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Efficiency of Utilization of Nitrogen Coated with Urease Inhibitor in Maize

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Abstract: This study aimed to evaluate under field conditions the efficiency in the use of N coated with urease inhibitor in maize. The experiment was conducted in the year of 2007/2008. The experimental design was a randomized block design in a factorial 2 x 6, with five repetitions, constituted the N sources (common and coated with urease inhibitor) and levels (0, 40, 80, 120, 160 and 200 kg ha^{-1} of N) sidedressing nitrogen application in the growth stage V_4. Based on the data obtained were determined recovery efficiencies, utilization, agronomic and physiological N applied. In all cases, the efficiency levels for maize were influenced by levels of sidedressing nitrogen application, in which increasing levels of N resulted in a decrease of the efficiencies, regardless of the source being common urea or coated with urease inhibitor.

Key words: *Zea mays* L., NBPT, agronomic efficiency, sidedressing nitrogen application

INTRODUCTION

The nutrient balance in the soil is an important factor that interferes in the yield of maize, in the activity of microorganisms and improve soil quality, which stresses the Nitrogen (N) to be the nutrient absorbed in greater quantity by maize (Cancellier *et al*., 2011), since it is a constituent of protein, coenzymes, nucleic acids, phytochromes, ATP, chlorophyll and several enzymes, which provide beneficial effects plant (Okumura *et al*., 2011a).

The increase in N availability to the crop is done by N-fixing bacteria (El-Hawary *et al*., 2002; Nezarat and Gholami, 2009) and/or sidedressing nitrogen application (Boroomandan *et al*., 2009; Celebi *et al*., 2011; Okumura *et al*., 2011a, 2013). However, the sidedressing nitrogen application are subject to losses through volatilization, immobilization, denitrification and leaching, which results in decreased recovery efficiency of applied N, in many cases less than 50% (Lara Cabezas *et al*., 1997), thereby, the rational use of nitrogen fertilization is essential, not only to increase the efficiency of recovery but also to increase crop yield and minimize the cost of production (Fageria *et al*., 2007).

The low recovery efficiency of fertilizer N has been attributed, mainly, to the losses caused by volatilization of ammonia, which can reach values of up to 78% of total N applied (Lara Cabezas *et al*., 1997). Several factors, alone and/or combined, that influence the potential for loss of ammonia, such as temperature, organic matter content, CEC, moisture, pH, vegetation cover and high levels of N applied to the soil (Rochette *et al*., 2009; Ma *et al*., 2010).

In this context, the use of N sources less subject to losses by volatilization is an alternative for reducing the nutrient losses (Cantarella *et al*., 2008). Furthermore, pretreatment of nitrogen fertilizer with a urease inhibitor, the NBPT (Christianson *et al*., 1990), which acts on the molecule of urea minimizing ammonia volatilization (Buresh *et al*., 1984) for a period of 14 days (Watson, 2000).

Experimental results show that the use of coated urea NBPT provides inhibition activity of the urease enzyme, thereby, retards the hydrolysis of urea and, therefore, decreases the amount of volatilized NH_3 (Cantarella *et al*., 2008; Rochette *et al*., 2009), resulting in a higher efficiency in the use of N (Silva *et al*., 2011a) and increasing the yield of maize (Okumura *et al*., 2013).

This study aimed to evaluate under field conditions the efficiency in the sidedressing nitrogen application coated with urease inhibitor in maize.

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MATERIALS AND METHODS

Experimental site: The experiment was conducted in the year of 2007/2008, in Mauá da Serra city, State of Paraná, Brazil, in the geographical coordinates 23°58'S and 51°19'W. The climate is subtropical Cfb (according to the classification of Köeppen), with the data of rainfall and soil chemical characteristics shown by Okumura *et al.* (2011a, 2013), observing a rainfall during the experiment above 214 mm, which is considered sufficient for development of maize (Kara and Biber, 2008; Mengu and Ozgurel, 2008).

