Assessing the Effect of N and P Supply on Dry Matter Yield of Three Tropical Grasses

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ASSESSING THE EFFECT OF N AND P SUPPLY ON DRY MATTER YIELD OF THREE TROPICAL GRASSES

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Abstract

The objectives are to study the effects of N and P supply and their interaction, on herbage dry matter yield and nutrient status of three tropical grasses. In order to estimate direct and indirect effects of P supply we express above-ground dry matter production as a function of the herbage nutrient status obtained from plant analysis. Results show that in absence of N, the significant increase in P nutrition status has only moderate consequences on herbage production and suggest that both N and P are limitant for herbage growth. P fertilization results in significant increase in dry matter yield only when N limitation is suppressed as well.

Keywords: Fertilizer, nitrogen, mineral nutrition, pastures, phosphorus,

Introduction

Numerous studies have shown that herbage degradation in Amazonia resulted from low P and N availabilities (Cadisch et al., 1994). On the other hand, it has been shown that P fertilizer increased herbage yield because it stimulated plant N uptake. Furthermore, soil N transformations could be fast following N application (Miranda et al., 1994). The interaction between N and P could occur through nutrient acquisition or nutrient efficiency for growth. As there is not a single critical P or N contents, we characterized the herbage N and P status from previously established critical curves of herbage mineral content according to above-ground dry matter (Lemaire and Gastal, 1997, Duru and Thélier, 1997). The objectives are: (i) to study the effects of N and P supply and their interaction on herbage dry matter yield and nutrient status of three tropical C4 grasses: (ii) to express above-ground dry matter production as a function of the herbage nutrient status in order to analyze direct and indirect effects of P supply on herbage growth.

Material and Methods

Experiments were carried out close to Marabà (Brazil) over the rainy season for two years (1996 and 1997). Three C4 grasses were studied: two bushy *Panicum maximum* (Pm) and *Brachiaria brizantha* (Bb) and one stoloniferous *Brachiaria humidicola* (Bh) on stands sown more than five years ago. Two N and P fertilizer (code 0 for 0 ; code 1 for 250 kg N and P ha^{-1} in 1996 and 300 kg N and P ha^{-1} in 1997) rates were combined in a factorial design with three replications. So there were four treatments: N1P1, N0P1, N1P0, N0P0. At the initiation of the experiment (day 0), each plot was harvested 15 cm above-ground and the fertilizers applied. Herbage dry matter yield was calculated every 10 days from the product of (1) Average tiller weight (15 cm above-ground) measured on $0.25m^2$ frames per plot and (2) Tiller density measured on 2 m^2 subplots. Lemaire and Gastal (1997) give the optimum nitrogen content (N %) for C4 species which is $N\%=3.6*DM^{-0.32}$, where DM is the above-ground biomass (t ha^{-1}), and propose an index in order to assess the nitrogen nutrition status in sub-optimal conditions. It is the ratio of the measured N content (Nm.) to the optimum N content found for the actual above-ground biomass (DMm.):

$$Ni=100 * Nm. /(3.6 * DMm.^{-0.32}) \quad [1]$$

For P assessement, we use the relationship between N and P contents established for C3 species (Duru and Thélier, 1997):

$$Pi = 100 * P\% / (0.15 + 0.065 * N\%) \qquad [2]$$

The value of the index for optimum herbage production is 100; a value greater than 100 means a luxurious consumption; if it is lower than 100, it means a deficiency which is in proportion to the optimum.

Results and Discussion

The effect of N addition on dry matter yield was significant, and there was a significant effect of P added (Bb and Bh) or of its interaction with N (Pm) in 1996 (Table 1). The same pattern is obtained in 1997, except for Pm. The increase in dry matter yield with N and P addition was more than twice the sum of the increase due to application of each fertilizer alone except for Pm in 1997. When dry matter yields were compared for N1P0 and N0P1 treatments, the N effect was significantly greater than the P effect only for one species in 1997. The low P indices computed for the control treatments (N0P0) confirm that soils are very P deficient ; they were the lowest for Bb and Bh. The values of N indices are representative of grasslands in this area, and prove that the amount of N available from soil organic matter mineralization is low. Following P addition, N indices increase signicantly for Pm and Bh canopies and to a greater extend, for N1 tratements than for N0 treatments (significant effect of the interaction). After P fertilization, we note a very significative increase of P index for all the species. Following N addition, there was a significant increase of N index for Pm and Bb canopies but in a greater extent for P1 treatments than P0 ones. Furthermore, there was a trend for a decrease in P index for N1P1 treatments. Cumulative N uptake for 50 days was in average 24, 41, 41 and 97 kg per ha respectively for N0P0, N0P1, N1P0 and N1P1 treatments. In situations with low P and N availability to plants, Braakhekke et al. (1993) observed that addition of one nutrient (N or P) increases the immobilization rate of the other by decomposing residues, and result with low crop yields. Following P addition, N index increased more than following N supply only. Taking N1P1 treatment as a control one (dry matter yield and N index being equal to 100 at each date), we computed the relative herbage dry matter yield and the relative herbage nitrogen index for the three other treatments (Figure 1). For a given relative herbage nitrogen index, there was no difference in relative dry matter yield between the P1 and P0 treatments. It means that the effect of P was only a result of the increase in N herbage indices (nitrogen acquisition). In other words, there was no direct effect of P supply on herbage growth. For Bb and Pm, addition of N on no P fertilized plots (N1P0) induces a moderate increase in relative herbage N index and relative herbage treatment yield. Similarly, addition of P on no N fertilised plots (N0P1) has the same effects for Bb, whereas for Pm and Bh, P application increases relative herbage N index without subsequent increase in herbage production. In those situations P supply is efficient only when associated with N. Both limiting factors have to be corrected in order to obtain optimum production.

