AGRONOMIC USE OF THE SOLID PHASE OF PIG SLURRY ON CUCUMBER CROP: NUTRIENT EXTRACTION AND BIOMASS PRODUCTION

R. Moral, J. Moreno-Caselles, M.D. Perez-Murcia, A. Perez-Espinosa, C. Paredes
Department of Agrochemistry and Environment, Miguel Hernandez University, EPSO, Ctra Beniel Km 3.2, 03312-Orihuela (Alicante), Spain. raul.moral@umh.es

ABSTRACT

In this experiment, the effect of the fresh and composted solid fraction of swine manure slurry on major nutrient NPK status in different plant parts of cucumber (stem, leaves and fruits) was studied, compared to traditional inorganic fertilisation. The biomass production (commercial and total aerial mass) was also monitored. Fertiliser treatments were: MF, mineral fertiliser, equivalent to 300 kg N ha^{-1}; FSF and CSF, organic fertilisation with fresh and composted solid fraction of swine manure slurry, respectively, at two different rates (supplying 300 kg N ha^{-1} and 450 kg N ha^{-1}) and C, a control treatment without fertilisation. In general, N concentration in the different plant parts analysed was not increased by the biosolids amendment and the application rates, compared to the inorganic fertilisation (MF). P extraction and plant content were positively affected by the organic amendment, with similar increase of this element for the composted and non-composted material. K concentration in the analysed vegetal plant was not significantly increased by the fertilising treatments compared to control plants. The use of the fresh and composted solid fraction of swine manure slurry as organic fertilisers produced a similar or higher yield of fruit and biomass of cucumber plants than the mineral fertiliser. In general, increasing rates of organic fertiliser application did not result in greater biomass production.

INTRODUCTION

The use of swine manure slurry as organic fertiliser represents an economical and widespread method, which can improve soil properties and recycle nutrients in agricultural soils thus reducing the need for mineral fertilisers. The influence of the swine manure slurry on crop production has been studied in several works. Bernal and Roig (1993) observed substantial increases of plant and fruit production in the soil with fertilisation up to 50 m^3 ha^{-1} of manure slurry in pepper, tomato and lettuce crops. In addition to this, Vasconcelos et al. (1999) found that wheat yield increases obtained with increasing solid fraction application rates greater than 15 t ha^{-1} swine slurry were comparable with yield obtained with standard mineral fertilisation. Moral et al. (2003) found that organic amendments based on the solid phase of pig slurry favored the nutrient extraction by Milan cabbage, especially for K and P. The aim of this experiment was to study the effect of fresh and composted solid fraction of swine manure slurry on major nutrient NPK contents in different plant parts of cucumber (stem, leaves and fruits), using different application rates of each waste, compared to traditional inorganically fertilisation. Furthermore, yield and total aerial mass were also monitored.

MATERIALS AND METHODS

The experiment was conducted in the Segura river valley in South East Spain. The soil of this area is a Xerofluvent with a clayey-loam texture. The organic wastes used in this study were fresh and composted solid fractions of swine manure slurry (FSF and CSF, respectively). In this

experiment, the solid fraction of fresh swine manure slurry was separated by screened solid separators (0.5 mm sieve size). This solid fraction (SF) was blended and then composted with dry straw (S), fresh garden refuse (GR) and swine manure slurry (SMS) (78% SF+20% S+2% GR+0.8 L SMS kg^{-1} compost, on a fresh weight basis) by the turned composting system during four months. The main characteristics of the soil and organic wastes are shown in Table 1.

Table 1. *Selected characteristics of the soil and organic wastes used (dry weight basis).*

	Soil	Organic wastes	
		FSF	CSF
pH	8,6	6.6	6.4
EC (S m^{-1})	0.07	0.23	0.29
Corg (g kg^{-1})	9.2	416.0	427.7
Nt (g kg^{-1})	1.0	19.4	15.7
C/N	9.2	21.4	27.2
P (g kg^{-1})	0.04	15.8	10.1
K (g kg^{-1})	3.8	6.3	7.9

EC: Electrical conductivity; Corg: total organic carbon; Nt: total nitrogen.

Six treatments, in a fully randomised design with three replicates per treatment, were established in experimental plots each one of 16 m^2, with a 0.5 m distance between plots. Fertiliser treatments were: MF, mineral fertiliser (with a complex 16 N-16 P_2O_5-16 K_2O) equivalent to 300 kg N ha^{-1}; FSF and CSF, organic fertilisation with fresh and composted solid fraction of swine manure slurry, respectively, at two different rates (supplying 300 kg N ha^{-1} and 450 kg N ha^{-1}), and C, a control treatment without fertilisation. The organic fertilisation was applied to soil 14 days before planting, while the MF was added on the day of planting. Cucumber seedlings of uniform size were selected and thirty-six seedlings were planted in each plot (equivalent to 2.25 plants m^{-2}). The fresh mass and dry mass of different parts of the plants were determined at the end of experiment, day 90 (after drying at 60ºC for 3 days). Plants samples were dried and mineralised by microwave acid digestion, using HNO_3/H_2O_2 in ratio 4:1 (v/v) (Kalra et al. 1988; Moral et al. 1996). Total K content was measured by flame photometry. N total Kjeldahl was measured according to Bremner and Britenbeck (1983). P was determined by measuring the absorbance of the phospho molybdovanadate complex at 460 nm. Statistical analyses were evaluated by ANOVA and differences among the treatments were separated by Tukey-b Test.

