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Short Communication

Ammonia volatilization from surface application of organic residues and urea on Marandu palisadegrass

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ABSTRACT - The objective of this study was to measure ammonia volatilization from surface application of pig slurry, poultry litter, urea and no fertilization. An experiment was conducted in a randomized block design, in plots repeated over time, with four treatments and four replications. The fertilizers tested were: mineral fertilizer (70 kg ha^{-1} N, 100 kg ha^{-1} P_2O_5 and 30 kg ha^{-1} of K_2O, as urea, triple superphosphate and potassium chloride, respectively), pig slurry (200 m^3 ha^{-1} applied in November 2008 and 200 m^3 ha^{-1} applied in April 2009) and poultry litter (10 t ha^{-1} applied in November 2008 and 10 t ha^{-1} applied in April 2009). Five evaluations were performed with 24-hour intervals. Foams were used with glycerin and sulfuric acid, internally fixed in PET bottles for collecting ammonia. After collected, the samples were sent to the laboratory to determine volatilized ammonia levels by the semi-micro Kjedahl distillation method. Fertilization with chicken litter had lower ammonia volatilization in relation to urea and pig slurry. Most of the ammonia volatilization from pig slurry occurred within 48 hours after application, totaling losses of 630 g kg^{-1} of a total of 8.25 kg ha^{-1} of volatilized ammonia. The biggest loss by ammonia volatilization was from fertilization with urea, totaling approximately 80 g kg^{-1} of N applied.

Key Words: *Brachiaria brizantha,* losses, nitrogen, pig slurry, poultry litter

Introduction

In southwest Goiás, Brazil, 300,000 birds and 4,000 pigs are slaughtered daily. For the production of these animals, from 12,000 to 13,000 m^3 of pig slurry are generated per lot of 3700 animals per year (Pohlmann et al., 2008). According to data from BRFoods (2010)[1], for the supply of birds in Rio Verde-GO, Brazil, about 158 000 t of poultry litter are generated annually.

In a study conducted in the region of Rio Verde, concentrations of nitrogen in pig slurry ranged from 0.18 to 3.85 kg m^{-3} according to density. On average, there is 1.00 kg m^{-3} of N in pig slurry from piglet production system and 1.37 kg m^{-3} of N in the vertical finishing system (Menezes et al., 2007). Poultry litter presents between 26.00 and 28.20 g kg^{-1} of N, 20.60 and 25.30 g kg^{-1} of P, 10.00 and 12.00 g kg^{-1} of K, 25.00 and 36.60 g kg^{-1} of Ca and 5.00 and 7.00 g kg^{-1} of Mg (Blum et al., 2003; Castro et al., 2005).

For the physical recovery of an Oxisol under degraded pasture of *Brachiaria decumbens*, it was found that application of poultry litter caused a reduction in the values of soil density and increased total porosity (Costa et al., 2009) and also increased dry matter productivity and crude protein, P, K and Zn in the shoot (Lana et al., 2010).

Despite the positive results with the use of chicken litter, the nitrogen present in this residue can be lost by ammonia volatilization. In poultry litter from rice husk evaluated in masonry experimental pens, ammonia volatilization was 57.40 and 83.82 mg kg^{-1} in new and reused beds, respectively. The gypsum added in the proportion of 40% of the weight of the bed can reduce the volatilization by up to 87% (Oliveira et al., 2003).

The use of pig slurry (PS) increased the amount of mineral N in the soil and dry matter production of cover crops and Marandu palisadegrass. It also improves the chemical-bromatological composition of the grass and can replace the generally recommended chemical fertilization (Aita et al., 2006; Barnabé et al., 2007; Medeiros et al., 2007).

The accumulated losses of ammonia up to 144 hours after application of PS can reach 390 g kg^{-1}, according to the dose and time of application of slurry, air and soil temperature and pH (Basso et al., 2004). The first 20 hours

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after PS application accounted for approximately half of the losses by ammonia volatilization (Port et al., 2003).

The objective of this study was to measure ammonia volatilization from surface application of pig slurry, poultry litter and urea.

Material and Methods

The experiment was conducted in the fall of 2009, at Centro Tecnológico Comigo (CTC), located in Rio Verde-GO, Brazil, at the following coordinates: 17º47'24" south latitude, 50°56'31" west longitude and altitude of 836 m; Cwa climate, according to Köppen. During the experiment, maximum and minimum temperatures, air humidity and rainfall were monitored daily.

The soil was classified as a clayey (525 g kg^{-1} of clay) Oxisol (Embrapa, 2006), of flat terrain with a slope of 1%, cultivated with Braquiarão (*Brachiaria brizantha* cv. Marandu) since 2005. The soil chemical characteristics were: Ca: 2.87, Mg: 0.94, K: 0.14, Al: 0.04, H + Al: 2.88; sum of bases: 3.95; cation exchange capacity: 6.83, $cmol_c$ dm^{-3}, P: 5.22 mg dm^{-3}; organic matter: 29.40 g kg^{-1}; and pH ($CaCl_2$): 5.28.

