Title

Yield and nitrogen levels of silage corn fertilized with urea and zeolite

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Introduction

Nitrogen fertilization is one of the factors that most contributes to an increase in DM production of corn. Urea has been the most used N-source in Brazil (Anda, 2003). But N use efficiency of urea may be reduced due of losses by volatilization of ammonia to the atmosphere.

The N-urea losses can be reduced using zeolites as additives in the fertilizers to control the retention and release of NH_4^+. There are several reports in the literature showing that the addition of zeolite to the source of N can improve the nitrogen use efficiency (Ming and Mumpton, 1989; Gruener et al., 2003; Rehakova et al., 2004). Zeolite minerals are crystalline hydrated aluminosilicates of alkali or alkaline-earth metals, structured in three-dimensional rigid crystalline network, formed by the tetrahedral AlO_4 and SiO_4, which come together to compose a system of canals, cavities and pores (Ming and Mumpton, 1989).

There are many reports in the literature demonstrating increase in efficiency of N utilization and crop yields when urea is used with zeolite (Crespo, 1989, Bouzo et al., 1994, Carrion et al., 1994). While zeolites are useful for increasing N use efficiency in a range of crops, no information exists on the degree to which they might enhance N use efficiency in agricultural systems where urea-N is used to fertilized corn, especially on acid soils. The objective of this study was to evaluate dry matter yield and nutritional levels of nitrogen of silage corn fertilized with urea and zeolite mixture.

Materials and methods

A two-year field study was conducted at Embrapa Cattle Southeast, in Sao Carlos (22°01' S and 47°54' W; 856 m above sea level), State of Sao Paulo, Brazil. The climate is Cwa type (Köeppen), with yearly average of low and high temperatures of 16.3 and 23.0°C, respectively, and a total precipitation of 1502 mm falling mostly in summer. Soil type was a Typic Hapludox, with the following chemical properties in the 0-0.2 m layer: $pHCaCl_2$ = 5.5, organic matter = 55 g dm^{-3}, P_{resine} = 19 mg dm^{-3}, K = 7.0 $mmol_c$ dm^{-3}, Ca = 54 $mmol_c$ dm^{-3}, Mg = 21 $mmol_c$ dm^{-3}, CEC = 116 $mmol_c$ dm^{-3} and basis saturation = 70%; and the physical characteristics: 636 g kg^{-1} of sand, 40 g kg^{-1} of silt and 324 g kg^{-1} of clay.

The zeolite used was collected in the North of the State of Tocantins, Brazil, in the basin of the Parnaiba River. It had 470 g kg^{-1} of stilbite. The material was crushed and part of it was concentrated, separating contaminants (quartz and iron oxides and hydroxides) from zeolite by means of gravitational concentration, using the Humphrey spiral, resulting in material with 650 g kg^{-1} stilbite. Therefore, two types of zeolite were obtained: natural (470 g kg^{-1} of stilbite) and concentrated (650 g kg^{-1} of stilbite), both with particle size of <1 mm (16 mesh).

Irrigated corn (*Zea mays* L.) was grown in a no-tillage system after fallow in both the 2005–2006 and 2006–2007 growing seasons. The experiment was carried out in 16-m^2 plots, formed by four sowing rows of 5-m length, with a 0.8-m interlinear space, using five plants per meter. Experimental plots were fertilized uniformly at planting with 30 kg ha^{-1} of N, 100 kg ha^{-1} of P_2O_5, 55 kg ha^{-1} of K_2O and 1.4 kg ha^{-1} of Zn.

The experiment was arranged in a 2×4×4 factorial randomized block design with three replications. Treatments comprised two types of stilbite (natural and concentrated), four levels of nitrogen (0, 50, 100 and 200 kg ha^{-1}) and four zeolite ratios (0%, 25%, 50% and 100% of N level). Zeolite was mixed with urea and recovered its granules. Nitrogen source was urea. Treatments were applied 60 days after planting with the topdressing fertilization. Potassium was also applied in the total amount of 100 kg ha^{-1} of K_2O as KCl. Corn ear leaves were sampled at the beginning of silking. Total concentration of N in leaf samples was determined after hot sulfuric digestion by a standard micro-Kjeldahl system (Nogueira and Souza, 2005).

Silage corn harvest was initiated in March 2006 and 2007, when whole-plant water concentration was between 600 and 700 mg kg^{-1}. A minimum of two 4-m length rows was harvested per plot. Aliquots of corn samples were dried at 65°C for 72 h for dry matter determination. Data of silage corn dry matter yield and nitrogen leaf concentrations were tested for differences among treatments using a complete randomized block analysis of variance. Response function and equations were adjusted as a function of treatments.

Results and discussion

All results presented in this study refer to a time scale of two cropping seasons: 2005–2006 and 2006–2007. Dry matter yield of silage corn as a function of N fertilizer level and zeolite ratio and type is illustrated in Figure 1. The highest DM yields (14.5 and 14.1 t ha^{-1}) were obtained respectively with 183 kg ha^{-1} of N plus 59.6% of concentrated zeolite and 161 kg ha^{-1} of N and with 42.2% of natural zeolite.

The highest values of DM yields were approximately 48% higher than those obtained without nitrogen fertilizer, and only 5.5% and 3.6% higher than DM yield obtained with N fertilizer but without concentrated or natural zeolite. These results confirms those reports from Gruener et al. (2003), Crespo (1989), Bouzo et al. (1994) and Carrion et al. (1994), who also found beneficial effects when using this mineral together with urea.

