Water, soil and phosphorus loss with cattle slurry application to Oxisols under no-tillage and natural rainfall

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Abstract
Milk dairy cattle production occurs in Paraná state, and the application to soils is an alternative for final disposal of the animal manure. This study aimed to evaluate the losses of soil, water and nutrients through runoff in a no-tillage system, under natural rainfall in a two soils with different doses of cattle slurry (0, 60, 120 and 180 m³/ha/yr). The experiment was carried out for two years in experimental areas being managed under no-till for over 12 years. The runoff was collected in 60 L containers after every rainfall event with occurrence of runoff. According to the data, 180 and 120 m³/ha/yr of cattle slurry are the best dose for the sandy clay loam and clay Oxisols, respectively, considering the two years of application, low slope (10%), low rainfall, and at least 10 days between the manure application and rainfall event. The flow-weighted average of dissolved, reactive phosphorus concentrations were above of the limit associated with eutrophication, indicating that even in unmanured no-till, the need for conservation practices to avoid the runoff for reach the water bodies.

Key Words
Runoff, manure, water quality, eutrophication, nutrients.

Introduction
The Paraná state, a pioneer in no-tillage in Brazil, is also an important milk dairy cattle producer, with mainly a confined system (free-stall). A concerning issue is the fate of the cattle slurry. Most of the manure is applied in areas under no-tillage, improving the levels of soil fertility and decreasing the mineral fertilizer costs. On the other hand, the manure applied to land is an important source of N and P, which can be carried by runoff to water bodies and cause eutrophication problems (Hooda *et al*. 2000; Shigaki *et al*. 2006), especially when there is no criterion of doses, period and form of application, as well as soil type, topography, soil conservation practices and distance from the field to the water body.
The objectives of this study were to evaluate the long term effect, loss of soil, water and nutrients through runoff in no-till systems, under natural rainfall in two Oxisols, a sandy clay loam and a clay, with low slope (10%) and different doses of cattle slurry (0, 60, 120, 180 m³/ha/yr), and to contribute to the best management practice definition.

Methods
Characterization of the area and treatments
The experiment was conducted at two stations, one with a sandy clay loam Oxisol, 13% slope, during November 2005 to May 2008, and another with a clay Oxisol, 10% slope, from May 2006 to May 2008. Both were under no-tillage for over 12 years. The plot area was 29.75 m^2 (9.0 m long and 3.5 m wide) bounded by metal plates of 10 cm in height with 5 cm under the ground. The last one meter was built in a "V" to collect the runoff in a 60 L container. The treatments consisted of four doses of liquid cattle manure (0, 60, 120, and 180 m^3/ha/yr), in four blocks, with half applied in the summer and half in the winter at the soil surface.

Collection and analysis of runoff
In the sandy clay loam Oxisol, the treatments were installed in November 2005, but due to low precipitation, runoff occurred only from September 2006 until May 2008. For the clay Oxisol, the treatments were installed in May 2006, and runoff occurred from September 2006 until May 2008. Runoff samples were collected after every rainfall event with occurrence of runoff. The minimal interval between the application of cattle slurry and the first rain was 10 days for both soils.

After the water loss determination, a runoff subsample from the 60 L container was collected for nutrient and

soil loss analysis. After mixing the subsample well, a 30 mL aliquot was dried to determine the sediment concentration. Dissolved reactive phosphorus was determined by spectrophotometry after filtering a subsample through a 0.45 □m membrane (ascorbic acid method, American Public Health Association 1995).

Statistical analysis
To assess the effect of cattle slurry on soil and water loss and on the flow-weighted average concentration of dissolved reactive phosphorus, adjusted quadratic polynomial regression models were used with the program SIGMA PLOT ® Version 10.0 (Sigma Plot 2006).

Results
Soil losses (Figure 1) decreased with increasing doses of cattle slurry in the sandy clay loam Oxisol, however they were not statically significant in the clay Oxisol. Application of manure also decreased water loss (Figure 2), however, in the clay Oxisol the beneficial effect occur when 120 m^3/ha/yr dose was used, while for the sandy clay loam Oxisol, rates of 180 m^3/ha/yr were needed. Short-term experiments where rainfall occurred soon after the application of liquid manure resulted in high soil and water losses, possibly by the soil surface sealing, (Bertol *et al.* 2007; Mori *et al*. 2008). In long-term experiments, the application of manure improves the soil physical quality (Mellek *et al*. 2008) and consequently reduces runoff and soil loss (Smith *et al*. 2001). There is evidence that the longer the interval between the application of manure and the rainfall event the lower the water, soil and phosphorus losses (Gilley *et al*. 2007, Allen and Mallarino 2008).