The treatments were composed of a control without fertilization; mineral fertilizer (70 kg ha^{-1} of N, 100 kg ha^{-1} of P_2O_5 and 30 kg ha^{-1} of K_2O as urea, triple superphosphate and potassium chloride, respectively); pig slurry (200 m^3 ha^{-1} applied in November 2008 and 200 m^3 ha^{-1} applied in April 2009); and chicken litter (10 t ha^{-1} applied in November 2008 and 10 t ha^{-1} applied in April 2009).

The experimental design was in a randomized block, in plots repeated over time with four replications. In the plots, the fertilizations were allocated, in which subsequently data were collected from three collection chambers of volatilized ammonia per plot, on different days of collection, for the quantification of ammonia losses. Each experimental unit consisted of an area of 5 meters in length by 6.3 meters in width, totaling 37.8 m^2.

The pig slurry used was from the Vertical Finishing System, obtained with farm owners in the integration system with the pig meat industry. The residues were stored in a decantation pond lined with waterproof blanket, for a period of 120 days for fermentation. Poultry litter used came from broiler-producing farms of the region.

The physicochemical characteristics of the residues before soil application were: N = 0.09 dag L^{-1}, P = 0.06 dag L^{-1}; K = 0.053 dag L^{-1}, pH 7.8 and density of 1,007.5 kg m^{-3} for pig slurry and N = 1.49 dag kg^{-1}, P = 0.98 dag kg^{-1}, K = 1.28 dag kg^{-1}, Ca = 1.36 dag kg^{-1} and Mg = 0.4 dag kg^{-1} for poultry litter on a dry basis.

The fertilizers were broadcast-applied on coverage on the plots on April 29, 2009. The pig slurry was applied by spraying. Immediately after the application of fertilizers on the soil, the collection chambers were settled, using a system of a semi-open static camera of transparent plastic, PET type of 2 liters, without the base, with an area of 0.008 m^2. In its interior, a 2.5 cm wide 25 cm long polyethylene foam tape soaked in a solution of H_2SO_4 0.55 mol L^{-1} + 2% glycerin (v/v) was used, according to the methodology described by Araújo et al. (2006). The tapes collecting volatilized ammonia were replaced in subsequent periods at 24, 48, 72, 96 and 120 hours after application.

The samples were sent to the laboratory to determine volatilized ammonia levels by the semi-micro Kjeldahl distillation method (Silva, 2009).

Data were subjected to analysis of variance and means were subsequently subjected to regression analysis using the statistical program Sisvar (Ferreira, 2000).

Results and Discussion

Significant difference was observed between fertilizations, time after application and interaction between these factors.

Surface application of pig slurry (PS) on soil, under Marandu palisadegrass, was the treatment that caused highest volatilization of ammonia up to 120 hours after application, followed by treatment with urea. The plots that received poultry litter and the control had lower ammonia volatilization, and the control was lower compared with all other treatments (Table 1).

In the first 48 hours after application of fertilizer, it was found that treatment with PS showed higher ammonia volatilization (28.70 g kg^{-1} of N applied) compared with the other treatments, which did not differ. These losses represented 630 g kg^{-1} of N volatilized during evaluations, which was 8.25 kg ha^{-1} of ammonia, totaling volatilization losses of 45.80 g kg^{-1} of total N applied within 48 hours.

Table 1 - Levels of ammonia volatilized as a function of time after application of fertilizers on Marandu palisadegrass

Treatment	Time after application (hours)					
	24	48	72	96	120	Mean
	kg ha^{-1} of ammonia					
Control	0.40b	0.23b	0.22b	0.34c	0.17b	0.27d
Urea	0.52b	0.73b	1.36a	2.07a	1.09a	1.15b
Pig slurry	2.73a	2.43a	1.24a	1.06b	0.79a	1.65a
Poultry litter	0.99b	0.82b	0.64b	0.77bc	0.55ab	0.75c
Mean	1.16	1.05	0.87	1.06	0.65	-

Means followed by the same letter in the column do not differ by Tukey's test (P<0.05%).

Similar results were obtained by Port et al. (2003), who found average losses of 65.00 g kg^{-1} of ammoniacal N applied at rates of 40 and 80 m^3 ha^{-1} on residues of black oat. Basso et al. (2004) also reported losses of up to 71.00 g kg^{-1} of ammonia volatilized within 48 hours after application of pig slurry at doses up to 80 m^3 ha^{-1} over a period of 144 hours of evaluations.

Evaluating losses by volatilization in relation to the amount of N applied, it was observed that fertilization with poultry litter had lower volatilization. Losses related to application of urea were more expressive: For every 12 kg of N applied approximately 1 kg are lost by ammonia volatilization, while for organic residue, the N dose should be increased by approximately 2 to 3 times to get the same volatilization (Table 2).

