Nitrogen and radiation use efficiency in temperate pastures for low quality soils

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Introduction

In the humid pampa of Argentina, tall fescue is used in wet or low fertility soils whereas tall wheatgrass is used in flooded and alkaline environments (Maddaloni y Ferrari 2005). Autumn and winter growth rates are lower than in spring, and higher in tall fescue than in tall wheatgrass. In these species, maximum responses to nitrogen (N) fertilization occurs when it is done at the end of winter, but livestock farmers sometimes fertilize swards in late summer with the aim to get more forage in late autumn and winter. Due to the characteristics of the environments to which they adapt and the morphogenetic processes inherent to each species, neither direct comparison is possible, nor is the use of the same treatments. However, when farmers must decide about pasture fertilization, they should know the effectiveness of this practice in each situation. According to that, two experiments were carried out to determine the radiation use efficiency (RUE) and N utilization indexes in tall fescue and tall wheatgrass swards fertilized with N.

Methods

Two independents experiments were performed at Pergamino (33°53'S; 60°34'W) in autumn 2009 on swards established in 2006. Two N levels were applied in tall fescue (TF) and tall wheatgrass swards (TW). In TF, N doses were 0 and 200 kg N/ha (N- and N+) whereas in TW they were 0 and 80 kg N/ha (N- and N+). According to the expected autumn pasture growth rates for each species, N levels were adjusted in such a way that they were not a limiting factor for sward growth. TF experiment was located in a typical Argiudol soil (3.0 % organic matter, 37 ppm of phosphorus, pH 6.0, 0.19 dS/m of electrical conductivity and 0.4 meq/g of Na). TW experiment was located in a typical Natracualf soil (2.4% organic matter, 6 ppm of phosphorus, pH 9.3, 0.67 dS/m of electrical conductivity and 2.3 meq/g of Na). This experiment was fertilized with 63kg P/ha using superphosphate as P source (0-46-0).

On March 31, after defoliation at 5 cm in height, swards were fertilized with urea (46-0-0). Experimental units were plots of 33.6 m^2 (TF) and 28.0 m^2 (TW). Both experiments were arranged in a randomized complete block design with 3 replicates. After the initial defoliation, and then with a frequency of 200 (TF) or 300 degree days (TW), aerial biomass accumulation at ground level and interception of photosynthetically active radiation (IPAR) were measured. With these variables radiation use efficiency (RUE) was estimated (Sinclair and Muchow 1999). With the same frequency, independent plots of 4 m^2 (TF) and 5 m^2 (TW) were cut to 5 cm in height and herbage yield and N percentage in forage were determined. With these variables, N utilization indexes were estimated. Data were analyzed for each experiment separately by the ANOVA procedure of SAS software. RUE was analyzed by the GLM procedure, as the slope of biomass and IPAR. Estimates of the parameters were compared by the Estimate function of SAS.

Results and Discussion

Tall fescue

At 660 degree days, 94 and 74% of IPAR was reached with N+ and N- treatments, respectively. Biomass accumulation were 465 and 200 g DM/m^2 and RUE was higher with N+ treatment with respect to N- treatment (P<0.002, Table 1). Herbage yield, percentage of N and N uptake by the sward were higher with N+ when compared to N- treatment (Table 2).

Tall wheatgrass

At 992 degree days 84 and 52% of PARi was reached with N+ and N- treatments, respectively. Biomass accumulation were 291 and 91 g DM/m^2 and RUE was higher with N+ treatment with respect to N- treatment (P<0.04, Table 1). Herbage yield, percentage of N and N uptake by the sward were higher with N+ when compared to N- treatment (Table 2).

Table 1. RUE in tall fescue and tall wheatgrass swards with two N levels.

Experiment	Treatment	Parameter Estimate	Standard Error	r2
TF	N-	0.94	0.06	0.84
	N+	1.79	0.09	0.89
TW	N-	0.66	0.11	0.8
	N+	1.36	0.16	0.89

Table 2. N utilization indexes in tall fescue and tall wheatgrass swards fertilized with N, at 660 and 992 degree days, respectively.

Treatment		Herbage yield (kg DM/ha)	N in forage (%)	N uptake (kg N/ha)	N recovery (kg N/ha)	N use efficiency (%)	Agronomic efficiency (kg DM/kg N)
TF	N-	280	1.42	3.8			
	N+	1965	2.54	49.9	46.1	23	8.4
	significance	0.001	0.001	0.001			
TW	N-	92	1.62	1.9			
	N+	840	1.78	15.6	13.7	17.1	8.8
	significance	0.001	0.001	0.001			

Both species showed a positive response to nitrogen fertilization in autumn with an increase in productivity and RUE. However, RUE values were rather low compared to those obtained by Belanger *et al.* (1992) in spring regrowth. This could be associated with assimilate partitioning as in autumn roots are a most important fate of assimilates than in spring (Bélanger *et al*, 1994).

N utilization indexes were low. This is consistent with the fact that, in autumn, there is a higher soil N availability (Vázquez and Barberis 1982) and, at equivalent mean air temperature (15.1°C), growth rates are lower than in spring. These facts determine that, even with adequate water supply, 150 kg N/ha did not increase herbage accumulation and N uptake. From the above, and considering that there were no excessive N concentrations in plant tissues, it is probable that high amounts of N were lost to the environment. Numerically, tall fescue had higher values of RUE and N utilization indexes than tall wheatgrass. Consistent with this, tall fescue has more growth potential than tall wheatgrass and the soils when the former grows have less edaphic constraints.

References

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