»* (CU). Accordingly, the energy content of one CU should be 7.76 MJ ME kg^{-1} DM (Cocimano *et al.,* 1975) or 8.84 MJ ME kg^{-1} DM (Rosso *et al*., 1995), and a DM digestibility (DMD) of approximately 515 or 586 g kg^{-1} DM (AFRC, 1993, Rosso *et al.*, 1995, respectively). However, the information available indicates that the DMD of tame ryegrass could be around 700 g kg^{-1} DM (Hidalgo *et al.*, 1998), ranging from 675 g kg^{-1} DM to 827 g kg^{-1} DM (Jaurena and Danelón, 2001), with an energy concentration range from 10.21 to 12.47 MJ ME kg^{-1}DM. Those values suggest that the currently accepted value as »ration (10 kg DM) leads to a loss of 14 to 38% in the efficiency of forage utilization.

In this context, the aim of this study were: 1) to test the hypothesis that the calculating ration approach, carried out at the farmer level, did not allow to correctly assess neither the quantity nor the energy density of herbage necessary to make one ration, as efficiently as the direct method through the herbage attributes, and 2) that enhancement technology actually increases the magnitude of winter forage supply over that of a crop of annual ryegrass.

Materials and Methods

On a farm placed in the flooded Pampas of the Buenos Aires province (S 34° 57′ 01" W 58° 38′ 04"), two winter pastures: a nine-year-old tame and enhanced Italian ryegrass (RGE), and a crop of annual ryegrass (*Lolium multiflorum* Lam. cv. Tama, RGT) were compared. Both pastures of 12 ha each were on an Argiudol type soil, pH 5.87; 34.6 g kg^{-1} organic matter (OM) and 28.71 mg kg^{-1} assimilable phosphorous.

Pastures

RGE: after natural reseeding between December 2004 and January 2005, was kept mechanically weeding until early February when 2.0 L ha^{-1} of Glyphosate (N- phosphonomethyl glycine) was applied. The ryegrass seedlings emergence was seen on March 5. In fractionated dose 130 kg ha^{-1} of NH_4NO_3 (AN, 340 g kg^{-1}N) and 80 kg ha^{-1} of $(NH_4)_2HPO_4$(ADP, 460 g kg^{-1} P_2O_5) in a granular form were applied.

RGT: was sown in March over corn stubble that had been grown in direct seeding. In early February, before sowing was a chemical fallow, and after sowing, the RGT received 60 kg ha^{-1} of ADP, 120 kg ha^{-1} of AN, and 70 kg ha^{-1} of urea. Fertilizer were applied in a granular form and placed in the seed row when the stands were being established, banded away from the seed.

The RGE was grazed 205 days, in eight cycles from April 23rd through November 14th meanwhile the RGT in 187 days allowed six cycles of grazing, from May 5th through end of November.

Grazing management and animal characteristics

For both RGE and RGT, forage budgeting and balance were done by ration calculation, estimating the ANPP biomass in relation to the target efficiency of grazing (70 %).

Grazing was carried out per hours, in striping paddocks divided with electrified wire. The average stocking rate was 6,524 kg ha^{-1}. The size of strips was adjusted according to the amount of above-ground available herbage (kg DM ha^{-1}), establishing an average herbage allowance of 11 kg DM cow^{-1} per each half a day, through the experimental period.

Grazing was carried out with two herds (R1 and R2) of milking cows, and one of dry cows (DC). The R1 consist of 139±2.6 cows of an average live weight (LW) of 606±6 kg, producing 27.5±2.88 l/day of milk. The R2 composed by 121±1.4 animals of 620 LW kg, producing 22.5±1.76 l/day of milk. Both pastures (RGE and RGT) were grazed always after pm milking in a complementary way, i.e. once grazed the last strip of the RGE by R1, it was started the first of RGT, and vice versa with R2.

The R1 and R2 diets consisted of grazed herbage (RGE or RGT) and a TMR of corn silage, wheat bran, brewers wet grains, ground corn, whole cottonseed, and a protein concentrate (ProteoPass) at a daily rate of 13.0±0.22 kg DM (R1) and 8.9±0.14 kg DM (R2) per animal, accounting for 2.1 and 1.4% of LW respectively. The TMR composition is shown in Table 1.

Pasture determinations:

At 3 cm above ground, the harvestable herbage aerial biomass of each plot was sampled cutting at least ten or more samples ha^{-1} with a 0.25 m^2 quadrat at randomly selected points. Each sample was classified into ryegrass, white clover and weeds, weighing each fraction fresh and further oven dried 48h at 60ºC to determine its DM content. Dry plant material was milled (1 mm through a Wiley-type mill) and a representative subsample kept for chemical composition.