In both control and the treatment with poultry litter there was no influence of time on ammonia volatilization after application. However, on the average of the days, the treatment with poultry litter had higher volatilization compared with control; however, it showed less loss of N compared with application of PS and urea.

Ammonia volatilizations of 5.77, 8.25 and 3.77 kg ha^{-1} were observed for the urea, PS and poultry litter treatments, respectively. These values correspond to losses of 82.40, 45.80 and 25.30 g kg^{-1} of total N applied in treatments, respectively. These losses can be considered low as compared with the results obtained by Basso et al. (2004), where accumulated losses of 150 to 390 g kg^{-1} of ammonia volatilized at 144 hours after surface application of PS were found. The volatilization of only 80 g kg^{-1} of ammonia in the urea treatment is also low as compared with results obtained by Martha Júnior et al. (2009) and Mattos Junior et al. (2002), where ammonia volatilizations of 720 g kg^{-1} and 440 g kg^{-1} were observed in relation to the total N applied as urea, respectively. In the present experiment, it was expected that ammonia volatilization would be higher as compared with the results obtained, due to the high temperatures and air humidity (Table 3), since climate factors directly influence ammonia volatilization (Martha Júnior, 2003). Mattos Junior et al. (2002) found higher values of ammonia volatilization after urea application in the plots where there was ventilation simulation in relation to no ventilation. Although the present experiment had been performed in a flat area, where there was good air circulation, there was no precipitation during the collection days, which probably delayed urea hydrolysis and consequently the ammonia volatilization. The canopy of the plants may also have diminished the effect of the wind, reducing the volatilization of ammonia with urea application.

Table 2 - Nitrogen loss by ammonia volatilization accumulated as a function of urea and organic residue application on Marandu palisadegrass

Treatments	N applied (kg ha^{-1})	N volatilized (kg ha^{-1})	N applied × N volatilized	N volatilized (g kg^{-1})
Control	0	1.36	-	-
Urea	70	5.77	12.13	82.40
Pig slurry	180	8.25	21.82	45.80
Poultry litter	149	3.77	39.52	25.30

With the application of urea, ammonia volatilizations were increased until the peak volatilization that occurred at 96 hours after application of fertilizer, and subsequently decreased, with a tendency to stabilize on the following days. This tendency of ammonia volatilization differed from the one of pig slurry (Figure 1). Similar results were obtained by Guimarães et al. (2010), who studied methods for coating urea. It was observed that the application of urea with urease inhibitor reduced ammonia losses by 60%. The urea granules used in this work contained high concentrations of N, but required humidity and time to react and volatilize, which did not occur due to lack of precipitation during the experiment.

There was a tendency of ammonia volatilization peak 24 hours after application of pig slurry, with subsequent decrease in volatilization until its stabilization (Figure 1). After the volatilization peak, there was a decrease of 15.00 g kg^{-1} in ammonia volatilization every hour after application of PS.

Table 3 - Maximum, minimum and average temperatures and air humidity during the five days of collection for determination of ammonia loss

Time after aplication (hours)	Temperature (°C)			Humidity (%)		
	Maximum	Minimum	Average	Maximum	Minimum	Average
0	28.70	20.80	22.62	69.00	46.00	62.75
24	28.20	20.80	22.74	79.00	48.00	67.25
48	28.40	21.80	23.12	72.00	45.00	65.00
72	28.40	20.60	22.42	73.00	37.00	62.00
96	28.20	20.00	22.00	74.00	44.00	64.00
120	27.70	21.20	22.56	74.00	49.00	67.25
Mean	28.27	20.87	22.57	73.51	44.83	64.70

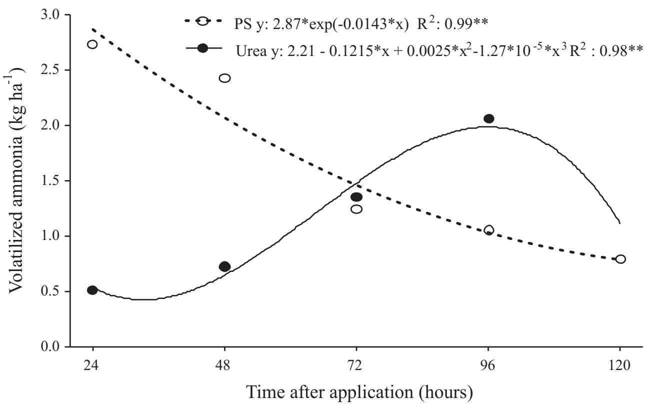

Figure 1 - Ammonia volatilization rate as a function of time after application of pig slurry (PS) and urea on Marandu palisadegrass.

Conclusions

The use of poultry litter in Marandu palisadegrass provided less ammonia volatilization in relation to urea and pig slurry. Most of the ammonia volatilization from pig slurry occurred within 48 hours after application, but the biggest loss by volatilization occurred with urea application.

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