Effect of the Application of Manure of Cattle on the Properties Chemistry of Soil in Tizayuca, Hidalgo, Mexico

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Abstract

Large amounts of fertilizers and pesticides applied annually to agricultural soils improve the physical and chemical properties of soil but, when they are applied without control they can cause serious environmental problems. The farms of Tizayuca in Hidalgo State produce about 30000 tons of manure per day, which are applied indiscriminately in the same region for agricultural use. The aim of this study was to determine the effect of cow manure application in soil chemical properties. Soil samples were collected in two cultivated sites with a history of six and seven years of manure application in uncultivated plot for ten years (control) and they were analyzed according to Mexican Official Standard 021 which sets the specifications of soil fertility. The results showed in the sites with manure application, organic matter content increased significantly compared to the control plot (1.24 and 1.43%), the addition of manure for several years contributed to lower soil pH. The decreased conductivity (0.66 and 0.72 $dS{\cdot}m^{-1}$). The inorganic nitrogen and phosphorus concentrations were significantly higher than the values in the plot with seven years of manure application; there was a process of leaching of these, which may affect the groundwater contamination.

Keywords: Organic fertilizers, conductivity, pH, organic matter, agricultural soil

Introduction

The application of manure into the soil improves its fertility and increases agricultural production. When applied for many years and in large volumes can impair certain soil properties and affect his production. There is evidence that the manure can increase the pH of acidic soils (Whalen *et al.*, 2000), but also there has been increase of salinity (Li-Xian *et al.* 2007) and some toxic metals (Qian *et al.*, 2003).

Various studies have shown that the application of manure has a significant effect on the chemical properties of soil and many of these effects are due to increased organic matter (Masto *et al.* 2007;) (Schœnau, 2006). However, there is little information about its effect on the electrical conductivity (Hao *et* Chang, 2003). On other properties of the soil cation exchange capacity, contents of available phosphorus and inorganic nitrogen, the existing information is heterogeneous because the effects on these properties may vary by many factors (Walker *et* Bernal, 2008; Zhao *et al.*, 2009).

Historically agricultural land adjacent to an agricultural complex, uses manure generated as fertilizer for crops in the region, because he is available of this waste in an immediate manner and at low cost. In the agricultural area adjacent to basin dairy Tizayuca, Hidalgo, manure is applied in large volumes and for prolonged periods without knowing the agronomic needs of crops or soil, so the aim of this study was to assess the effect of the application of manure on some chemical properties of the soil pH, electrical conductivity (EC) content of organic matter (COM), capacity of exchange cation (CEC), exchangeable bases, inorganic nitrogen and phosphorus available in three batches of the municipality. These properties are important attributes that affect the quality of the soil and its agricultural production, so the hypothesis that arises is that the chemical properties of agricultural land are modified by the indiscriminate application of cattle manure for prolonged periods.

Materials and Methods

Studied farming lots are between coordinates 19° 47' and 19° 54´ N and 98° 59´ and 99° 00' W, at an altitude of 2190-2350 m in the municipality of Tizayuca in the South of the State of Hidalgo, Mexico. The climate is temperate subhumid with a rainy summer; the average annual temperature is 15.5° C, and annual precipitation is 611 mm The Phaeozem háplico is the unit of soil that stands out in the region with 51% (SEMARNAP, 2003).
Agricultural soil samples were taken in the years 2006 and 2007 (Phaeozem háplico) at two sites of cultivation one was paid for six continuous years (L1) and the other by seven (L2) with manure of cattle, both annually planted with maize under conditions of temporary (irrigation for rain) and a third site that had not been paid or planted (LT) ten years (before these last 10 years was a lot of maize crop) which was considered as batch control. This lot is located approximately a1 km of other lots and also corresponds to a Phaeozem háplico with the same environmental conditions. The application of manure made every year in the months of February-March with a dose of approximately 80 Mg has^{-1}

Soil samples were obtained with a tubular barren at three depths: 0-20, 20-40 and 40-60 cm in the months of July and December of 2006 and 2007; 10 simple samples in each site were taken in each collection to form a composite sample. What total corresponds to 4 composite batch, in the 2 years of collecting samples. The manure is collected in each batch before that it was incorporated into the soil. These samples of approximately 2 kg each were taken with a plastic shovel and were placed in plastic bags. Soil and manure were dried outdoors and passed through a sieve with 2 mm in diameter prior to chemical analysis.