Maximum leaf N concentrations observed were 34 and 31 g kg^{-1} achieved with 199 and 165 kg ha^{-1} of N and 65% and 54% of natural or concentrated zeolite, respectively (Figure 2). These values are 46% and 41% higher than those of the control and 33% and 28% higher than those without zeolite but with the same N fertilizer level.

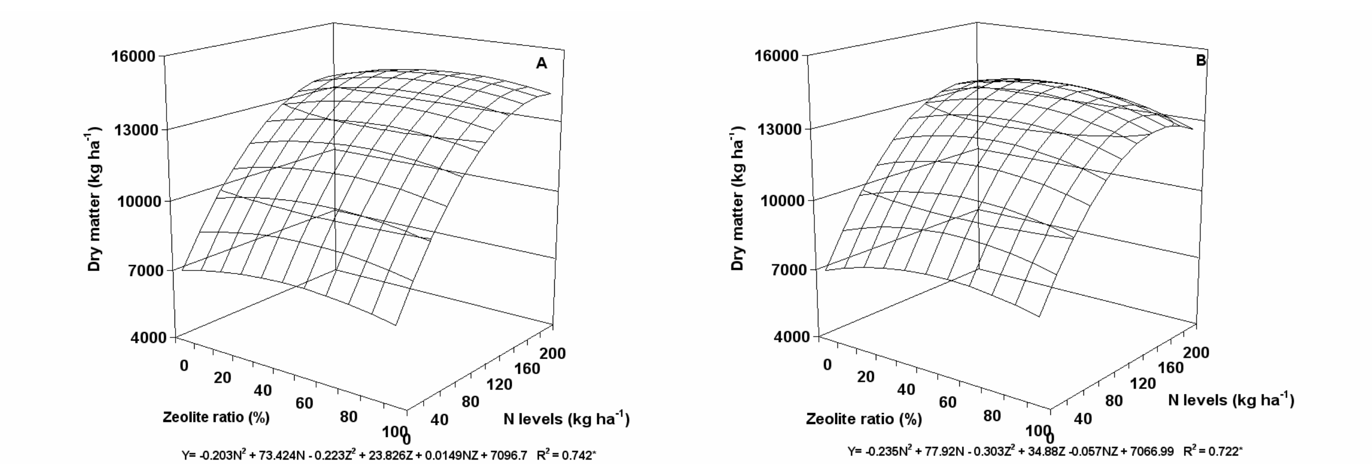

Figure 1. Silage corn dry matter yield according to level of urea-N and ratio of concentrated (A) and natural (B) zeolite. Results are average of two crop seasons.

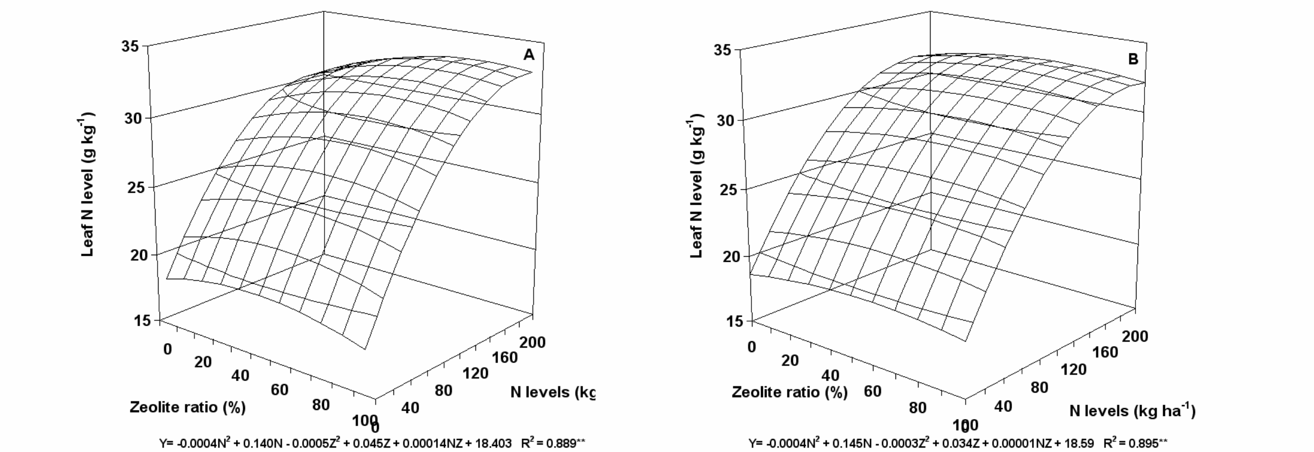

Figure 2. Silage corn nitrogen levels in ear leaf according to level of urea-N and ratio of concentrated (A) and natural (B) zeolite. Results are average of two crop seasons.

Considering the economics of zeolite-urea use, results indicated that the high proportion of zeolite required to provide the relatively small effect on the DM yield increasing, due the reduction of losses, may be a limiting factor for achieving the commercial use of this mineral. Eyde and Holmes (2006) reported that prices of zeolite for agricultural or industrial use in the U.S.A. ranged from 30 to 70 dollars per tonne of coarse size products (below 40 mesh). The mixture of both should be interesting just when the price of the mineral is lower than a 4 or 6% increase in productivity obtained with zeolite and urea.

Conclusion

The use of concentrated or natural zeolite with urea increased silage corn dry matter production and N leaf concentrations.

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