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Leaching of N and Initial Development of Maize as a Function of Urea and Urea Doses Coated with Sulfur

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Abstract

Urea is the most important source among nitrogen fertilizers, but leaching losses are highly susceptible. The fertilizer industry has the challenge of improving the chemical characteristics of fertilizers, ensuring the best efficiency in the application and utilization of nutrients. An alternative is sulfur treatment to reduce this problem. The present work had as objective to evaluate the soil nitrogen loss by leaching, treated with urea doses with and without sulfur coating (FH Nitro Gold®). For this, leaching experiments were set up in the laboratory and initial corn cultivation in a greenhouse. The soil used was classified as Red Yellow Argisol, collected at the UFS Rural Campus. Two treatments were applied, which consisted of the application of the two sources of Nitrogen, with doses of 0, 50, 100, 150, 200 and 250 kg per hectare, where nitrogen losses were evaluated by leaching (ammonium, nitrate and total N). A second leaching experiment was set up at the following rates: 0, 25, 50, 75, 100 and 125 kg per hectare, and after leaching the corn was cultivated for 30 days under greenhouse conditions. After 30 days of cultivation, the biometric parameters were assessed (leaf number, stem diameter and height of plants). The source of nitrogen fertilizer coated with sulfur provided reduction of nitrogen loss by leaching when compared to uncoated urea. The application of coated urea presents higher soil nitrogen absorption and better results in the development of maize plants grown under greenhouse conditions.

Keywords: Urease inhibitors, Mineral fertilizer, Additives Key

Introduction

The fertilizer industry has the challenge of improving the chemical characteristics of fertilizers, ensuring the best efficiency in the application and utilization of nutrients. Technological advances in a posterity should be associated with the reduced environmental impact and the best cost / benefit ratio for farmers. Nitrogen (N) is a nutrient of management and recommendation of the most complex, due to the multiplicity of chemical and biological reactions to which it is subject and its great dependence on edaphoclimatic conditions for absorption by plants. However, the factor that makes it difficult to recommend fertilization efficiently is its soil dynamics, which involves reactions such as: immobilization / mineralization; nitrification / denitrification; leaching / volatilization; adsorption / sorption [1]. These results are based on the interaction between microorganisms and soil colloids and are mediated by climatic factors that are difficult to predict. In order to decrease the rate of urea hydrolysis and / or temporary inhibition of urease activity, some chemical compounds have been mixed with urea for this purpose, delaying the transformation of amide N to ammonium and, consequently, nitrification. Sulfur, as a macronutrient, is indispensable in the growth and development of plants, mainly because it participates in the protein constitution. It is a vital part of all plant proteins and some plant hormones; the amino acids cystine, cysteine and methionine have sulfur [2]. According to [3], through microorganisms the sulfur found in the soil mostly in the organic form, is converted into products available to the plant. Industry's main strategy to increase fertilizer efficiency is the advent of new technologies called enhanced efficiency fertilizers or "smart" fertilizers, which are characterized by granules coated with organic substances (resins, rubber) or inorganic (synthetic polymers, sulfur or minerals). According to Trenkel slow or controlled release fertilizers are those that present technologies for nutrients are slower than conventional sources. Increased efficiency comes with the assertion of increasing nutrient use efficiency by reducing losses by leaching, volatilization, fixation and emission of nitrous oxide (depending on the source N, P or K), or by increasing the absorption by the plants by means of of the gradual supply, according to the demand of the plant [4]. According to [5], corn is considered one of the world's major crops. This plant is cultivated in all continents, mainly because it is a species of great importance in animal and human feeding, besides the use as raw material of numerous products for the industry. The importance of maize crop in the Brazilian and world agricultural scenario is justified by the great potential of productivity and the good adaptability of the crop, besides its consumption in the agribusiness chain [6]. In Sergipe, according to IBGE data (2017), 170,182 thousand hectares of maize were cultivated. The state is the fourth largest producer in the Northeast in planted area, responsible for 12.34% of production with 4,662 kg per hectare.

