FERTILIZATION OF BARLEY WITH PIG SLURRY: RESIDUAL AND CUMULATIVE EFFECTS

D. Hernández, J.M. Fernández, R. del Río, H.M. Fritis, A. Polo.
Center for Environmental Sciences, C.S.I.C. Serrano 115 bis, 28006 Madrid, Spain.
dhernandez@ccma.csic.es

ABSTRACT

Five doses of pig slurry (30, 60, 90, 120 and 150 $m^3ha^{-1}year^{-1}$) were applied to a barley crop experiment in Central Spain. The area was divided into two sets of plots in order to study the residual (a single pig slurry application) and cumulative (annual pig slurry application) effects on crop yield and mineral composition of barley after five years of the beginning of the experiment. All treatments were compared to mineral fertilization (MF) and control plots.

Cumulative pig slurry addition had a positive effect on total dry matter; however, there were not significant differences among the treatments in grain yield. On the contrary, total and grain yield in the residual plots were similar or lower than the control and MF plots.

Macro and micronutrients in both grain and straw were very similar in all residual plots with the exception of P and K, which decreased in grain with the increase of the dose of slurry. In cumulative treatments, N was the most affected nutrient by pig slurry addition, so the higher the dose was, the greater the N content resulted. With respect to the content of Cu and Zn, there were not problems of contamination by heavy metals accumulation.
Keywords: *pig slurry, barley, crop yield, nutrient content.*

INTRODUCTION

Intensification of livestock production has led to a great increase in the production of animal waste, including pig slurry (PS). Frequently, PS is spread on soil as a means of waste recycling, in order to make use of its fertilizer value. Thus, agricultural lands can be supplied with valuable amounts of plant nutrients and organic matter (Plaza, 2002). Several studies indicate that PS addition can replace mineral fertilizer if the rates, methods and time of disposal are properly selected (Daudén and Quílez, 2004, Sieling et al., 1998, Petersen, 1996). However, this practice is not without environmental risks, like pollution of surface and ground waters, volatilization of ammonia, release of odors and accumulation of excessive amounts of micronutrients or potentially toxic metals in the soil (Cabral et al., 1998).

The aim of this work was to assess the effectiveness of PS amendment on barley yield and mineral composition. Both the residual effect of a single PS addition and the cumulative effect of five consecutive fertilizations were studied.

MATERIALS AND METHODS

A field experiment was carried out on the experimental farm "La Higueruela" (Santa Olalla, Toledo, in Central Spain). The area is semi-arid with an annual rainfall of 487 mm and a mean annual temperature of 14 ºC. The soil used is classified as a *Typic haploxeralf* (U.S.D.A.).

Seven treatments were applied in October 1997 to 10 x 8 m plots: a control (C), without fertilization; a mineral fertilization (MF), consisting of 400 kg ha^{-1} of NPK 15-15-15 before sowing and 150 kg ha^{-1} NH_4NO_3 at beginning of barley tillering; and five different rates of slurry corresponding to 30 (PS30), 60 (PS60), 90 (PS90), 120 (PS120) and 150 m^3 ha^{-1} y^{-1} (PS150). In the following years, half of the plots were left unamended, in order to study the residual effect of PS fertilization. The rest of the plots were amended every year in October (cumulative effect). Each treatment was in triplicate.

Each year a barley crop (*Hordeum vulgare* L. cv. Reinette) was yielded during the experiment. The barley samples used in this study were collected randomly from plots taking the above-ground plant at the moment of the fifth harvest (June 2002). Total dry matter yield, grain yield and nutrient content, both in grain and in straw, were measured.

The results were statistically analyzed by ANOVA using the least significant difference test (LSD) when F-test was significant at a 0.05 probability level.

RESULTS AND DISCUSSION

The main characteristics of soil and the average composition of the five PS applied during the experiment are shown in Table 1. In short, the soil is a sandy loam soil (U.S.D.A.) with a low salinity, organic matter and nutrient content. The PS exhibited a low nutrient content due to a high dilution.

***Table 1**. Characteristics of the soil at the beginning of the experiment and the PS applied from 1997 to 2001 (Mean ± SD).*

Soil				Pig slurry			
Sand (g kg^{-1})	590	P (g kg^{-1})	41	Dry matter (g L^{-1})	18 ± 6	P (mg L^{-1})	393 ± 132
Silt (g kg^{-1})	220	K (g kg^{-1})	487	Ash (g L^{-1})	6 ± 1	K (mg L^{-1})	774 ± 226
Clay (g kg^{-1})	190	Ca (g kg^{-1})	1440	QOD (g L^{-1})	26 ± 9	Ca (mg L^{-1})	366 ± 155
		Mg (g kg^{-1})	150	BOD_5 (g L^{-1})	11 ± 3	Mg (mg L^{-1})	214 ± 78
pH	5.8	Na (g kg^{-1})	15	pH	7.4 ± 0.1	Na (mg L^{-1})	266 ± 136
EC (dS m^{-1})	0.10	Fe (mg kg^{-1})	8895	EC (dS m^{-1})	14 ± 3	Fe (mg L^{-1})	35 ± 9
		Mn (mg kg^{-1})	143	TOC (g L^{-1})	7 ± 2	Mn (mg L^{-1})	5 ± 2
TOC (g kg^{-1})	12.9	Zn (mg kg^{-1})	15	Total N (g L^{-1})	2.5 ± 0.4	Zn (mg L^{-1})	35 ± 18
Total N (g kg^{-1})	1.2	Cu (mg kg^{-1})	5	N-NH_4^+ (mg L^{-1})	1565 ± 267	Cu (mg L^{-1})	15 ± 4
				N-NO_3^- (mg L^{-1})	27 ± 18		