RESULTS AND DISCUSSION

In general, N concentration in the analysed plant parts was not increased by the biosolids amendment and the application rates compared to the inorganic fertilisation, MF, (Table 2). Similar or lower N extraction was observed with the increasing application dose of the solid phase of pig slurry, being this aspect more significant for the composted biosolids. N extraction by cucumber plants was the highest for the mineral fertilisation and for the low application rate of composted pig slurry (CSF).

In general, P extraction and plant content were positively affected by the organic amendment, with similar increase of this element for the composted and non-composted material. The increase of the application rate of the biosolids augmented P concentration in stem and leaves, but not in fruits. Inorganic fertilisation was not very efficient as P fertiliser compared to pig slurry-derived biosolids, especially considering total plant extraction.

Table 2. *NPK plant contents and nutrient extraction.*

	Nitrogen (g/kg)			Extraction
Treatment	Stem	Leaves	Fruit	(mg/plant)
C	12.3 ab	23.7 b	21.6 c	2698 a
MF	14.7 c	23.2 b	18.8 ab	3551 c
FSF-300	12.6 b	18.8 a	17.7 ab	3122 b
FSF-450	11.3 a	19.5 a	17.1 a	2920 ab
CFS-300	11.2 a	24.3 b	19.8 bc	3747 c
CFS-450	12.4 ab	24.2 b	17.0 a	2822 ab
ANOVA	***	***	***	***
	Phosphorus (g/kg)			Extraction
Treatment	Stem	Leaves	Fruit	(mg/plant)
C	3.9 a	4.1 ab	6.2 a	656 a
MF	3.4 a	4.6 bc	6.3 a	886 b
FSF-300	5.1 b	3.6 a	7.4 b	948 bc
FSF-450	5.9 c	5.3 c	7.6 b	1086 de
CFS-300	5.0 b	4.7 bc	7.5 b	1136 e
CFS-450	7.0 d	6.1 d	7.3 b	1035 cd
ANOVA	***	***	***	***
	Potassium (g/kg)			Extraction
Treatment	Stem	Leaves	Fruit	(mg/plant)
C	57 bc	20 ab	48 a	5190 a
MF	51 a	18 a	46 a	6481 bc
FSF-300	53 ab	19 ab	52 a	6933 c
FSF-450	53 ab	20 ab	49 a	6537 bc
CFS-300	51 a	22 b	57 b	8333 d
CFS-450	61 c	22 b	46 a	6184 b
ANOVA	***	*	**	***

****, ** and *: Significantly different at P<0.001, 0.01 and 0.05, respectively.*

In general, K concentration in the analysed vegetal parts was not significantly increased by the fertilising treatments compared to control plants. This effect could be associated to the dilution effect due to the higher biomass production in fertilised scenarios. In accordance with this, K extraction by plants was higher in the fertilised treatments, being this effect similar for all the treatments except for the CFS-300. Therefore, the solid phase of pig slurry can also supply K as well as the traditional inorganic fertilisation.

The fruit yield obtained by means of the fertilisation with CSF-300 and, in lesser degree FSF-450, was higher than the fruit yield produced by the MF or the control, whereas the greatest yield of cucumbers was observed in plots with CSF-300 treatment. The mass yield of aerial biomass was greater in the plots with inorganic or organic fertilisation compared to the control (Table 3). The aerial total biomass was the greatest in the crop harvested from CSF-300 plots, whereas in the other cases, this parameter was not affected by either fertilisation treatment or application rate (Table 3). A similar response pattern was observed by Smith et al. (2001) in an experiment with common bean grown on soil-compost mixtures, obtaining a lower bean yield when a high rate of garden and municipal market refuse compost was applied (50% (w/w) soil-compost mixture). The positive effect of the compost on the aerial total biomass yield might have been the result of a slower, but continuous release of nutrients throughout the experiment, as was reported by Laos

et al. (2000) with ryegrass grown with composted and non-composted residues.

***Table 3**. Yield and biomass production of cucumber plants.*

Treatment	Yield (g f.w./plant)	Total aerial biomass (g f.w./plant)	Marketable / non marketable biomass ratio
C	1443 a	1955 a	2.6 b
MF	1753 ab	2594 b	2.1 a
FSF-300	1553 ab	2359 b	1.9 a
FSF-450	1822 bc	2555 b	2.5 b
CSF-300	2053 c	2922 c	2.4 b
CSF-450	1670 ab	2322 b	2.5 b
ANOVA	**	***	***

****, ** and *: Significantly different at P<0.001, 0.01 and 0.05, respectively.*

The use of fresh and composted solid fraction of swine manure slurry as organic fertilisers showed a similar or higher effect on the yield and biomass production of cucumber plant than the mineral fertiliser. In general, increasing rates of organic fertiliser application did not result in greater biomass production. This fact is especially important for establishing the application rates for the composted solid fraction, where a reduction of the biomass production with the increment of rate was detected. The application of organic fertilisation seemed to induce and increment of the marketable/non marketable ratio compared to the inorganic fertilisation. This could indicate their better synchronism between nutrient availability and plant uptake in order to optimise crop production.

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