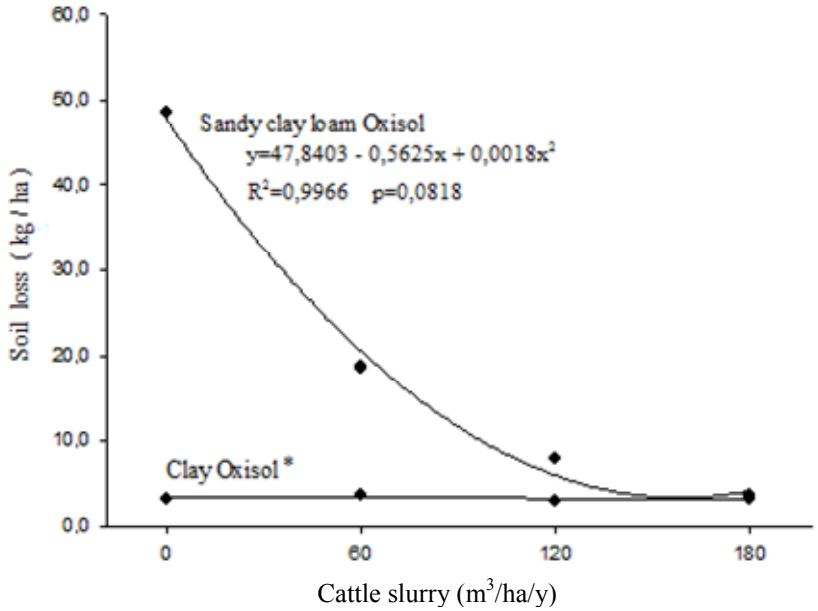

Figure 1. Total soil loss in sandy clay loam Oxisol and clay Oxisol with application of cattle slurry in a no-tillage system and natural rainfall.

The losses of dissolved reactive phosphorus (Figure 3) decreased up to a dose of 120 m^3/ha/yr for the clay Oxisol and up to 180 m^3/ha/yr for the sandy clay loam Oxisol. However, the flow-weighted average concentration of dissolved reactive phosphorus (Figure 4) increased with manure application in the clay Oxisol. For the sandy soil, the flow-weighted average concentration of dissolved reactive phosphorus reduced with the manure application up to the high dose.

Losses of phosphorus in all treatments did not reach 1% of total P applied, which is consistent with other studies (Sharpley *et al*. 1994; Mori *et al*. 2008), but the weighted average concentrations of DRP were above the maximum allowed by Brazilian legislation. Agronomical this loss is not significantly, but environmentally this loss is of concern if the flow reaches a water body.

Conclusion
The application of cattle slurry decreased soil, water and dissolved reactive phosphorus losses. According to the data, 180 and 120 m³/ha/year of cattle slurry are the best dose for the sandy clay loam Oxisol and clay Oxisol, respectively, considering the two years of application, low slope (10%), low rainfall and at least 10

days between the manure application and rainfall event. The flow-weighted average concentration of dissolved reactive phosphorus was above the limit associated with eutrophication, indicating, even for unmanured no-till, the need for conservation practices to avoid runoff reaching water bodies.

