Scientific Notes

Injection of liquid swine slurry and effects on properties of a Nitossolo Vermelho

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Abstract – The objective of this work was to evaluate the superficial and injected applications of swine slurry and urea to the soil, regarding their effects on the physical properties of a Nitossolo Vermelho distroférrico under a no-tillage system. The treatments were: injected slurry into the groove with a liquid swine slurry injector (LSSI); slurry on surface, applied on the lines by the LSSI kept raised; urea injected by opening the groove with the LSSI and distributed manually; and corn, under no-tillage, as a control. Sowing and the injection of liquid slurry or urea do not modify the organic carbon content, pH, and aggregation, but alter the soil bulk density and porosity in the mobilized line, and increase the macropores.

Index terms: porosity, soil structure, urea.

Injeção de dejeto líquido de suínos e efeitos sobre as propriedades de um Nitossolo Vermelho

Resumo – O objetivo deste trabalho foi avaliar as aplicações superficial e injetada de dejeto líquido de suínos e ureia ao solo, quanto aos seus efeitos sobre as propriedades físicas de um Nitossolo Vermelho distroférrico, em um sistema de semeadura direta. Os tratamentos foram: dejeto injetado no sulco, com injetor de dejeto líquido de suínos (IDLS); dejeto em superfície, aplicado às linhas com o IDLS erguido; ureia injetada, por meio de abertura do sulco com o IDLS, e distribuída manualmente; e milho, em semeadura direta, como controle. A semeadura e a injeção de dejeto líquido ou de ureia não modificam o teor de carbono orgânico, o pH e a agregação, mas alteram a densidade e a porosidade do solo na linha mobilizada, e aumentam os macroporos.

Termos para indexação: porosidade, estrutura do solo, ureia.

Swine breeding occurs close to slaughterhouses, and the generated waste is distributed near the production system, with environmental consequences, such as the addition of heavy metals, phosphorus, nitrogen, and microorganisms that are potentially pathogenic to soil and water. These problems can be minimized when waste is incorporated into the soil, with less N loss by volatilization (Tao et al., 2008). To this end, an equipment, with cutting discs and furrows similar to those used in no-tillage, has been tested to inject liquid swine slurry into the soil, whose purpose is to incorporate the waste with soil mobilization only in the line of injection. Therefore, it can be used in no-tillage to keep the soil covered, and to reduce nutrient losses. The application of liquid swine slurry increases organic carbon stocks (Gong et al., 2009), and improves soil structure (Rauber et al., 2012).

The objective of this work was to evaluate the superficial and injected applications of swine slurry and urea to the soil for their effects on the physical properties of a Nitossolo Vermelho distroférrico under a no-tillage system.

The experiment was carried out in the experimental area of Embrapa Suínos e Aves, in the municipality of Concórdia, in the state of Santa Catarina, Brazil, characterized by a Nitossolo Vermelho distroférrico of a very clayey texture (660 g kg^{-1} clay and 66 g kg^{-1} sand), with a smooth undulating relief. The climate is Cfa, according to the classification of Köppen-Geiger, with mean annual rainfall of 1,853 mm.

The experimental area remained for seven years in fallow, with ryegrass (*Lolium multiflorum* Lam.) and Bermuda grass (*Cynodon dactylon* L.). In 2010, 2 Mg ha^{-1} dolomitic limestone, with 85% of effective neutralizing power (ENP), was applied on soil surface, then common black oat (*Avena strigosa* Schreb.) was planted in the winter and corn (*Zea mays* L.) in the summer, under no-tillage, for two years.

The experimental design was a randomized complete block with split plots, and four replicates. The following treatments were established on 10/15/2012: injected slurry (IS); injected liquid swine slurry (ILSS), for which the liquid swine slurry injector (LSSI) equipment was used to open the groove and distribute 50 m^3 ha^{-1} slurry; liquid slurry on surface (LSS), applied on the lines with the LSSI, kept raised to avoid soil mobilization; injected urea (IU), by opening the grooves with the LSSI and distributing the urea manually; and corn cultivated under no-tillage, as a control. The slurry and urea were distributed on the line mobilized by the LSSI to 0.12 m soil depth, with 0.35 m distance between lines. The ILSS dose was 50 m^3 ha^{-1}, and the dose of common urea was 50 kg ha^{-1}. The slurry was characterized by pH 7.3; dry matter concentration of 50 g dm^{-3}; and N, P, K, Cu, and Zn contents, respectively at 5, 1.1, 2.8, 0.04, 0.18 kg m^{-3}. The dose of organic fertilizer was recommended according to the N, P, and K requirements, and there was complementation with mineral fertilizer, with expected yield of 10 Mg ha^{-1} (Manual…, 2004).

