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COATED AND COMMON UREA AS AFFECTING UPLAND RICE PRODUCTION

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Introduction

Nitrogen is one of the most yield limiting nutrients in rice production and it is responsible for increasing straw yield and yield components which are positively related to grain yield (Fageria et al., 2011a). It is also responsible for improving leaf area index (LAI) and photosynthesis in crop plants (Fageria and Baligar, 2005). The recovery efficiency of N is low in crop production around the world. It is reported to be less than 50% in most agroecological conditions by cereals, including rice (Raun and Johnson, 1999). Galloway et al. (2002) reported that even in well-managed cereal crops, about 40 to 60% N is lost. One factor contributing to the low efficiency of N fertilizers is the highly dynamic nature of the soil N cycle. The main paths of N losses or low recovery efficiency of N is related to its loss by soil erosion, volatilization, leaching and denitrification (Fageria and Baligar 2005; Fageria 2009). If urea is applied as topdressing it converted to ammonia, N is lost through volatilization. Frame et al. (2012) reported that N loss through volatilization may be as great as 70% of the applied fertilizer. Frame et al. (2012) also reported that urea hydrolysis raises soil pH adjacent to urea granules, inhibiting nitrification, resulting in excess NH_3 and conditions favoring NH_3 volatilization.

Urea is the most common N source in rice production worldwide (Fageria, 2009). Tisdale et al. (1993) also reported that the most cost effective granular form of N is urea [(CO(NH2)2], which is widely used as a N source because it has a high N concentration (45%) and lower relative manufacturing, handling, storage, and transportation cost. Once applied to the soil, urea is hydrolyzed by the enzyme urease to ammonia-N (NH_3^-), which temporarily creates a high concentration of NH3-, and then converts to ammonium N (NH4+). The conversion from NH_3^- to NH_4^+ can be delayed by dry soil conditions or coarse-textured soils, which increase the potential for volatilization in wet, windy conditions, or phytotoxicity to seeds and plants when seed placed (Tisdale et al., 1993).

Polymer coated urea has been reported to minimize N loss under many cropping systems (Noellsch et al. 2009). Surface applications of PCU also have been found to reduce ammonia volatilization loss by 60% compared to non-coated urea (Rochette et al. 2009). Beres et al. (2012) called polymer coated urea as environmentally smart nitrogen (ESN) source that provides controlled release, allowing highest safe rates of urea fertilizer. Data related to comparison of PCU and common urea in upland rice grown on Brazilian Oxisols are limited. The objectives of this study were to evaluate performance of polymer coated and common urea in upland rice growth, yield and yield components.

Methods

Two greenhouse experiments were conducted at the National Rice and Bean Research Center of EMBRAPA, Brazil to evaluate two sources of nitrogen in upland rice production. The soil used in the experiment was classified as Oxisol (Red Latossol according to Brazilian Soil classification system). Soil chemical and physical properties determined before the application of N treatments were: pH (H_2O) 5.3, Ca 0.2 $cmol_c$ kg^{-1}, Mg 0.2 $cmol_c$ kg^{-1}, Al 0.1 $cmol_c$ kg^{-1}, P 0.3 mg kg^{-1}, K 33 mg kg^{-1}, Cu 1.4 mg kg^{-1}, Zn 0.7 mg kg^{-1}, Fe 3 mg kg^{-1}, Mn 5 mg kg^{-1} and organic matter 13,6 g kg^{-1}.Soil textural analysis was clay 694 g kg^{-1}, silt 94 g kg^{-1} and sand 212 g kg^{-1}. The properties were determined according to methods described in EMBRAPA (1997). The field capacity of the unstructured soil portion (sieved) in free drainage was determined at -0.03 MPa in a Richards extractor device, and the value obtained was 180 g kg^{-1}.

Each pot received 2.5 g lime per kg soil and incubated five weeks before sowing the rice. Two N sources used in the experiment were polymer coated urea (PCU) and common urea (CU). The N rates used were 0, 50, 100, 200, and 400 mg kg^{-1} soil. Nitrogen was broadcast on the soil surface one day after rice sowing. Experimental design was a complete randomized block with four replications. Basic fertilizer levels used were P 200 mg kg^{-1} and K 200 mg kg^{-1}. Phosphorus was added with triple superphosphate and K with potassium chloride. Experiments were conducted in plastic pots with 7 kg of soil. Cultivar used was BRS Sertaneja of upland rice recommended for central part of Brazil. Four plants were maintained in each pot after germination. Soil moisture was monitored daily during the experiment by weighing the pots, and water was replaced when transpiration reached 85% of the soil water holding capacity.

At harvest (105 days after sowing) plant height (the distance between the soil surface and the top end of the highest panicle) was measured and panicle density or number of panicles was counted in each pot. Shoot and grain were harvested separately from each pot. Plant materials (shoot and grain) were dried in a forced-draft oven at about 70 ^{0}C to a constant weight.

Analysis of variance was used to data analysis and quadratic regression model was used to describe yield and yield components responses to N fertilizer for each source of N. These analyses were performed using SAS statistical software.