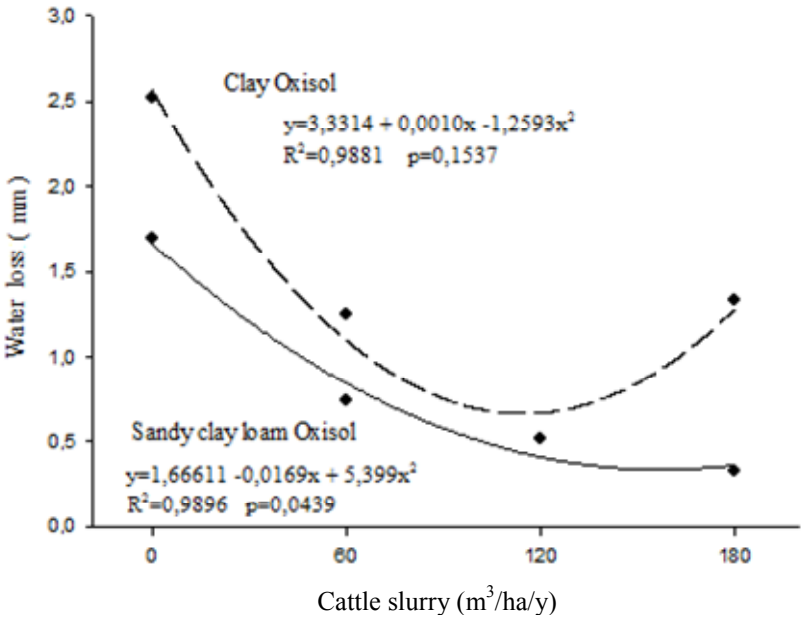

Figure 2. Total water loss in sandy clay loam Oxisol and clay Oxisol with application of cattle slurry in a no-tillage system and natural rainfall.

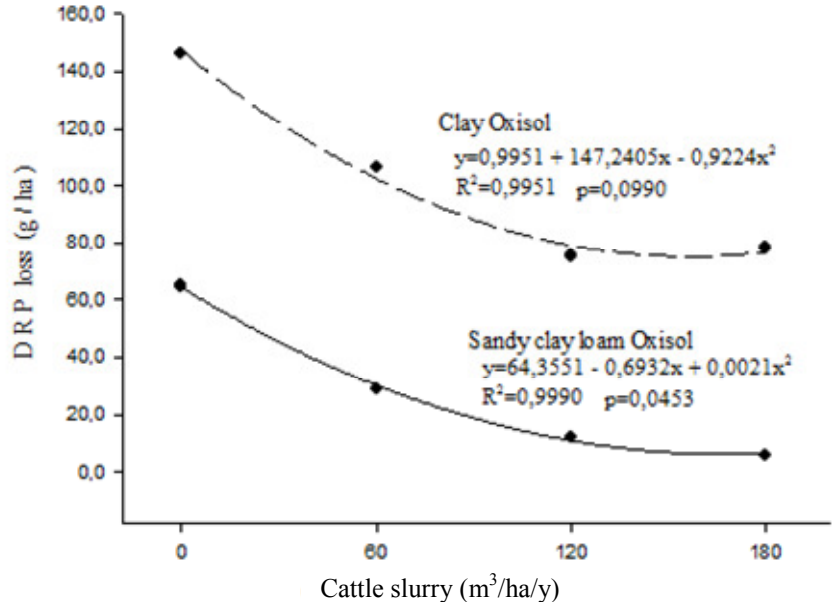

Figure 3. Dissolved reactive phosphorus (DRP) loss in sandy clay loam Oxisol and clay Oxisol with application of cattle slurry in a no-tillage system and natural rainfall.

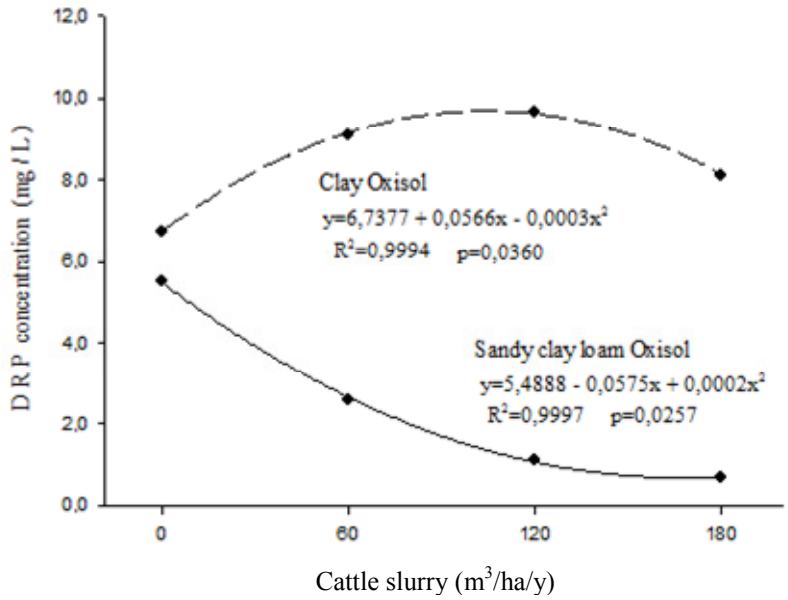

Figure 4. Flow-weighted average concentration of dissolved reactive phosphorus (DRP) in sandy clay loam Oxisol and clay Oxisol with application of cattle slurry in a no-tillage system and natural rainfall.

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