Material and Methods

The experiments were conducted at the Soil Remediation Laboratory of the Department of Agronomic Engineering - DEA (leaching experiment), and in a greenhouse of the Department of Agronomic Engineering, Federal University of Sergipe, São Cristóvão-SE. The soil used in the experiment was classified as Red Yellow Argissolo, and was collected at the UFS Rural Campus. In order to set up the leaching experiment, the soil was dewormed and sieved in a 2 mm mesh and later packed in plastic bags, where the nitrogen doses equivalent to 0, 50, 100, 150, 200 and 250 kg per hectare of nitrogen were applied, with two sources of nitrogen (uncoated urea and sulfur urea). The N dose was determined based on the soil weight, equivalent to the 0-20 cm layer, based on soil density. The experimental design was randomized blocks with factorial scheme 2 x 6, being two sources of nitrogen and six doses, and 4 replications, totalizing 48 experimental units. Nitrogen was applied to the soil and homogenized, and transferred to PVC columns, the soil was incubated with distilled water for 100% of vessel capacity for 48 hours. The soil was conditioned, identified according to each treatment. For leaching, a water slide equivalent to 50mm rain was applied. Immediately at the end of the leaching, the determination of N-NH4 + and N-N03-, using the Kjeldahl distillation method, with subsequent quantification by titration with sulfuric acid [7]. In order to avoid problems with the saline effect on seed germination in a new soil, the nitrogen dosage was: 0, 25, 50, 75, 100 and 125 kg per hectare. At 8 days after emergence of the seedlings, thinning was performed. Soil moisture was maintained close to 80% of CRA. After 30 days of cultivation the plants were evaluated the biometric parameters (leaf number, stem diameter and height of plants). Subsequently, the area was collected, determined the dry matter and the determination of the nitrogen content in the plant. From the nitrogen content of the aerial part and the dry matter, nitrogen phytoextraction by corn plants was determined. The data were submitted to analysis of variance and Tukey's test was applied at 5% of probability [8].

Results and Discussion

The use of sulfur-coated urea was efficient in reducing soil nitrogen leaching loss (Table 1,2). The loss of ammonium was higher than that of nitrate. The higher leaching of ammonium in relation to nitrate may be related to the saturation of the soil in the columns (for 48 hours), because in soils reduced there may be a predominance of NH4 + in relation to NO3-. Higher ammonium loss than nitrate was observed in leachate. Similar results of nitrogen loss were observed by [9], using urea and sulfur-coated urea, with sulfur-reversed urea presenting lower nitrogen loss by leaching, and higher doses representing the highest loss values of nitrogen by leaching, corroborating with the results observed in the present study. The low ammonium retention in the soil exchange complex may be related to low soil CTC. However, it was observed that the increase of soil CEC reduces the loss of NH4 + by lightening but could increase the loss by volatilization. Boeira [10], observed that at the beginning of a nitrate and ammonium leaching experiment in a soil, the availability of nitrate increased significantly only after 15 days of incubation, whereas ammonium was high since the beginning of the experiment, and remained constant over time. In the present study the incubation time was only 2 days, which may justify the low nitrate values of the leachate. With the leaching study, it was observed that the lower loss by leaching of N can increase the efficiency of the nitrogen fertilization for the diverse agricultural crops. The biometric data were not influenced by the urea coating with elemental sulfur, except for the number of leaves, where the plants fertilized with sulfur coated had a larger number of leaves. These results indicate that the coating does not interfere with plant growth, but reduces the loss of nitrogen by leaching, which is an environmental advantage due to the lower risk of eutrophication of surface and subsurface waters [10,11]. The concentration of nitrogen in the aerial part was positively influenced by the application of urea coated with sulfur. This indicates that the use of sulfur reduces the loss of nitrogen by leaching and significantly influences the increase of soil nitrogen uptake (Table 3) by maize plants. There was no difference in the dry matter yield of the aerial part of the plants, when supplied with the same dose of N, regardless of the source. N and S are present in all vital functions, including hormonal control, which are part of plant growth and production. The increase in N content in the plant tissue is dependent on the supply of S, and the increase in maize productivity is closely linked to the correct supply of N and S to the formation of essential amino acids and plant proteins (STIPP). It was possible to observe that the plants supplied with urea at the end of the experiment showed typical symptoms of nitrogen deficiency. While the plants supplied with sulfur coated urea were green at all applied doses. Confirming the results obtained in (Table 3).