Sampling was done after noon, before and after grazing, at the beginning, middle and end of each grazing cycle. Dry matter intake (DMI) and efficiency of harvesting were estimated in both pastures at each sampling date, through the difference between initial and final herbage DM available (IHA and FHA respectively) (Meijs, 1981). Since this methodology does not account for losses of herbage due to grazing (trampling, feces, urine, etc), and assumes that the missing biomass (IHA - FHA) represents the pasture DMI, such estimate was corrected for losses due to the accumulation of feces, the mixer transit damage and for some TMR lost on the ground. Herbage productivity (kg DM/ha day^{-1}) was estimated as the sum of positive differences between two successive measurements of

Table 1. Composition of the TMR supplement, kg DM and as fed.

Ingredients	Grazing cycles				MJ ME/kg DM
	1º& 2º	3º	4º& 5º	6º& 7º	
Corn Silage	2.80	3.92	3.92	2.24	10.63
Wheat bran	1.30				10.88
Brewers grains	1	1	1	0.5	10.04
Ground corn	3.72	4.17	4.63	3.68	13.39
Whole cottonseed	1.80	2.70	2.25	1.35	14.64
ProteoPass 25%®	0.86	1.66	1.19	0.92	
Total kg DM	11.8	13.8	13.4	8.9	
Total kg as fed	23	28	28	17	

alive and dead material per unit of time (Singh *et al.,* 1975). The accumulation of grass aerial biomass in each pasture was determined at the end of the experimental period, complemented with analysis of quality (Danelón *et al.,* 2005). Ryegrass DM digestibility (DMD) was estimated as DMD (%) = 118.3 - (1.63 x % ADF), r = 0.88, and that of white clover, as DMS (%) = 91.9 - (0.97 x % ADF), r = 0.96. Finally, for both components the metabolizable energy content (Mcal ME/kg DM) was estimated following the AFRC (1993) recommendation.

Ration Calculation:

To calculate the number of rations produced per pasture, was necessary to establish the relationship between CU (cow unit) and the amount of herbage (actually energy) required per "cow equivalent" (CE). The number of CE equals the daily energy requirements (maintenance including 30% voluntary activity plus production (AFRC 1993, NRC 2001)) divided by the energy value of one CU, i.e.:

N° CE = (MJ MEm + MJ MEl) / 77.59 (or 88.41) MJ ME

Then,

N° CE * 10 kg DM = kg DM daily required per cow.

Finally the number of observed and calculated rations was compared to estimate total forage DM produced by mean of Student t test with a significance level of 5%.

Results

Weather conditions

According to the National Weather Service (SMN, 2008) the 1,219 mm rainfall all over the experimental period was consistent with the last 12 years average 1,246 ± 344 mm, (SMN, 2008). Its distribution along with monthly average temperatures is shown in Figure 1.

Forage Production for RGE

Figure 2 illustrates the dynamics of the available herbage aerial biomass (kg DM/ha) of ryegrass and white clover at each measurement dates and year time. The IHA (kg DM/ha ± SD) of ryegrass and white clover were respectively 1,664 ± 551 and 260 ± 223 (autumn); 2,238±546 and 191±166 (winter); 4,179±710 and 305 ± 226 in the spring. In the period, there was a greater proportion of ryegrass in basal coverage (60%±8.1%) and aerial biomass (87%±9.9%) than to white clover, which although presented 19%±10.4 of basal coverage, its contribution to the aerial biomass was just 8%. As a result of chemical control and tapestry coverage that left 1% of bare soil, was important the low proportion of weeds, which only in the first grazing (April) its presence reached 22% of the total aerial biomass.

Table 2 summarizes results obtained in the RGE in seven cycles of grazing. Available herbage biomass allowed keeping a high livestock stocking rate. The high quality of herbage sets an average of 6.46 ± 0.24 kg of DM required to build one ration, 35.6% less than expected (Magaz, 2004).

Herbage DM produced annually was distributed 35% in winter and 45% in spring, determining a growth pattern typical for the species (Figure 3). The rate of growth allowed for graze every 30 days.

Integrating the polynomial (Equation 1) corresponding to the curve in Figure 3 from 0 to 205 days the cumulative herbage DM yield was 16,041 kg DM/ha year^{-1}.