On 10/16/2012, corn was sown throughout the experimental area, considering the same direction of the LSSI lines, with 0.80 m spacing between them. The control treatment was carried out in the plots without N fertilization and without slurry as basic fertilization, that is, without the use of LSSI.

After 28 days, soil samples with preserved and altered structure were collected in the layers 0.0–0.1, 0.1–0.2, and 0.2–0.3 m, in the line (L) of the injector (treatments IS, IU, and LSS) and of the sower (control), and in-between the lines (I) (0.18 m away from the line). The L and I were considered as subplots. The soil porosity and bulk density were determined according to Gubiani et al. (2009). The stability of aggregates was determined by wet sieve, and expressed by the weighted mean diameter (WMD) (Kemper & Chepil, 1965). The total organic carbon content (TOC) and pH were determined according to Donagema et al. (2011).

For each layer, the analysis of variance was performed. For the variables with significant effect ($F \leq 0.05$), the means were compared by the Tukey's test, at 5% of probability.

Significant differences were observed for total porosity (TP), macroporosity (macro), microporosity (micro), and bulk density (BD) (Tables 1 and 2). For TP, macro, and BD, changes occurred up to 0.1 m soil depth and, for micro, up to 0.2 m soil depth. There was a significant interaction between treatment and collection position for macro and micro. There was a reduction of BD and increase of TP in the line, due to the revolving promoted by the plow, confirming Silva et al. (2005), who compared these properties in the sowing line and in-between the lines. This

Table 1. Total porosity and bulk density of a Nitossolo Vermelho distroférrico, after treatments with liquid swine slurry and urea, in and in-between the lines[1].

Position	Treatment[2]				Mean
	IS	LSS	IU	Control	
			Total porosity (m^3 m^{-3})		
			0.0–0.1 m layer		
Lines	0.66	0.62	0.66	0.67	0.65a
In-between	0.64	0.63	0.62	0.65	0.64b
Mean	0.65	0.63	0.64	0.66	
			0.1–0.2 m layer		
Lines	0.58	0.60	0.58	0.6	0.59
In-between	0.58	0.60	0.6	0.59	0.59
Mean	0.58	0.60	0.59	0.60	
			0.2–0.3 m layer		
Lines	0.63	0.63	0.64	0.63	0.64
In-between	0.64	0.64	0.65	0.63	0.63
Mean	0.64	0.64	0.64	0.63	
			Bulk density (g cm^{-3})		
			0.0–0.1 m layer		
Lines	0.93	1.05	0.96	0.87	0.95b
In-between	1.01	1.04	1.05	0.95	1.01a
Mean	0.97ab	1.04a	1.00a	0.91b	
			0.1–0.2 m layer		
Lines	1.17	1.13	1.13	1.1	1.13
In-between	1.13	1.12	1.15	1.12	1.13
Mean	1.15	1.13	1.14	1.11	
			0.2–0.3 m layer		
Lines	1.12	1.16	1.15	1.18	1.15
In-between	1.11	1.13	1.15	1.15	1.14
Mean	1.11	1.15	1.15	1.17	

(1)Means followed by equal letters do not differ, by the Tukey's test, at 5% probability. (2)IS, injected swine slurry application; IU, injected urea; LSS, liquid slurry on surface; control, direct corn sowing.

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effect is important in areas of consolidated no-tillage, where compaction occurs by anthropic action, or by the densification of its structure, which may reduce the development of the crop root system (Veiga et al., 2008). The application of slurry or urea did not alter these properties, similarly to the results of another experiment, of long duration, with application of ILSS (Rauber et al., 2012).