Experimental design: The experimental plots consisted of six rows spaced 0.70 by 8.0 m in length. The experimental design was a randomized block design in a factorial 2 x 6, with five repetitions, constituted the N sources (common and coated with urease inhibitor) and levels (0, 40, 80, 120, 160 and 200 kg ha^{-1} of N) sidedressing nitrogen application in the growth stage V_4 (Okumura *et al.*, 2011b) the scale of Ritchie *et al.* (1993).

Agronomic practices: For the experiment used the maize hybrid P30F53, sown on October 3, 2007, with a density of 70,000 plants ha^{-1} (Dourado Neto *et al.*, 2003; Flesch and Vieira, 2004). In furrow applied 40, 90 and 60 kg ha^{-1} of N, P_2O_5 and K_2O, respectively (Oliveira, 2003). Agronomic practices, control weeds and insects, were performed when necessary (Fornasieri Filho, 2007).

Crop measurements: Based on data presented by Okumura *et al.* (2011a, 2013), determined the following efficiencies: recovery, utilization, agronomic and physiological N applied, according to calculations described by Fageria and Baligar (2005).

Statistical analysis: Experimental data were analyzed to verify the normality and homoscedasticity through the Shapiro-Wilk (Shapiro and Wilk, 1965) and Levene test (Box, 1953) ($p>0.01$), by use of SAS statistical software (SAS, 2008), then, the analysis of variance ($p<0.05$) and depending on the significance, were adjusted regression equations (Cruz and Regazzi, 2001), by use of SISVAR statistical software (Ferreira, 2011).

RESULTS AND DISCUSSION

The indices of efficiency in the use of nitrogen sources with urease inhibitor were calculated in order to identify the relative contribution of the molecule in the acquisition and distribution of N and efficiency of its use. The efficiency indices evaluated were significant for sources of N used.

Utilization efficiency: The efficiency of utilization of N (Fig. 1), which corresponds to the physiological efficiency and product recovery efficiency, decreased with the increase of level of N, independent of the nitrogen source applied. The reduction in efficiency of utilization of N with increasing levels was also observed in other crops such as rice (Fageria *et al.*, 2009) and beans (Santana *et al.*, 2011), this is due to the grain yield is positively associated with agronomic efficiency, recovery and use of N, which differ with the management and supply of nitrogen fertilizer (Dos-Santos and Fageria, 2007).

Recovery efficiency: The efficiency of recovering the N applied (Fig. 2) by the fertilizer refers to the percentage of total N was applied by nitrogen sources which additionally absorbed and accumulated by the plants of plot fertilized compared to unfertilized, this is, that index is easy estimate and inexpensive, since it uses only the N

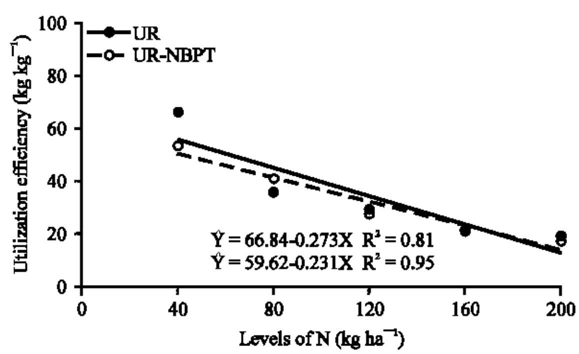

Fig. 1: Efficiency of utilization of N applied in function of N sources, common urea (UR) and coated with NBPT (UR-NBPT) and levels of sidedressing nitrogen application (0, 40, 80, 120, 160 and 200 kg ha^{-1} of N) in maize