Equation 1

$$\int_0^{205} f(x)dx = -5*10^{-7}\frac{X^5}{5} + 9*10^{-5}\frac{X^4}{4} + 0.002\frac{X^3}{3} - 0.0255\frac{X^2}{2} + 35.617X$$

Where:

X = independent variable (days = 205)

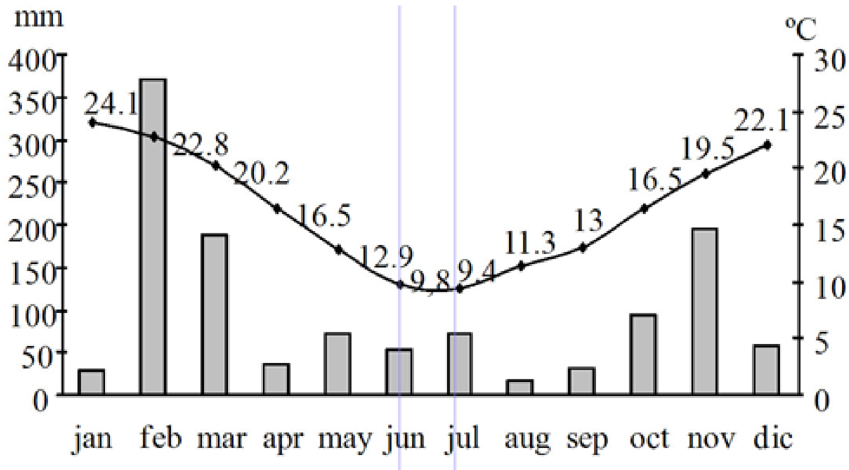

Figure 1. Monthly rainfall (bars, mm) and mean temperature (ºC).

Y = rate of growth H» adjusting line = f(x), kg DM/ha.day^{-1}

Using the cumulative yield and quality of herbage (Magaz, 2004) the number of rations actually produced by grazing cycle were compared with the number of rations estimated by ration calculation (Table 3).

Results showed that in all cycles of grazing, rations observed exceeded by 118% the theoretical (2,001 ± 79.3 vs. 916 rations/ha), among which 18% were obtained in autumn, 38.2% in winter and 43.8% in the spring. Table 4 shows the herbage aerial DM produced until the 7th grazing cycle.

Forage Production for RGT

The RGT allowed seven grazing cycles, beginning grazing with an IHA of 2,716 ± 739 kg DM ha^{-1}. It was remarkable the low DM content in autumn and winter (130 g kg^{-1} and 160 g kg^{-1} respectively), and the gradual increase as the season progressed, resulting in an annual average of 170 ± 29.6 g kg^{-1}. Its quality allowed an average of 6.42±0.41 kg DM ration^{-1} (Magaz, 2004). The rate of growth enabled grazing intervals of 25 to 38 days, with a dramatic increase at early spring, when the highest rate of growth (135 kg DM/ha día^{-1}) was recorded.

The cumulative yield of herbage DM, resulting from the polynomial integration between days 0 and 187 (Equation 2, Figure 4) was 12,269 kg DM ha^{-1}, of which 60% was in spring and the remaining 40% by autumn-winter halves.

Equation 2

$$\int_0^{187} f(x)dx = 9*10^{-6}\frac{X^4}{4} + 0.001\frac{X^3}{3} + 0.2472\frac{X^2}{2} + 16{,}127X$$

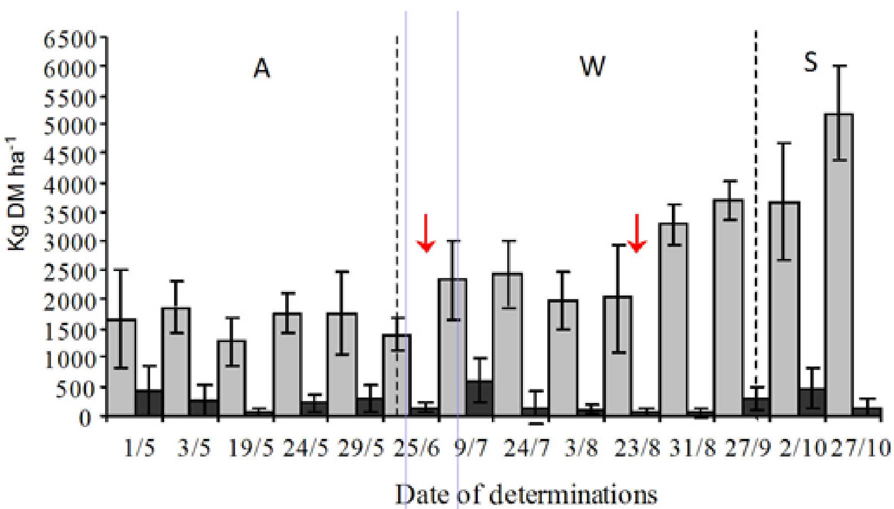

Figure 2. Aerial herbage DM biomass (kg of natural ryegrass (grey bars) and white clover (black bars) at each evaluation date. Dotted lines separating the seasons during utilization period (A: Autumn; W: winter; S: Spring). Arrows indicate fertilization time.