Total dry matter increased significantly with the rate of PS in cumulative plots (Figure 1). Grain yield also improved when PS was applied annually, but it did not show significant differences among the treatments. Therefore, adequate PS additions can be considered similar to mineral fertilization (Daudén and Quílez, 2004, Sieling et al., 1998). In residual plots, only the higher doses had dry matter and grain yields equivalent to MF (Figure 2). Nevertheless, it is noteworthy that control plots exhibited similar yields to MF treatment, and greater than the

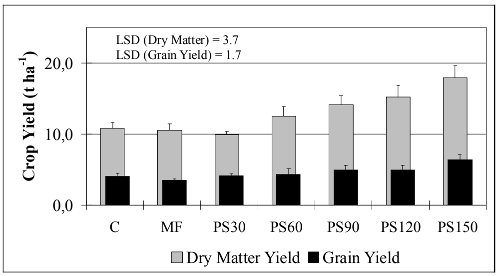

***Figure 1**. Total dry matter and grain yield of harvested barley in cumulative plots.*

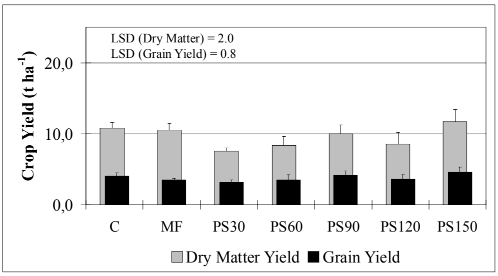

***Figure 2**. Total dry matter and grain yield of harvested barley in residual plots.*

yields obtained in preceding years. This may be due to the favorable weather conditions during this year (Plaza, 2002).

Increasing the rate of PS resulted in greater N content (Table 2), both in grain and in straw, when the PS was applied annually. The same trend was observed for P in grain and K in straw. On the contrary, the PS effect on nutrient concentration was considerably reduced when the plots were left unamended. Significant differences were only detected in P and K contents in grain, which decreased with the increase of the dose of slurry. The differences in nutrient concentrations may be related to unlike nutrient availability in soil after the PS amendment (Chang et al., 1994). Significant amounts of N in PS are immobilized in soil after application, and subsequently released (Chantigny et al., 2004), improving the N availability in the following years (Sørensen and Amato, 2002). However, these results suggest that the residual fertilizer effect of PS has disappeared after five years of the application.

Table 2. *Total N, P and K concentration (g kg^{-1}) in grain and straw of barley grown in the different treatments. R, residual plots; C, cumulative plots.*

	Grain						Straw					
	N (g kg^{-1})		P (g kg^{-1})		K (g kg^{-1})		N (g kg^{-1})		P (g kg^{-1})		K (g kg^{-1})	
	R	C	R	C	R	C	R	C	R	C	R	C
C	17.2	17.2	5.7	5.7	6.0	6.0	3.3	3.3	0.8	0.8	15.9	15.9
MF	15.1	15.1	5.4	5.4	6.0	6.0	3.8	3.8	1.0	1.0	19.6	19.6
PS30	17.8	15.6	5.4	5.5	5.8	5.8	3.0	2.8	0.9	0.8	17.5	16.3
PS60	17.2	17.4	5.4	5.6	5.5	6.5	3.3	4.0	1.0	1.4	18.4	23.0
PS90	15.9	19.5	5.2	5.9	5.3	5.9	2.9	4.9	1.2	1.0	16.9	22.4
PS120	15.9	19.4	5.1	6.0	5.2	6.0	3.7	4.4	1.5	0.7	19.1	18.1
PS150	15.6	21.1	5.0	5.9	4.7	5.7	3.1	5.6	1.1	0.6	15.5	21.2
LSD	5.1	2.6	0.2	0.4	0.6	0.7	1.1	1.3	0.5	0.6	4.1	4.2

In cumulative plots, a significant increase in the contents of Zn and Cu in grain was observed when higher PS rates were applied (Table 3). Likewise, Zn concentration in grain has shown significant response to residual PS treatment. However, these values are not high enough to consider Zn and Cu content a limiting factor for PS amendment (Cabral et al., 1998).

Table 3. *Zn and Cu concentration (mg kg^{-1}) in grain of barley grown in the different treatments. R, residual plots; C, cumulative plots.*

	Zn (mg kg^{-1})		Cu (mg kg^{-1})	
	R	C	R	C
C	18	18	2.1	2.1
MF	22	22	2.0	2.0
PS30	27	21	2.9	2.4
PS60	29	23	2.8	1.9
PS90	25	22	2.5	3.3
PS120	27	26	2.2	3.8
PS150	35	32	2.0	4.8
LSD	5	7	0.5	0.9

CONCLUSIONS

PS fertilization achieved comparable barley yields to traditional fertilization when it was applied annually; moreover, the nutrient content showed a general increase with the rate of PS, especially in the case of N. Although Zn and Cu grain contents also increased, they did not mean toxic levels for the plant. On the other hand, the residual treatments hardly exhibited differences with the control and the mineral fertilized plots, after five years of the PS addition.

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