Each composed of manure and soil sample you were, in triplicate, the following determinations: pH in a suspension of suelo:agua (1: 2), the electrical conductivity (EC) in the extract of saturation (Bower *et* Wilcox, 1965), the content of organic matter by the method of Walkley – Black (Nelson *et* Sommers, 1986), inorganic nitrogen (nitratos+amonio+nitritos) by the ACE-08 (DOF, 2002) method, available phosphorus by extraction with baking soda (Bray *et* Kurtz, 1945). The ability to Exchange and exchangeable bases by extraction with ammonium (Schollenberger *et* Simon, 1945) acetate, was only held in soil samples.

The average result of the analysis of each parameter studied (in two years of collection) was used for the test of comparison of means of Tukey ($p \leq 0.05$) and the Pearson correlation with the statistical programme Statgraphics plus for Windows version 5.

The results were evaluated by means of the analysis of variance (ANOVA), test comparison of means of Tukey ($p \leq 0.05$) and Pearson correlation with the statistical programme Statgraphics plus for Windows version 5.

Results and Discussion

pH

The pH of the soil of the L1, L2 and LT lots was moderately alkaline (7, 4-8, 5) according to the official Mexican standard (DOF, 2002). Statistically, there was no significant difference in the pH of the soil between the L1 and L2 lots, but with the lot LT where pH was greater (0.57 and 0.66 units for batches L1 and L2, respectively) (table 1).

Table 1: Chemical Properties of Soil and Lot Control Lots Paid With Manure

Property	Batch L1	Lot L2	Lot LT
pH	7, 86th **	7, 77th	8, 43b
Conductivity(dS·m^{-1})	0, 49th	0, 45th	1, 21b
Organic matter (%)	3, 39a	3, 33a	2, 15b
(C) organic (%)	1, 97th	1, 99a	1, 25b
N inorg. (mg kg)$^{-1}$)	37, 86a	40, 05a	21, 25b
P aprov. (mg kg)$^{-1}$)	10, 17a	11, 31st	4, 85b
CIC (cmol (+) kg)$^{-1}$)	24, 45th	27, 12th	11, 93b
CA (cmol (+) kg)$^{-1}$)	4, 12a	4, 95th	3, 09b
Mg (cmol (+) kg)$^{-1}$)	5, 80a	6, h	6, 25th
K (cmol (+) kg)$^{-1}$)	2, 19a	2, 21st	1, 25b
NA (cmol (+) kg)$^{-1}$)	3, 04a	3, 15a	4, 43b

L1 and L2 lots paid with manure by six and seven years respectively. Batch control LT
L1 and L2 lots fertilized with manure for six and seven years respectively. LT lot control
** Stockings with different letters in each row are statistically different (Tukey), ($p < 0,05$)
** Means with different letters in each row are statistically different (Tukey), ($p < 0,05$)

Has been published that the pH of acidic soils increases due to the application of manure (Whalen *et al.*, 2000), was observed in this case otherwise, a significant decrease in comparison with the lot without payment (LT), which means that the application of manure for several years contributed to decrease the pH of the soil due to the mineralization of organic matter as proposed it Chang *et al.* (1990 and 1991), as well as the organic acids that are incorporated into the soil at the beginning of the manure decomposition. Li-Xian *et al.* (2007) also reported decrease in pH of soil by application of chicken manure in the first five crops and later in the sixth harvest pH increased. Probably this behavior is observed in lots of study if continues in effect because manure accumulation of salts that this fertilizer contributes.

The decrease in pH of the L1 and L2 batch has not been drastic probably by the dampening of manure effect, because the pH of the manure was not very high (table 2) and as the implementation period was short compared with that reported by Chang *et al.* (1990) with application for 11 years and Sommerfelt *et al.* (1988) for 40 years.

Table 2: Chemical Properties of the Manure Applied on Agricultural Lots

Properties	Cow dung
pH	9,07 (0,35)
Conductivity dS·m^{-1}	4,84 (0,28)
Total carbon %	10,85 (3,5)
Inorganic nitrogen mg kg^{-1}	3,17 (1,3)
Available phosphorus mg kg^{-1}	133,6 (17,7)

The values are the average of six determinations
Values are the means of six determinations. (STD. Dev.)