Results and discussion

Plant height, straw yield, grain yield and panicle density were significantly influenced by the addition of N by both the sources of N (polymer coated urea and common urea) (Table 1). The increase in plant height, straw yield, grain yield and panicle density was quadratic in nature by the application of N by both the sources (Table 2). Fageria et al. (2011b) also reported increases in these characteristics in upland rice with the addition of common urea and ammonium sulfate as N sources, which provided a quadratic fashion when N was applied in the range of 0 to 400 mg kg^{-1}. Similar results with increasing values of plant height, straw yield, grain yield and panicle density with addition of N rates were also achived by Fageria et al. (2010) and Fageria et al. (2011b).

Conclusions

Both the sources of N were equally effective in upland rice production in Brazilian Oxisol.

Keywords: *Oryza sativa*, nitrogen**,** yield components, grain yield

References

Beres, B. L., R. H. McKenzie, R. E. Dowbenko, C. V. Badea, and D. M. Spaner. 2012. Does handling physically alter the coating integrity of ESN urea fertilizers? Agronomy Journal 104:1149-1159.

EMBRAPA (Empresa Brasileira de Pesquisa Agropecuaria). 1997. Manual for methods of soil analysis, 2nd ed. Rio de Janeiro, Brazil: National Service for Soil Survey and Soil Conservation.

Fageria, N. K. 2009. The Use of Nutrients in Crop Plants. Boca Raton, FL: CRC Press.

Fageria, N. K., and V. C. Baligar. 2005. Enhancing nitrogen use efficiency in crop plants. Advances in Agronomy 88:97–185.

Fageria, N. K., V. C. Baligar, and C. A. Jones. 2011a. Growth and mineral nutrition of field crops. 3.ed. Boca Raton, Florida: CRC Press.

Fageria, N. K., O. P. Morais, A. B. Santos. 2010. Nitrogen use efficiency in upland rice genotypes. Journal of Plant Nutrition 33:1696-1711.

Fageria, N. K., A. Moreira, and A. M. Coelho. 2011b Yield and yield components of upland rice as influenced by nitrogen sources. Journal of Plant Nutrition 34:361-370.

Frame, W. H., M. M. Alley, G. B. Whitehurst, B. M. Whitehurst, and R. Campbell. 2012. In vitro evaluation of coatings to control ammonium volatilization from surface applied urea. Agronomy Journal 104:1201-1207.

Galloway, J. N., E. B. Cowling, S. P. Seitzinger, and R. H. Socolow. 2002. Reactive nitrogen: Too much of a good thing? Ambio 31:60-63.

Noellsch, A. J., P. P. Motavalli, K. A. Nelson, and N. R. Kitchen. 2009. Corn response to conventional and slow-release nitrogen fertilizers across a claypan landscape. Agronomy Journal 101:607-614.

Raun, W., and G. V. Johnson. 1999. Improving nitrogen use efficiency in cereal production. Agronomy Journal 91:357-363.

Rochette, P. J. D. MacDonald, D. A. Angers, M. H. Chantigny, M. Gasser, and N. Betrand. 2009. Banding of urea increased ammonia volatilization in a dry acidic soil. Journal of Environmental Quality 38:1383-1390.

Tisdale, S. L. W. L. Nelson, J. D. Beaton, and J. L. Havlin. 1993. Soil fertility and fertilizers. 5.ed. New York: Macmillan Publishing Company.

Table 1. Plant height, straw yield, panicle density and grain yield of upland rice as influenced by polymer coated urea (PCU) and common urea (CU)

N rate	Plant height		Straw yield		Panicle density		Grain yield	
	PCU	CU	PCU	CU	PCU	CU	PCU	CU
mg kg^{-1}	*------ cm ------*		*------ g plant^{-1} ------*		*------ nº plant^{-1} ------*		*------ g plant^{-1} ------*	
0	108.5	104.0	3.08	3.38	1.00	1.00	2.18	2.06
50	121.5	128.2	4.84	5.36	1.56	1.25	4.05	3.61
100	123.0	131.7	5.41	5.31	1.87	1.93	4.52	4.47
200	123.5	137.7	6.76	7.29	1.75	2.18	4.46	4.24
400	124.5	124.0	6.53	5.90	1.56	2.00	2.28	3.79
F-test	*	**	**	**	*	**	**	**
CV (%)	7.27	5.51	6.67	6.54	22.23	13.07	15.49	17.37

*, ** Significant at the 0.05 and 0.01 probability levels, respectively

Table 2. Relationship between N rate of two sources, polymer coated (PCU) and common urea (CU), and plant height (PH), straw yield (SY), panicle density (PD) and grain yield (GY) of upland rice. NRMV = N rate (mg kg^{-1}) for maximum value

Variable	Regression equation	R^2	NRMV
PCU vs PH	$Y = 111.91 + 0.12X – 0.00022X^2$	0.22*	273
CU vs PH	$Y = 108.65 + 0.29X – 0.00063X^2$	0.69**	230
PCU vs SY	$Y = 3.25 + 0.03X – 0.000048X^2$	0.94**	313
CU vs SY	$Y = 3.51 + 0.03X – 0.000059X^2$	0.86**	254
PCU vs PD	$Y = 1.14 + 0.007X – 0.000015X^2$	0.38**	233
CU vs PD	$Y = 0.95 + 0.01X – 0.000018X^2$	0.81**	278
PCU vs GY	$Y = 2.57 +.02X – 0.000061X^2$	0.76**	167
CU vs GY	$Y = 2.45 + 0.02X – 0.000042X^2$	0.56**	238

*, ** Significant at the 0.05 and 0.01 probability levels, respectively