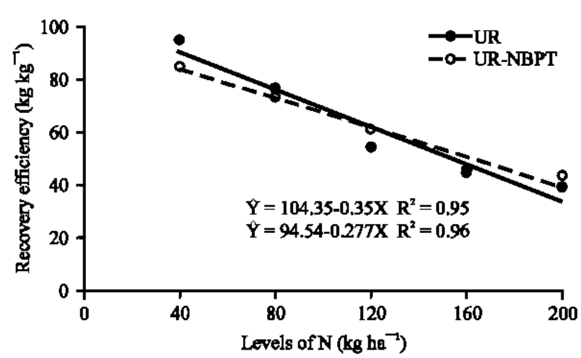

Fig. 2: Efficiency of recovering the N applied in function of N sources, common urea (UR) and coated with NBPT (UR-NBPT) and levels of sidedressing nitrogen application (0, 40, 80, 120, 160 and 200 kg ha^{-1} of N) in maize

content and the total plant dry weight of the culture of fertilized and unfertilized plots (Primavesi *et al*., 2006).

The results of recovery efficiency of the N applied from the maize plant show maximum recovery of 94.5 and 84.5% for UR and UR-NBPT sources, respectively (Fig. 2), a percentage similar to those described by Halvorson *et al.* (2004) and Fernandes *et al.* (2005) and above the reported by other researchers (Lara Cabezas *et al*., 2004, 2005; Villas Boas *et al*., 2005; Gava *et al*., 2006; Lange *et al*., 2008, 2010).

The obtained results were calculated by the difference method, in which assumes that both mineralization, immobilization and other transformations of N, as well as the size of the underground parts of plants and the volume of soil explored are the same in areas fertilized or not, providing values well above those originated by the isotopic method (Fernandes and Libardi, 2007). Thus, shows the difference method, often, a higher efficiency of N applied than over the isotopic method (Neptune, 1977).

The fertilizer shows decreased linearly, independent of the presence or absence of NBPT, this is, the recovery rate of the nitrogen applied as fertilizer decreased as increasing the level applied to the soil. The lower recovery of applied N by increasing levels has been reported by other authors (Gava *et al*., 2006; Silva *et al*., 2006, 2011b; Primavesi *et al*., 2006), this occurs due to higher dry matter production, nutrient concentration and extraction of N by plants in larger levels of sidedressing nitrogen application. Accordingly, the highest levels increase the chance of nutrient losses through volatilization, leaching, denitrification and surface wash, large responsible for the low recovery of N fertilizer by crop (Lara Cabezas *et al*., 1997).

The use of the inhibitor at lower levels, caused a decrease in recovery from N relative to the absence of inhibitor, however, in higher levels, the inhibitor source showed a greater recovery of N applied (Fig. 2). These results reveal a greater benefit in the use of technology in high levels, probably, due to the presence of NBPT coated in urea slow hydrolysis by enzymes of soil urease (Cantarella *et al*., 2008; Civardi *et al*., 2011), which allowed a longer period so that this part of the fertilizer N penetrates into the soil by rain water (Okumura and Mariano, 2012) and thereby, reduce the concentration of NH_4^+ in soil (Longo and Melo, 2005) and minimize losses N by volatilization (Tasca *et al*., 2011; Werneck *et al*., 2012).

The ground surface at the time of application of N founded wet due to rainfall of 5.5 mm occurred the previous day, however, after the sidedressing nitrogen application of soil was subject to a short drought, 5 days (Okumura *et al*., 2011a, 2013). According to Hargrove *et al.* (1987), the biggest problem related to the amount of water is the fact that often the precipitating incident or moisture present in the soil alone are enough to make the changes NH_4^+ in NH_3 occurs, not promoting the incorporation of fertilizer (Freney *et al*., 1992).

