Influencia de la aplicación de vinaza en actividad y biomasa microbiana en un *entic dystropept* y un *fluventic haplustoll* del Valle del Cauca, Colombia

Influence of the vinasse application on activity and microbial biomass in an *Entic dystropept* and a *fluventic haplustoll* soil of Cauca Valley, Colombia

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RESUMEN

Con la aplicación de vinaza, residuo de la producción de alcohol carburante a partir de la caña de azúcar, se evaluó el efecto sobre la actividad y biomasa microbiana del suelo y el suministro de K^+ al cultivo de maíz dulce *(Zea Mays)* en un *Entic Dystropept* y un *Fluventic Haplustoll* del Valle del Cauca, Colombia. Se utilizó un diseño completamente al azar con cuatro tratamientos y cinco repeticiones: **T1** (100% requerimiento de K^+ con KCl), **T2** (100% requerimiento de K^+ con vinaza), **T3** (50% requerimiento de K^+ con KCl +50% con vinaza) y **T4** (25% requerimiento de K^+ con KCl +75% con vinaza). Se estimó biomasa microbiana por el método de fumigación-extracción. Se realizó análisis de varianza, prueba de comparación de medias, regresiones y correlaciones (SAS). Se presentaron diferencias significativas en la actividad y biomasa microbiana por época de muestreo y entre los diferentes muestreos; al final del cultivo el *Entic Dystropept* presentó el contenido mas alto de biomasa microbiana-C en el T2, mientras que en el *Fluventic Haplustoll* fue en el T1. El menor qCO_2 fue para el T2 del *Entic Distropept* y T1 del *Fluventic Haplustoll*, estos tratamientos presentaron mayor acumulación de biomasa en cada suelo respectivamente T2 (30 450 kg ha^{-1}) y T1 (21 015.6 kg ha^{-1}).

Palabras clave: Inceptisol; Mollisol; biomasa microbiana; cociente metabólico; acumulación de biomasa.

ABSTRACT

Vinasse is a residue from the production of fuel ethanol from sugarcane. This study assessed the effect of application of vinasse on the activity and biomass of soil microbiota. and the supply of K^+ to sweet corn (*Zea Mays)* in two soils of the Cauca Valley, Colombia: *Entic Dystropept* and *Fluventic Haplustoll*. We used a completely randomized design with four treatments and five replications: T1 (100% requirement of K^+ with KCl), T2 (100% requirement of K^+ with vinasse), T3 (50% requirement of K^+ with KCl + 50% with vinasse), T4 (25% requirement of K^+ with KCl +75% with vinasse). The microbial biomass was estimated by the fumigation-extraction method. The CO_2 was estimated according to the methods of Vance *et al*. (1987) and Cadena and Madriñan (1998). The microbial metabolic quotient (qCO_2) was calculated as: qCO_2 = *microbial activity (ugC-*CO_2 g^{-1} *soil day* $^{-1}$*) / microbial biomass (ugCg*$^{-1}$ *soil*). We determined the accumulation of stem and leaf biomass, transforming this production to kg.ha^{-1}. The results were evaluated using analysis of variance, mean comparison test, correlation and regression (SAS). There were significant differences in the activity and microbial biomass as a function of sampling date and among different samples. At harvest time, the *Entic Dystropept* had higher content of microbial biomass-C in T2, while the *Fluventic Haplustoll* showed higher content of microbial biomass-C in T1. The lowest qCO_2 was for the *Entic Distropept* with T2, and T1 in *Fluventic Haplustoll*. These treatments had a greater accumulation of biomass in each soil respectively: T2 (30 450 kg ha^{-1}) and T1 (21 015.6 ha kg^{-1}).

Key words: Inceptisol; Mollisol; microbial biomass; metabolic quotient; accumulation of biomass.