The treatments with urea injection, slurry, and corn sowing (in the line or in-between the lines) did not significantly alter the macroporosity. The main difference was observed for macroporosity increase in the control treatment in comparison to LSS. This effect was observed in relation to the corn sowing line revolving and the soil mobilization by the groove opener, which did not occur in the LSS treatment.

In the control treatment, microporosity was smaller in the line than in-between lines, and smaller in the lines than in the other treatments due to the revolving caused by the groove opening system of the seeder (seed drill), which momentarily altered soil porosity (Veiga et al., 2008). For 0.1 to 0.2 m soil depths, in-between lines for the IU and control systems, the differences were due to the spatial variation of the soil.

The treatments did not significantly alter TOC, WMD, and pH (Table 2). The dose of ILSS was shown to be low and insufficient to significantly alter the TOC; other factors that could alter it would be the soil mobilization and biological activity. These variables, analyzed at 28 days after implantation of the treatments, did not differ, confirming what had been observed by Cassol et al. (2011). The Nitossolo Vermelho has a cohesive consistency and a stable structure, and changes in properties such as stability of aggregates occur more slowly, therefore, WMD was not altered (Table 2). The stability of aggregates is also associated with the TOC (Silva et al., 2005) and soil pH, and these attributes were not altered by the application of slurry and by soil revolving in the lines of LSSI and the seeder.

Sowing, injecting liquid slurry, or injecting urea do not modify the organic carbon content, pH, and aggregation, but they alter the bulk density and porosity of the soil in the mobilized line, causing the increase of macropores.

Table 2. Soil pore size distribution, total organic carbon (TOC), pH, and weighted mean diameter (WMD) of a Nitossolo Vermelho distroférrico after treatment with liquid swine slurry and urea, in the lines and in-between the lines[(1)].

Position	IS		LSS		IU		Control	
	Lines	In-between	Lines	In-between	Lines	In-between	Lines	In-between
				0.0–0.1 m layer				
Macropores (m^3 m^{-3})	0.20abA	0.14aA	0.12bA	0.14aA	0.20abA	0.13aA	0.28aA	0.13aA
Micropores (m^3 m^{-3})	0.46aA	0.49aA	0.49aA	0.48aA	0.46aA	0.48aA	0.40bB	0.48aA
TOC (g $100g^{-1}$)	2.72	2.89	2.8	2.97	2.69	2.88	2.86	2.99
pH	5.1	5.5	5.1	5.4	5.2	5.2	5.1	5.2
WMD (mm)	6.2	6.2	6.2	6.1	6.2	6.1	6.2	6.2
				0.1–0.2 m layer				
Macropores (m^3 m^{-3})	0.09	0.1	0.1	0.12	0.09	0.09	0.12	0.09
Micropores (m^3 m^{-3})	0.49aA	0.48abA	0.49aA	0.47abA	0.50aA	0.5aA	0.47aA	0.47bA
TOC (g $100g^{-1}$)	1.98	1.98	1.94	2.14	1.78	1.7	1.98	2.04
pH	5.0	5.2	5.3	5.2	4.8	5.4	4.9	4.8
WMD (mm)	6.2	6.2	6	6.1	6.1	6.1	6.1	6.2
				0.2–0.3 m layer				
Macropores (m^3 m^{-3})	0.14	0.14	0.12	0.13	0.12	0.12	0.12	0.13
Micropores (m^3 m^{-3})	0.50	0.5	0.51	0.5	0.52	0.52	0.5	0.51
TOC (g $100g^{-1}$)	1.77	1.8	1.72	1.85	1.64	1.47	1.94	1.89
pH	4.2	4.9	5.1	4.9	4.4	5.3	4.8	5
WMD (mm)	6.1	6	6.2	5.8	5.8	5.8	5.9	6.2

[(1)]Mean followed by equal letters, lowercase compare treatments of the same position and uppercase letters compare values between positions of the same treatment, do not differ by Tukey's test, at 5% probability. IS, application of injected swine slurry; IU, injected urea; LSS, liquid slurry on surface; control, direct corn sowing; L, in the lines; I, in-between the lines.

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