Electrical Conductivity

According to the Mexican official norm (DOF, 2002) electrical conductivity for lots L1 and L2 classify as a negligible effect of salinity soils (< 1,0 dS.m^{-1}) and the LT lot as slightly saline (< 1, 1-2, 0 dS.m $^{-1}$).

They found no significant difference between L1 and L2 lots, but yes to the lot LT ($p < 0,05$), which introduced higher values (1, 10-1, 78 dS.m^{-1}). Linear increase in electrical conductivity due to the application of manure has been reported for eleven years (Chang *et al.*, 1990).

Salazar-Sosa *et al.* (2004) found that the conductivity increases in soils treated with 40-160 Mg has^{-1} of manure, (rank 3, 14-6, 98 $dS.m^{-1}$) which was greater than that found in the soil of Tizayuca with 80 Mg has^{-1} annual manure. The results observed in the batch L1 and L2 (slightly less than lot T), are comparable to described by Clark *et al.* (1998) who detected relatively stable levels of electrical conductivity and concluded that the application of manure not substantially increased the conductivity of the ground for a period of eight years that lasted his studio. On the other hand not found any significant correlation between the conductivity of the three lots and manure, which indicates that the application of manure did not influence this property.

Organic Matter

In three batches of soil organic matter content was less than 4 per cent (table 1), so according to the official Mexican standard were classified as soils of very low class. Was observed no statistically significant difference in the content of organic matter between L1 and L2 lots but there is difference with batch LT ($p < 0,05$), which indicates that the fertilizer applied in these lots contributed to increase the content of organic matter in the soil, which was consistent with that reported in other studies that they observed the same effect in the short and long term (Larney *et al*., 200; Pulleman *et al.* 2000). This slight increase in the content of organic matter of lots L1 and L2 occurred in a short time since the years of collecting were noted in abundant rainfall (550-600 mm per year) who favored the incorporation of manure organic matter in the soil, which was consistent with the study conducted by Yaduvanshi and Sharma (2008) who reported that irrigation helps this process.

Cationic Exchange Capacity

According to the Mexican standard (DOF, 2002), the L1 batch cation exchange capacity it was middle-class (16-25 $cmol(+)kg^{-1}$), in lot L2 high (24-40 $cmol(+)kg^{-1}$) and the lot LT was low (4-15 $cmol(+)kg^{-1}$) (table 1). Statistically, there was no significant difference between the CIC of the L1 and L2 lots and both were significantly different to the lot LT ($p < 0,05$), which indicates that the application of manure increases the CIC on the ground when it has been used for many years, these results are similar to that reported by Gao and Chang, (1996) and Walker and Bernal (2004) who investigated increase in the CIC of soils which were paid with chicken and pig manure.

Where batches are L1 and L2 found a high correlation between the content of soil organic matter and its cation exchange capacity ($r = 0.73$ batch L1 and $r = 0.75$ in the L2 lot) close which was also observed by Walker and Bernal (2008) who found a relationship between the content of organic carbon and the CIC in soils improved with pig manure. The increase of the CIC in paid lots was observed in the short term, which may be related to the type of manure, its composition, the applied amount and climatic factors.

According to the Mexican official norm (DOF, 2002), the values obtained for calcium (Ca) of change in the L1, L2 and LT lots were classified as low (2-5 cmol (+) kg^{-1}); magnesium (Mg) and potassium (K) of change were of high category (> 3 and > 0.6 cmol(+) kg^{-1} respectively). Statistically, K, Ca, and sodium (Na) of change were similar in the L1 and L2 lots and significantly different from the lot LT ($p < 0,05$). These elements relate to the application of manure because they are introduced to food supplements and medications that is being provided to livestock which is consistent with that reported by Goff (2006). With the Mg of change there were significant differences between the batches, so the main source of this element was possibly from natural magnesium rocks of the area of study.