INTRODUCTION

The vinasse is a byproduct of the production of fuel ethanol. It has an elevated biochemical demand for oxygen-BOD, however the buffering power of soil reduces the contaminating potential (Korndörfer *et al.*, 2004). As vinasse may contain between 2.1-3.4 kgm^{-3} of K_2O, it is currently used to supply potassium requirements to some crops, without having assessed its impact on biological properties of the soil, decomposition of organic residues, sequestration and detoxification of toxic substances, amongst others (López and da Silvieira, 2004).

Microorganisms, representing only a small fraction of the organic material of the soil, are responsible for the process of mineralization (Jenkinson, 1988). The microbial biomass of the soil is a catabolic agent for biochemical processes and also a reserve of energy and nutrients. However it is very susceptible to changes in agricultural practices and the physical-chemical characteristics of the medium, determining the productive equilibrium of the ecosystem.

Estimation of biomass contributes to knowledge regarding the quality and fertility state of the soil, and to maintaining this characteristic over time (Powlson, 1994). Microbial biomass is the most important indicator of the microbial composition of the soil, especially in combination with an activity parameter, such as CO_2 production (Anderson and Domsch, 1993).

The present study aimed to estimate the effect of vinasse application, in different doses, on microbial biomass and activity in two soil groups in the Cauca Valley, Colombia, attempting to supply the potassium requirements of a sweet corn crop *(Zea Mays)*.

MATERIALS AND METHODS

The study was carried out in screened houses at the National University of Colombia, Palmira campus, Cauca Valley (N 03º 30’ 45.6” y W 76º 18’ 29.91”, 1050 masl., 23ºC and 70% relative humidity) with two soils with a low potassium content (Table 1). The vinasse was obtained from the Providencia Sugar Mill (Table 2).

A completely randomized design was used, with four treatments generated through the provision of nutritional requirements of K^+ in sweet corn *(Z. Mays)* (K_2O: 124 $kgha^{-1}$), with two sources (KCl and Vinasse), alone or supplying 50% and 25% of the KCl (Table 3). The remaining nutrients required for the crop to harvest of three to four tons per hectare, were approximately N: 190kgha^{-1}, P_2O_5: 62 kgha^{-1}, Ca: 1kg., Mg: 6 kg., S: 6 kg. (Valencia, 2005).

Table 1. Chemical properties of the soils Entic dystropept (A), Fluventic Haplustoll (B)

	pH	M.O	Ca	Mg	K	Na	CIC	P	Cu	Zn	Mn	Fe	B
	1:1	%	Cmol^{+} kg^{-1}					ppm					
A	5.50	8.10	6.89	2.63	0.21	0.18	14.52	51.00	2.40	11.00	57.21	263.00	0.35
B	7.64	3.84	8.74	3.54	0.20	0.17	11.76	34.90	16.00	3.36	44.13	96.75	0.31

Table 2 Chemical composition of 25% vinasse

Element	**Content kgm^{-3}**
N	0.007
P_2O_5	0.020
K_2O	33.91
CaO	1.73
MgO	3.48
SO_4	0.031
Na	2.236

Table 3. Potassium applications before (50%) and after flowering (50%) of sweet corn.

Potassium mixes	
T1	100% KCl
T2	100% vinasse
T3	50% vinasse+50% KCl
T4	75% vinasse+25% KCl

Estimation of microbial biomass was performed using the method of extraction-fumigation using K_2SO_4 0.5M (Vance *et al*., 1987). CO_2 was estimated with the method of Vance *et al*. (1987) and that of the Agrobiology Center of Brazil CAB (described by Cadena and Madriñan, 1998). During soil incubation in a closed system, it was captured in a solution of NaOH, which was later titred with HCl. The metabolic quotient (qCO_2) was calculated in the following manner: qCO_2 = *microbial activity (ugC-*CO_2 *g*$^{-1}$ *soil day* $^{-1}$*) / microbial biomass (ugCg*$^{-1}$ *soil*).