Table 2. Grazing cycles from the ryegrass enhancement (RGE) during the utilization period

Seasons	Autumn		Winter			Spring		Mean
G. Cycles[1]	I	II	III	IV	V	VI	VII	
IHA[2]	2,110(±548)	1,800(±424)	2,247(±469)	2,331(±478)	2,709(±681)	4,057(±662)	5,338(±789)	2,942(±579)
DM[3], g kg^{-1}	120	140	150	160	180	160	190	160± 24
BGi[4] (days)	22	34	32	29				
GR[5](min-max)	42 (33-50)	66 (23-105)	99	62				
Cum. Growth[6]	3,301	5,776	7,426					
kgDM/Ratión[7]	6.54 (7.46)	6.26 (7.13)	6.58 (7.50)	6.46 (7.36)				

[1]Grazing cycle
[2]Initial Herbage Available, kg DM ha^{-1}(±SD) per grazing cycle
[3]Dry Matter content
[4]Between grazing interval (days) per season.
[5]Average growing rate per season (kg DM/ha day^{-1}). In brackets the lowest and the highest rate of growth
[6]Seasonal cumulative growth of forage biomass (kgDM ha^{-1}).
[7]kg DM to make up one ration. Between brackets, value considering 21.13 Mcal ME per CE.

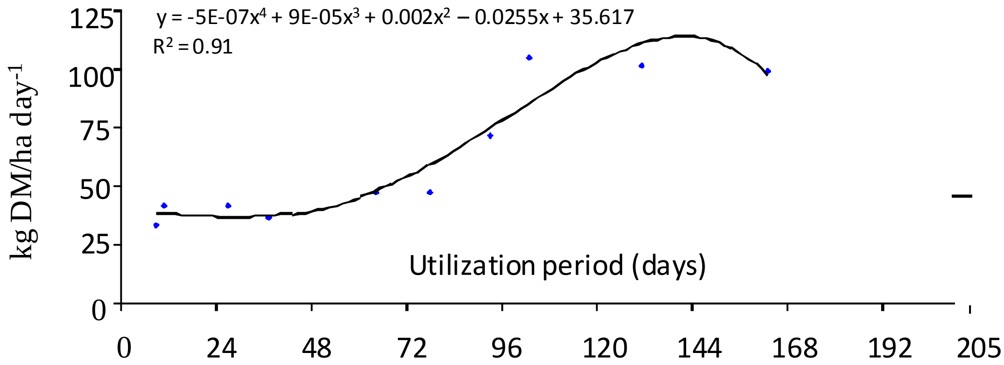

Figure 3. Growht curve of ryegrass enhancement (RGE)

Discussion

The availability of water (370mm and 188mm of rain in February and in March) and the chemical control of the existing biomass, created the conditions of light, temperature and humidity appropriate to allow germination, growth and development of seedlings of the RGE without weeds competition.

In forage-animal production systems, grass-legume mixtures are favored over pure monocultures (Sengul, 2003). The mixtures do impart challenges in forage management such as fertilization, cutting time and frequency, and maintaining the desired proportion of legume and grasses in the mixture (Baylor, 2002). In mixed forage production, dry matter yield is generally more balanced or evenly distributed throughout seasonal cuts because grasses are more productive in the autumn, winter and spring, while legumes are more productive in the summer. In addition, the vertical nature of grass leaves vs. horizontal leaves of legumes minimizes interspecific plant competition for light.

The low level of soluble phosphorus and the reduced nitrogen availablity recorded from winter to early spring (Marino *et al.*, 1995), produce a significant interaction with the fertilization responses (García *et al.*, 1999). Considering the rainfall in the region, it has been demonstrated that if phosphorus requirements are covered, nitrogen fertilization will impact the growth of natural grasses allowing increasing the animal stocking rate. Thus, Fernandez Grecco (2001) found significant winter responses in the forage rate of growth up to a maximum of 250 kg N ha^{-1}, yielding at the end of the experimental period 7,114 kg DM ha^{-1}. Agnusdei *et al.*, (2001) got productions eight times greater than those of the control, with spring regrowth 30 days ahead. For these authors the annual ryegrass (*Lolium multiflorum* L.) contributed most to the total production of DM.