Table 1: Concentration of ammonium, nitrate and total nitrogen, obtained from the leachate of a red yellow Argisol from the coastal boards of Sergipe, fertilized with urea and urea doses coated with sulfur.

Nitrogênio Aplicado (Kg/ha)	Ureia Sem Enxofre				Ureia Com Enxofre	
	Amônio	Nitrato	N total	Amônio	Nitrato	N total
	--(mg/L)---------------------------					
0	9:00 AM	26 BC	35 CD	13 AB	31 CD	45 D
50	211 BC	37 A	249 C	83 A	40 A	123 AB
100	265 C	46 AB	311 C	115 AB	34 A	149 B
150	287 A	44 A	332 B	131 A	51 A	182 A
200	605 B	57 A	662 B	155 A	52 A	207 A
250	1064 B	48 A	1112 B	183 A	62 A	246 A
CV (%)	40,47	19,31	36,26	17,09	19,50	14,99

Equal capital letters in the rows and for the same analyzed variable do not differ among themselves by the Tukey test at 5% probability.

Table 2: stem diameter, plant height and number of leaves of maize plants grown in a red yellow Argissolo of the coastal boards of Sergipe, fertilized with doses of urea and urea coated with sulfur. Stem Diameter (DC), Plant Height (AP), Number of Leaves (NF).

Nitrogênio Aplicado (Kg/ha)	Ureia Sem Enxofre			Ureia Com Enxofre		
	DC	AP	NF	DC	AP	NF
	(mm)	(cm)	(Unidade)	(mm)	(cm)	(Unidade)
0	0,74 C	16,13 C	4,00 EF	0,81 BC	17,38 BC	3,75 F
25	1,02 AB	22,00AB	3,75 F	1,07 A	24,88 A	5,00 CDE
50	1,10 A	23,00 AB	3,75 F	1,20 A	23,63 A	5,25 CD
75	1,14 A	25,00 A	4,25 DEF	1,20 A	24,75 A	6,00 BC
100	1,21 A	23,63 A	4,00 EF	1,14 A	23,00 AB	7,00 AB
125	1,12 A	20,13 ABC	4,00 EF	1,17 A	22,33 AB	7,67 A
CV (%)	9,37	10,52	9,93	9,37	10,52	9,93

Equal capital letters in the rows and for the same analyzed variable do not differ among themselves by the Tukey test at 5% probability.

Table 3: Dry matter production, nitrogen concentration and nitrogen extraction by corn plants grown in soil fertilized with two nitrogen fertilizer sources and nitrogen rates in soil after leaching in PVC columns.

Nitrogênio Aplicado (Kg/h)	Ureia Sem Enxofre			Ureia Com Enxofre		
	MS	CN	EM	MS	CN	EM
	(g/vaso)	(g/kg)	(mg/vaso)	(g/vaso)	(g/kg)	(mg/vaso)
0	1,57 B	6,64 F	10,33 G	2,03 B	7,31 EF	15,18 FG
25	4,08 A	8,64 EF	34,78 EFG	5,20 A	23,37 C	120,67 C
50	4,29 A	9,61 DEF	41,35 DEF	4,96 A	29,90 B	148,38 BC
75	4,64 A	10,31 DEF	48,42 DE	5,02 A	33,15 AB	166,07 AB
100	5,39 A	12,69 DE	68,89 D	4,53 A	36,79 A	164,87 AB
125	4,59 A	15,39 D	69,17 D	5,00 A	35,96 A	179,63 A
CV (%)	13,04	12,39	13,94	13,04	12,39	13,94

Equal capital letters in the lines and for the same analyzed variable do not differ among themselves by the Tukey test at 5% probability.

Dry Matter (DM), Nitrogen Concentration (CN), Nitrogen Extraction (MS)

Conclusion

The use of sulfur-coated urea gave reduction of nitrogen loss by leaching when compared to urea. The application of sulfur - coated urea shows better results in the initial development of maize plants grown under greenhouse conditions. The use of sulfur - coated fertilizer, besides presenting greater agronomic advantages in maize cultivation, represents a lower environmental risk of eutrophication of the aquatic environment.

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