ENVIRONMENTAL AND ECONOMIC ADVANTAGES OF RECYCLING PIG SLURRIES

Gomez Garrido M., Estevez Rodriguez MD., Büyükkılıç Yanardağ A. ,Olivares AB., Faz A.

Research Group of Sustainable Use, Management and Reclamation of Soil and Water. Technical University of Cartagena. Paseo Alfonso XIII, 52 CP: 30203 Cartagena - Spain, E-mail melisa.gomez@upct.es
, y angel.fazcano@upct.es.

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INTRODUCTION:

The pig farming industry has grown in Murcia in recent years. This fact involves an important slurry accumulation close to the farm. Slurry management plays a crucial role in the integration of crops, livestock production systems and the interaction between agriculture and the environment. Excess manure from intensive livestock production is a recognised environmental hazard as its mismanagement threatens the quality of water resources and contributes to emissions of NH_3, CH_4 and N_2O. For these reasons, farmers search for options to reduce environmental impacts of excess manure, while remaining productive and economically viable. One interesting option is the agronomical use for slurry as an organic and inorganic fertilizer that besides being an additional source of macronutrients and micronutrient to plants is also an alternative for manure disposal (Ceretta et al., 2005)

Given the volume of slurry generated in Murcia, and the total cultivable area and considering the legislation, Royal Decree (RD) 261/1996, which allows a maximum application of 170 kg N/ha/year in areas designated as vulnerables, it is estimated that to implement the slurry generated in the region in a year, would require only half the arable land devoted to irrigation. In this way, this study includes a detailed monitoring of the effect of the application of pig slurry at a recommended concentration on the chemical, physical and biological properties of soil, water and plant to determine the influence of slurry on the reserve of macronutrient in each of these crops, as well as on soil contamination and to give some economical advantages for farmers and pig farmers besides the sustainable management of slurry and organic soil amendment taking into account the cost of fertilizer has increased in the last years. The effects of nitrogen (N) fertiliser and slurry management practices in agricultural systems has been calculated based on three application dose: valorised slurry pig as the only fertilizer, valorised slurry pig + chemical fertilizer and only chemical fertilizer. This pilot system put in contact pig farmers and farmers to collect the stored slurry for their valorisation and land distribution, in accordance with preventive measures that allow for their optimal use, without risk of contamination for the water-soil-plant system.

METHODS:

The present work was carried out in the most representative area in the Province of Murcia, SE Spain, with the highest pig production, as well as it is the most important horticultural area. For this work it has been selected 5 farmers (F) and 5 pig farmers (PF) according to the optimal distance between them.

Information about the farm management as well as crop cycles was collected by farmer's interview. Later, samples of soil and slurry were taken before and after slurry application. Plant samples also were taken at the end of each cultural cycle depending on the crop.

The pig slurry application was made as an organic-inorganic amendment soil before the crop cycle. The form of this application was in spreading band using a tanker. The N maximum dose of application is mandatory regulated (RD 261/1995) and established in 170 kg ha^{-1} $year^{-1}$ in special sensitive areas. In this work the dose of valorised slurry to apply has been calculated based on N content.

The rest of the chemical fertilizers doses were applied following the rules reported in the CBPA (Code of Good Agrarian Practices) as nutrients complement crop requirements.
Soils and pig slurries samples were collected in two consecutive years, 2008 and 2009. Soil samples were collected at surface level (0-30 cm) and at subsurface level (30-60 cm), with and without slurry application in order to see the influence of this application on soil composition. All the samples were analyzed by standard methods to obtain the texture classification for determining soil suitability for manure application according to the three fertilizer selected systems, values of total N (Duchafour, 1970), pH (Peech, 1965), electrical conductivity (Bower and Wilcox, 1965) and total P (Watanabe and Olsen 1965).

RESULTS AND DISCUSSION:

At the beginning of the study, farmers had to complete a questionnaire where they reported all the necessary information about the farm management (TABLE 1). In this questionnaire it is possible to find very important information such as slurry application method (surface spreading or injection), application time or the additional use of chemical fertilizer.
The most important decision about slurry spreading concern is the selection of spreading date and choosing the fields which are likely to produce only moderate leaching effects (Lewis et al, 2003). In this study the application method was surface spreading in all cases, as well as the date of application was in autumn, before the crops cycle starts. Application of slurry in autumn (as a single or split loading), invariably leads to large losses through N leaching, with a single application always resulting in the highest loss. Significant differences are evident for N leaching from different soil types (Lewis et al., 2003). Also climatic variation produces noticeable and significant differences in both N leached and harvest crop totals (Lewis et al., 2003). Nevertheless, in this study the farm manager can recognise and match the soil type and drainage condition of the fields on which spreading is to occur, as all the soil samples are analyzed in order to identify the textural classes. But, as it is shown in TABLE 3 the predominant textural class is *Clay*, what means low permeability and decreased risk of N leaching. Other important advantage is that this study has been developed within a similar climate region.

TABLE 1: **Farming management and crop information**.