In absence of N, the significant increase in P nutrition status has only moderate consequences on herbage production. Both N and P are limitant for herbage production on these soils. The decline in pasture productivity can not be alleviated solely by phosphorus supply. N and P fertilization have to be managed together. The assessement of P and N herbage status through plant analysis has allowed to specify which process is at the origin of response in herbage growth following fertilizer supply, distinguishing between their direct and indirect effects.

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Table 1 - Effect of N and P treatments on dry matter yield (t.ha^{-1}), nitrogen and phosphorus herbage indices (average data for the 3rd, 4th and 5th sampling dates).

		1996												1997			
Pastures	Fertilization code	Yield	Treatment effect			N index	Treatment effect			P index	Treatment Effect			Yield	Treatment effect		
			N	P	NxP		N	P	NxP		N	P	NxP		N	P	NxP
Pm	N1P1	4.41	***		*	84.4	**	**	*	64.4		***		4.40	***		
	N0P1	1.43				63.6				82.2				2.60			
	N1P0	2.74				59.1				33.3				3.86			
	N0P0	1.72				51.4				32.5				1.99			
Bb	N1P1	3.94	**	**	*	64.0	**	*	*	48.0	**	***	*	4.56	***	*	*
	N0P1	2.00				43.4				50.0				1.53			
	N1P0	1.98				47.7				19.2				2.20			
	N0P0	1.36				42.7				13.5				1.36			
Bh	N1P1	3.62	*	*	*	69.3		**		83.2		***		3.83	***	***	**
	N0P1	1.62				55.2				84.5				146			
	N1P0	1.46				42.3				18.2				1.23			
	N0P0	1.25				44.2				17.1				0.84			

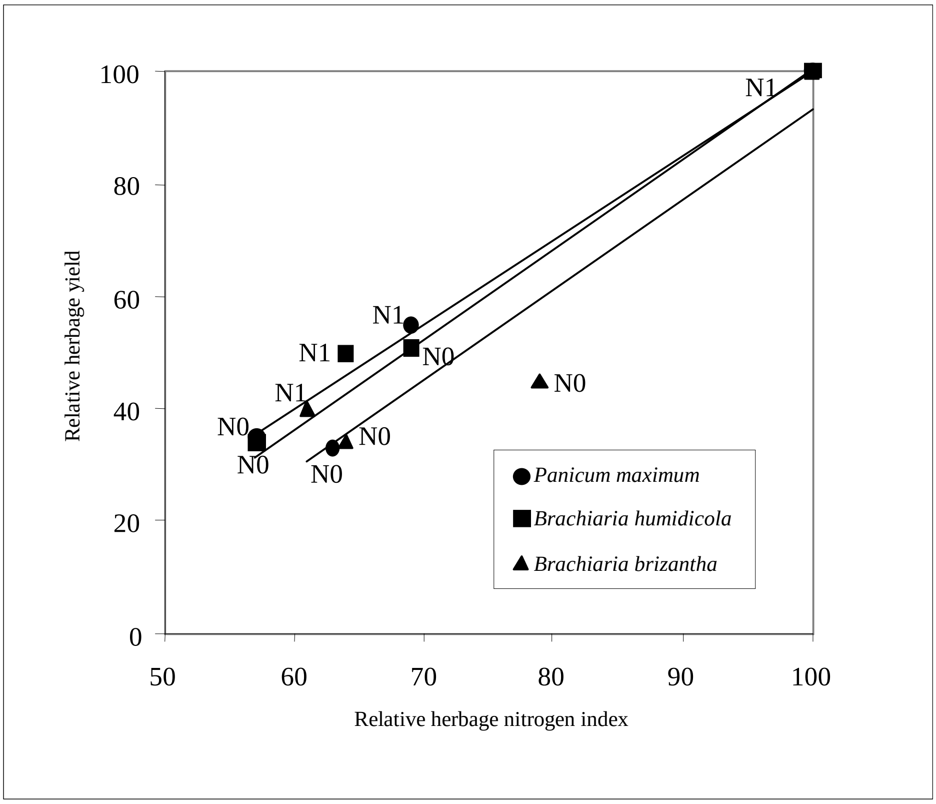

Figure 1- Relationship between relative herbage nitrogen index and relative herbage yield (open symbol : P0 treatment, full symbol P1 treatment).