Stem and leaf biomass accumulation was determined and transformed to kgha^{-1}. The results obtained were analyzed using analysis of variance, comparison of means test, regressions and correlations (SAS).

RESULTS AND DISCUSSION

At the flowering stage of the maize crop, both soils tended to a reduced C in the microbial biomass (Figure 1), concordant with that reported in lettuce (Constantini *et al.*, 1997). It is possible that the results are related to the crop stage and the rhizospheric effect, as the microbiota is stimulated or inhibited through root exudates and microorganism remains (Carrillo, 2003).

The final C content of microbial biomass in both soils presented a similar behavior in the treatment without vinasse (T1), with a tendency to recuperate the microbial biomass content. With the application of vinasse, the behavior was different in each soil, with a marked difference in T2; in the final sample, the *Entic Dystropept* showed a greater recuperation of microbial biomass, while the *Fluventic Haplustoll* showed reduced biomass from the treatment application to the end of cultivation (Figure 1). The results in *Entic Dystropept* agree with those seen in plantain by Bolaños (2006), the same author citing that Sparling (1997) and the Vepsalainen group (2004) found greater microbial biomass in soil with more developed vegetation.

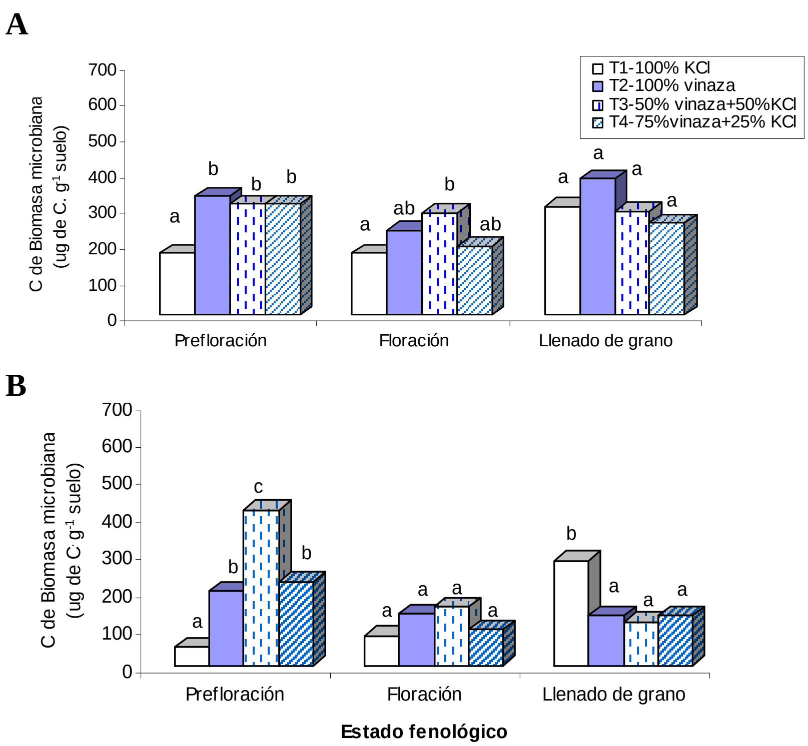

Figure 1. Microbial biomass-C in an inceptisol (A) and mollisol (B) from the Valle del Cauca-Colombia submitted to different doses of vinasse and KCl.
Values of the phonological stages with the same letter in the same treatment are not significantly different according to the Duncan test ($P<0.05$).

Microbial respiration showed a response to treatment application in a shorter time in *Fluventic Haplustoll*. Both soils presented a cycle of high respiratory activity, followed by a reduction (Figure 2), concordant with that found by Silva (2005), and attributed to the stabilization of populations after an intense respiratory cycle caused by the application of fertilizers.