At initial vegetative stage, the mixed phosphorus and nitrogen fertilization created the key condition to generate a competitive advantage over the weeds. Thus the first grazing was at 49 days post-emergence of the RGE and 60 days from the sowing of RGT. In eight grazing sessions of RGE, the whole period lasted 205 days, from April to November, when the pasture was closed to allow for natural reseeding.

Table 3. Number of observed and estimated rations in ryegrass enhancement (RGE), per grazing cycle, total and differences (D%).

Grazing cycle	Estimated	Observed	Δ%
I	123	187	+52
II	133	180	+35
III	147	253	+72
IV	107	253	+136
V	105	261	+148
VI	157	369	+135
VII	143	499	+249
	916	2 001	+118

Table 4. Estimated production of forage and piled up growth (kg DM ha^{-1}) of the ryegrass enhanced (RGE) per grazing cycle and total.

	Piled up growth estimated of forage during the period of use (kg DM ha^{-1})						
Grazings	I	II	III	IV	V	VI	VII
Nº Rations ha^{-1}	123	133	147	107	105	157	143
tDMI[1]	1 235	1 331	1 470	1 073	1 047	1 571	1 434
IHA[2]	1 764	1 901	2 100	1 532	1 495	2 245	2 049
FHA[3]	529	570	630	460	449	673	615
PAG/grazing[4]	1 764	1 372	1 530	902	1 036	1 796	1 375
Total piled up growth[5]	9 775						

[1]tDMI = theoretical DM intake (kg DM ha^{-1})
[2]Initial Herbage Available (kg DM ha^{-1})
[3]Final Herbage Available (kg DM ha^{-1})
[4]Piled up growth of herbage per grazing period (kg DM ha^{-1})
[5]Total piled up growth of herbage (kg DM/ha.year^{-1})

The aerial biomass accumulation in both RGE and RGT pastures lasted to mid-November when were closed to allow maintaining themselves next year by self sown seed. Former studies on enhancing technology for tame grassland of ryegrass showed that an application of 2.5 L ha^{-1} of Glyphosate combined with 50 kg N ha^{-1} allowed to pile up at the end of winter an amount of herbage DM 3.8 times higher than the control (Fernández Grecco, 2000).

The high proportion of ryegrass in basal coverage (60%±8.1) and in herbage aerial biomass (87%±9.9) of the RGE was attributed mainly to weeds control, this being one of the key aspects of the technique.

The findings objectively supports the empirical perception that the technique of enhancement increases the quantity and quality of winter herbage supply from tame ryegrass, with higher digestibility values and lower losses as the season progresses than that observed under extensive management (Hidalgo *et al.*, 1998) allowing increasing the stocking rate.

The growing rate obtained allowed to increase the frequency of defoliation with an average of 71.2% harvest efficiency of the herbage produced. The 30 days resting between grazings was consistent with those determined by Agnusdei *et al.*, (1998) in grasslands of the Depressed Pampas. These authors concluded that due to the rapid leaf replacement of *L. multiflorum*, a 60 days break would determine a 50% loss of ryegrass DM, and a 20 days advance for maximum accumulation.

Former studies (Marino *et al.*, 1995) detected an increase and an improvement in the growth of ryegrass during winter-spring period with split

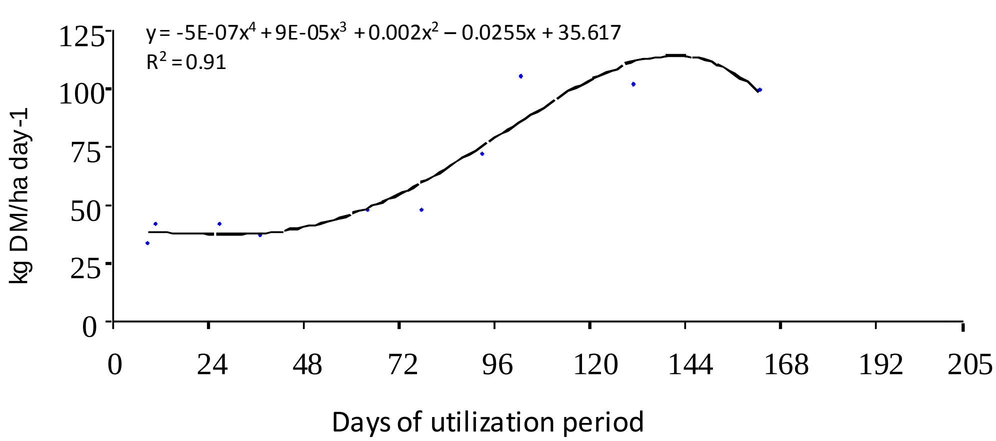

Figure 4. Growht curve of ryegrass Tama (RGT)

fertilizations between autumn and winter compared to a single autumn fertilization.