Inorganic Nitrogen

Inorganic nitrogen concentrations detected in the batches lot L1 and LT, ranked according to the official Mexican standard in the range of class media (20-40 mg kg^{-1}) and in the lot L2 concentrations were high (40-60 mg kg^{-1}).
There was no significant difference in the content of inorganic nitrogen between L1 and L2 lots with manure application and both lots were significantly different to the lot LT ($p < 0,05$), which means that the contribution of inorganic nitrogen in the soil due to the manure being applied, which was consistent with that reported by Walker and Bernal (2008) who noted that soil improved with manure increased significantly nitrogen due to the fact that in the process of decomposition of manure generated nitrites and nitrates that are incorporated into the soil.
The content of inorganic nitrogen increased with depth (table 3) which indicates a process of leaching of nitrites and nitrates; This export of nitrogen in soils improved with manure due to leaching, surface runoff and erosion has been documented previously (Whalen *et al.,* 2001).

In this particular case it is likely in the future are affecting the quality of groundwater in the area since the manure without control, with high content of inorganic nitrogen in the composition of the liquid manure (table 2), and the high precipitation in summer in this region continued to be applied.

Table 3: Concentration of Inorganic Nitrogen and Phosphorus Available to Three Levels Deep

Depth cm		Nitrogen Inorganic	mg kg^{-1}		Phosphorus available	
	L1	**L2**	**LT**	**L1**	**L2**	**LT**
0-20	33,45 (0,9)	35,62 (0,6)	17,97 (1,1)	8,65 (0,4)	9,76 (0,3)	3,6 (0,5)
20-40	36,0 (0,7)	39,51 (2,5)	20,64 (0,6)	10,02 (0,4)	11,35 (0,6)	4,52 (0,3)
40-60	44,11 (6,7)	45,03 (1,3)	25,15 (2,9)	11,81 (0,8)	12,82 (0,6)	6,42 (1,8)

(STD. Dev.)

Available Phosphorus

According to the standard, usable phosphorus determined in the L1 lot belongs to the middle class (5, 5-11 mg kg^{-1}), in the lot L2 was high (> 11 mg kg^{-1}) and the lot LT low (< 5.5 mg kg^{-1}). No significant difference in the concentrations of phosphorus in the L1 and L2 batch is observed, but there was a significant difference with the lot LT (table 1), which means that applied manure provides much of the phosphorus reported.

L1 and L2 batches with higher concentration of available phosphorus than the LT lot show a residual of this by the continuous manure application effect, as reported it Eghball *et al*. (2004), this residual phosphorus behavior occurs because the availability of phosphorus is slow, due to the pH of the soil (Basic), as well as by the fixation of phosphorus by the oxy-hydroxides of iron and aluminum and carbonates of calcium from the soil making it slightly soluble (Park *et al.,* 2004). Despite this, L1 and L2 lots noted slight concentration of phosphorus into the lower layers (table 3). This phenomenon of phosphorus leaching is not common because of the complexation of phosphorus with certain ions from the soil, but can occur when the sites pricing are blocked by molecules released from the decomposition of manure (Eghball *et al.*, 2004). Phosphorus leachate to groundwater is of great environmental interest when groundwater is near the surface. With lots of Tizayuca it is possible to register a portion of leachate phosphorus but it is unlikely to reach groundwater because it lies approximately 100 m in depth, but this can happen by discontinuity of the parent material (fractures), the flow preferential phosphorus towards lower horizons and high precipitation (Kleinman *et al.,* 2003). Whalen and Chang (2001) also claim that the transport of organic and inorganic phosphorus dissolved through the soil profile is favoured by the applied irrigation.

The concentration of available phosphorus found in the manure was very high (table 2), 13.2 and 11.8 times greater in the batch L1 and L2 respectively found in the soil phosphorus concentration, what it is that much of it is lost by erosion and a minor part by leaching (as noted in table 3), that there is evidence that the application of manure for several years and in large volumes it favors the accumulation of phosphorus in the soil, which makes it vulnerable to erosion and leaching processes (Andraski *et al.,* 2003).

Conclusions

The application of manure increased organic matter content in lots paid by six and seven years in comparison with the lot without paying which presented very low organic matter content.

Cation exchange capacity and content of exchangeable bases (except the magnesium and sodium change) improved substantially compared with the lot without paying.

We detected high concentrations of inorganic nitrogen and phosphorus available in lot L2 with seven years of application of manure, and transport them to lower layers of soil.

It is proposed the need to monitor the quality of the groundwater of nearby wells to areas of cultivation with intense application of manure, as well as to apply manure in the doses recommended according to the needs of each crop.

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