A

B

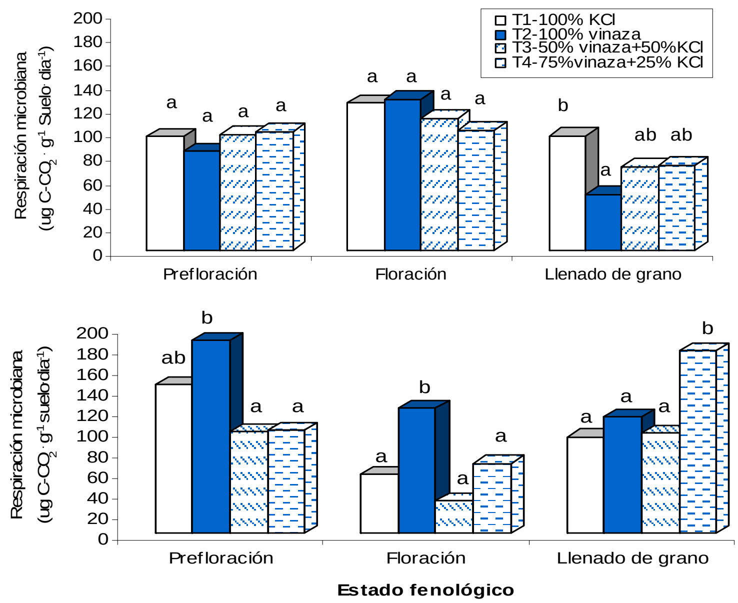

Figure 2. Microbial activity -CO_2 in an inceptisol (A) and mollisol (B) from the Valle del Cauca-Colombia submitted to different doses of vinasse and KCl.
Values of the phonological stages with the same letter in the same treatment are not significantly different according to the Duncan test ($P<0.05$).

The metabolic efficiency of each soil showed different behavior in each treatment application. In *Entic Dystropept* the qCO_2 of the vinasse treatments stabilized over time, and reduced towards cultivation end; in *Fluventic Haplustoll* the qCO_2 increased, mainly in those treatments with the greatest vinasse content (T2 y T4), presenting values greater than 1 (Figure 3), which indicates less efficiency in the utilization of carbon, resulting in a greater liberation of CO_2 per unit of substrate. This reflects microbiotic stress, and dormancy state, as a survival mechanism to avoid possible toxicity (Insam *et al.*, 1996, Lopez and Silvieira, 2004).

The results in *Fluventic Haplustoll* could be related to the increase in the bulk density caused by the application of the vinasse treatments, in concordance with that seen by Santruckova *et al.*(1993), who concluded that, in soil compaction treatments, the destruction of compacted layers and gradual re-compaction of these, would be the principal cause of loss of microbial biomass, accompanied by an increase in microorganism activity.

The accumulation of biomass (Figure 4) in *Entic Dystropept* averaged 27 331.7 kg ha^{-1} and in *Fluventic Haplustoll* 16 856.1 kg ha^{-1}. Although there was not a statistical correlation, it is worth mentioning that in the soil from Florida (Valle), with a greater content of organic material, there was a greater quantity of microbial biomass-C. This is usually correlated with plant growth and productivity (Paul and Clarck, 1989).