Fractional fertilization during autumn and winter would explain the steadiness of growing rate and the large herbage accumulation observed towards the end of grazing season since between July and September winter species suffer a nitrogen deficiency produced by low mineralization (Echeverria and Bergonzi, 1995).

Throughout the experimental period, the estimated DM energy density of the RGE was higher and more persistent than expected (12.05±0.1 vs. 7.74±0.4 MJ ME kg^{-1} DM) (Magaz, 2004). Along with an underestimation of the DM consumption this could explains at least in part, the difference between the observed and estimated rations (Table 3).

Since the procedure to estimate pasture DMI does not account for losses of herbage due to grazing (trampling, feces, urine, etc), and assumes that the missing biomass (IHA - FHA) represents the pasture DMI, such missing biomass was adjusted for a percentage of losses due to the accumulation of feces, the mixer transit damage and for a quantity of TMR lost on the ground. Such losses were steadily increasing as the experiment progressed. Thus, the estimated pasture DMI resulted to be 90% of the disappeared biomass between the 1st and 4th grazing cycle and 85% between the 5th and 7th respectively.

Because the forage budgeting does not consider losses in the consumption of supplements which have implications for estimating the total DM and thus on the IHA which should exist, it seems that the indirect methodology of ration calculation did not assess correctly the herbage production of RGE. Table 5 shows the observed and estimated DM consumption of RGE, corrected for losses observed in using the TMR supplementation. Those losses were not quantified; instead data from Bermejo (2003, not published) who found a relationship between the amount of corn silage supplied under electrified wire and losses, were used. In such a way, it was estimated that inherent losses for this feeding system could have been an average of 21.3%, 28.2% and 13% for the amount of supplement offered in the grazing cycles 1st to 2nd, 3rd to 5th and 6th to 7th respectively. The observed DMI per grazing cycle tended to increase as the season progress following a pattern corresponding to the herbage growth (Figure 3).

Table 5. Theoretical and observed dry matter intake (DMI, kg ha^{-1}) corrected for losses in using the supplement.

Grazing cycle	Estimated	Observed	D%
I	123	187	+52
II	133	180	+35
III	147	253	+72
IV	107	253	+136
V	105	261	+148
VI	157	369	+135
VII	143	499	+249
	916	2,001	+118

Conclusions

- The hypothesis that indirect methodology of ration calculation is not precise to assess the cumulative herbage DM production for a grassland enhancement must be accepted.

- The rejected methodology does not reflects the actual contribution of forage DM from the RGE, thus understating its real potential. The ignorance of its daily growing rate (kg DM/ha day^{-1}) could be the reason of that.

- The technology of enhancing natural grasslands effectively improved production (amount) and quality of tame ryegrass (RGE) to be used in the winter period.

Implications

In intensive livestock production systems where grasses are a key part of the diet, it is important to count on reliable methods of budgeting herbage DM able to reflect the reality as well as possible. While in the long and medium term planning is usually based on estimates, objective measures are a must in the short term. This requires keeping a daily record of more accurate DM production and consumption of pastoral resource and would imply to be able to make more precise adjustments to decide how much supplement to offer, which would result in greater economic efficiency.

Results of this study reflect the interaction of a number of complex factors, among which the experience is not a minor one. The nine-year implementation of this technique, constituted a learning process that generated a steady improvement in the use of it. However, it should deepen the understanding of the management critical points. The minimum closing time to grazing to ensure the required quantity of seeds suitable to achieve an adequate herbage production in the coming season, needs further research.

Considering the input dependence of this technology is important to guide studies to optimize the application of herbicides and fertilizers and to develop simulation models that would make the technique more predictable and profitable.

From biodiversity standpoint, enhancement could be questionable to natural grasslands. The systematic application of non-selective herbicides (E class) should be contrasted against the overall convenience of using contact herbicides or conduct enhancement through more natural grazing management strategies.

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