The recovery efficiency in the application of common urea, possibly, was influenced by the amount of enzyme urease present in the soil, since it is directly related to the organic matter content (Reynolds *et al*., 1985) and in this study the soil used had 40.72 g kg^{-1} of organic matter content (Okumura *et al*., 2011a, 2013), which suggests that is a soil with high urease enzyme activity and reinforces the hypothesis of higher hydrolysis rate

In assessing the recovery efficiency of applied N is important to note that besides the losses of N applied by the processes mentioned, the plants are, actually, in competition with the soil microbial population (Silva *et al*., 2011b) and the N applied to the soil is, also, subject to a number of changes mediated by microorganisms, which will determine the equilibrium relationships among the organic and inorganic forms (Moreira and Siqueira, 2006).

Agronomic efficiency: The agronomic efficiency (Fig. 3) refers to the grain production of maize in fertilized plots compared to non-fertilized per unit of N applied by the sources used, that in the present study, the best fit curve was obtained by the following equations Y = 33.62-0.087X and R^2 = 0.58 and Y = 40.49-0.140X and R^2 = 0.90 to the common and urea coated with inhibitor sources, respectively.

The agronomic efficiency, by definition, is higher as the smaller the amount of applied N (Cazetta *et al*., 2007),

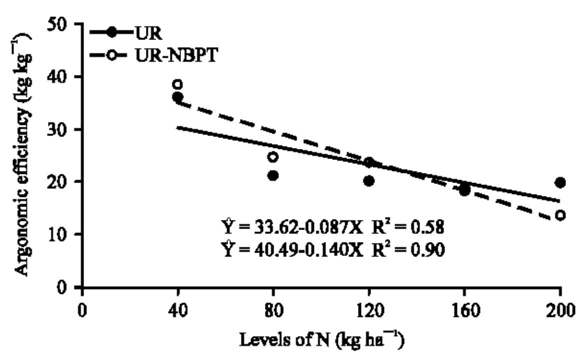

Fig. 3: Agronomic efficiency in function of N sources, common urea (UR) and coated with NBPT (UR-NBPT) and levels of sidedressing nitrogen application (0, 40, 80, 120, 160 and 200 kg ha^{-1} of N) in maize

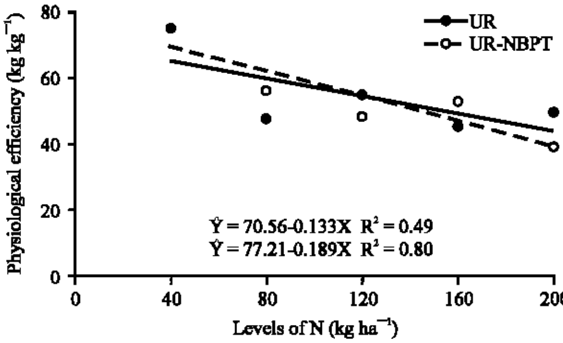

Fig. 4: Physiological efficiency in function of N sources, common urea (UR) and coated with NBPT (UR-NBPT) and levels of sidedressing nitrogen application (0, 40, 80, 120, 160 and 200 kg ha^{-1} of N) in maize

this is, the response of plants to fertilizer follows the law of diminishing returns, where, smaller in the N level applied (40 kg ha^{-1} of N), each kg of N applied yielded 30.14 kg of grain to common urea and 34.89 kg of maize grain for coated urea with urease inhibitor (Fig. 3). So, the fact of the agronomic efficiency be higher with less N applied only becomes important if, compared with usual care, there is no reduction in grain yield (Barbosa Filho *et al.*, 2008).

Physiological efficiency: The physiological efficiency (Fig. 4) is characterized by organic production (grains) on the maize crop in fertilized plots compared to non-fertilized per unit of N accumulated in plants in these plots, in which it provided the best fit to the model decreasing linear, Y = 70.56-0.133X and R^2 = 0.49 to common urea and Y = 77.21-0.189X and R^2 = 0.80 for the coated urea with urease inhibitor.

CONCLUSION

The recovery efficiencies, utilization, agronomic and physiological in maize decreased with increasing levels of side dressing nitrogen application, regardless of the source being common urea or coated with urease inhibitor.

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