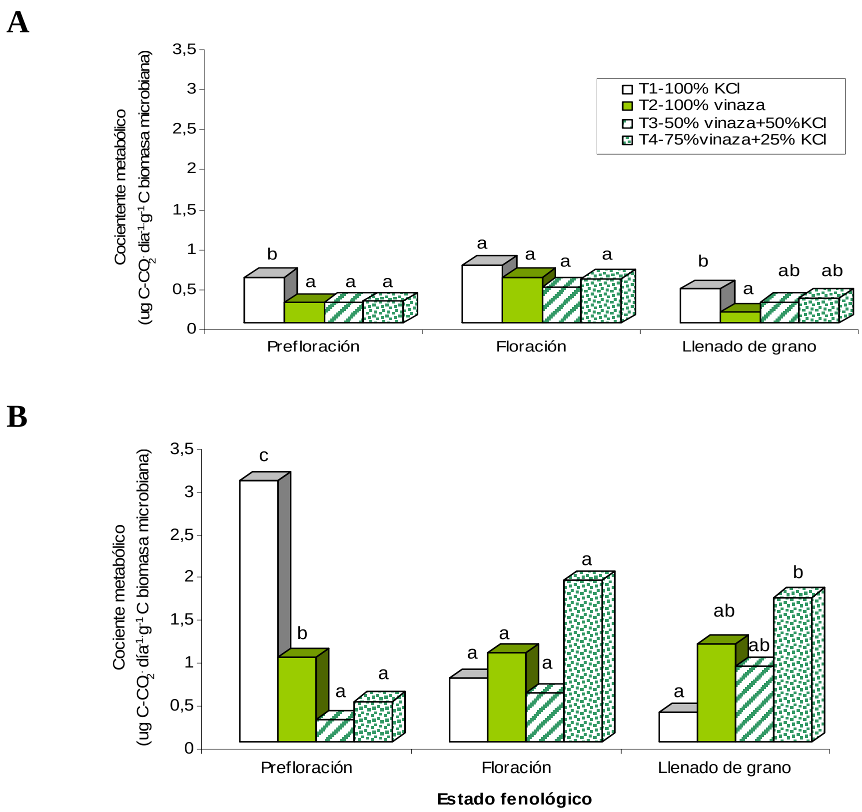

Figure 3. Metabolic quotient (qCO_2) in an inceptisol (A) and mollisol (B) from the Valle del Cauca-Colombia submitted to different doses of vinasse and KCl.
Values of the phonological stages with the same letter in the same treatment are not significantly different according to the Duncan test ($P<0.05$).

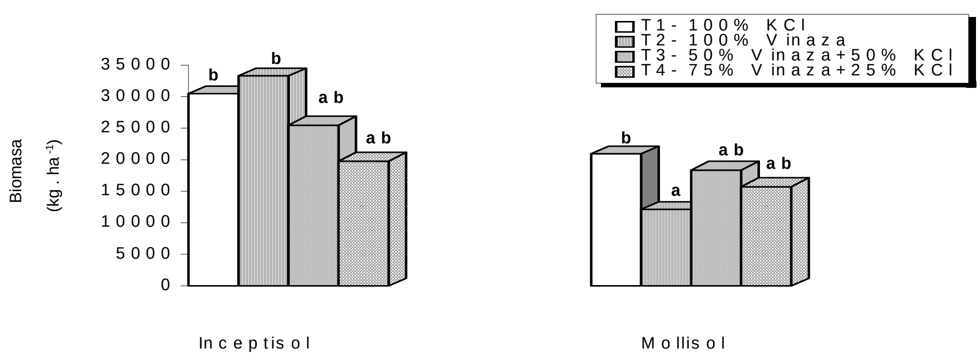

Figure 4. Biomass accumulation in an inceptisol and mollisol from the Valle del Cauca-Colombia submitted to different doses of vinasse and KCl.
Values of the phonological stages with the same letter in the same treatment are not significantly different according to the Duncan test ($P<0.05$).

A greater accumulation of biomass in *Entic Dystropept* was seen in the treatments with 100% vinasse (33 372 kg ha^{-1}) and without vinasse (30 450 kg ha^{-1}); in the soil from the Sugar Mill Manuelita, the highest values were observed in the treatments without vinasse (21 016 kg ha^{-1}) y with 50% KCl (18 457 kg ha^{-1}).

CONCLUSIONS

1. In the *Fluventic Haplustoll* microbial biomass and metabolic efficiency of treatments including vinasse did not show recuperation over the period of the study.

2. The accumulation of biomass in sweet corn was greater in *Entic Dystropept*; the application of vinasse affected this parameter in *Fluventic Aplustoll*.

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