FARMER	YEARS USING PIG SLURRY LIKE FERTILIZER	MACHINERY POSSESSION	CROPS	CHEMICAL FERTILIZATION
F1	3	NO	CEREAL	NO
F2	30	NO	ARTICHOKE, BROCCOLI AND CEREAL	YES
F3	2	YES	ARTICHOKE, CEREAL AND WATERMELON	NO
F4	3	NO	ARTICHOKE, BROCCOLI AND LETTUCE	YES
F5	5	YES	ARTICHOKE, BROCCOLI AND LETTUCE	YES

TABLE 2: **Physic and chemical data of pig slurry.**

PIG FARMER (PF)	EC dSm-1 2008	EC dSm-1 2009	pH 2008	pH 2009	Moisture (%) 2008	Moisture (%) 2009	NH4+ (g/L) 2008	NH4+ (g/L) 2009	TOTAL N (g/L) 2008	TOTAL N (g/L) 2009	P (mg/L) 2008	P (mg/L) 2009
PF1	30,270	27,750	6,360	7,120	96,020	84,400	2,120	2,150	2,460	2,510	94,000	75,500
PF2	40,770	36,500	7,380	6,950	89,150	92,220	4,350	3,150	6,260	2,500	111,670	323,300
PF3	25,730	26,530	8,190	7,440	96,520	89,020	3,000	2,790	3,950	3,120	174,330	397,000
PF4	31,770	28,970	7,910	7,730	97,260	91,260	3,310	2,480	5,050	2,930	207,000	110,700
PF5	30,270	41,670	7,630	7,710	98,340	95,230	3,340	5,580	3,870	6,640	270,000	277,700

The physic and chemical characterization of pig slurry (TABLE 2) showed that the changes produced in slurry pig nutrients composition, could be considered as a minimum variation due to changes in animal and farm management. Thus, this data allow calculate application dose according to the N content for both years. The additional amount of chemical fertilizers is applied, in each case, based on the published data in the current normative.

The results obtained in soil samples (TABLE 3) showed that the selected fields had optimal characteristics to agronomical use; the N and P content were lower than the published references values. Also is possible to see that the nutrient's content is higher at the surface level than subsurface level. This is due to the fertilizers application method, always by surface spreading, as well as the textural class (mainly Clay) (TABLE 3·). Even it is possible to see that the N content between years has suffered a minimum variation.

TABLE 3: **Soil data of sustainability areas of pig slurry selected.**

		AVERAGE	AVERAGE	2008	2009	2008	2009	2008	2009	AVERAGE
FARMER	**SAMPLE**	**pH**	**EC (mS/cm)**	**N Kjeldahl (g/kg))**		**P Olsen (mg/kg)**		**OC (%)**		**TEXTURAL CLASS**
F1	surface	7,825	0,942	1,273	1,528	263,481	650,110	0,871	1,540	CLAY-LOAM
	subsurface	8,192	0,462	0,935	1,259	148,540	463,630	0,585	1,280	CLAY-LOAM
F2	surface	7,814	1,203	2,172	1,134	313,331	259,380	0,990	1,330	CLAY-LOAM
	subsurface	7,856	1,545	1,816	1,028	159,952	262,280	0,644	1,150	CLAY-LOAM
F3	surface	8,349	0,241	0,875	0,557	257,848	316,280	0,685	0,620	SANDY-LOAM
	subsurface	8,090	0,682	0,625	0,513	177,455	237,030	0,413	0,850	SANDY-LOAM
F4	surface	7,644	0,885	1,122	1,025	545,457	474,750	0,890	0,670	CLAY-SILTY
	subsurface	7,797	1,142	0,897	0,951	360,208	349,610	0,737	0,580	CLAY-SILTY
F5	surface	8,053	0,442	0,962	1,148	480,171	380,690	0,911	0,500	CLAY-SILTY
	subsurface	8,068	0,914	0,759	0,887	353,483	283,080	0,684	0,420	CLAY-SILTY

TABLE 4 show the macronutrients required for each crop cycle en the case of irrigated and unirrigated crops such as barley, lettuce, watermelon and broccoli, according to technical management in Integrated Production Technical Standards (BORM Nº 138, 1998) and in TABLE 5 we can see the average content of macronutrients and oligoelements in accordance to the different stages of growth. In this way the estimation price has been adapted to the available crop information.

TABLES 4 AND 5: **Nutrient uptake according to the crop cycle (based on INTEGRATED PRODUCTION TECHNICAL STANDARDS, BORM Nº 138, 1998) and macronutrient per doses.**

CROP	PRODUCTION (kg/ha)	NITROGEN (kg/ha)	PHOSPOROUS (kg/ha)	POTASIUM (kg/ha)	CALCIUM (kg/ha)	MAGNESIUM (kg/ha)
BARLEY	**2.500**	**65**	**25**	**50**	**10**	**5**
LETTUCE ICEBERG	**50.000**	**100**	**58**	**245**	**25**	**5**
WATERMELON	**60.000**	**165**	**105**	**275**	**50**	**20**
BROCCOLI	**20.000**	**245**	**100**	**300**	**35**	**15**

AVERAGE	NITROGEN (kg/ha)	PHOSPOROUS (kg/ha)	POTASIUM (kg/ha)	CALCIUM (kg/ha)	MAGNESIUM (kg/ha)
FAT PIGS	**170,0**	**19,1**	**153,2**	**82,7**	**57,5**
COMPLETED CYCLE	**170,0**	**11,6**	**302,5**	**8,3**	**3,6**
BREEDING PIGS AND FAT PIGS	**170,0**	**6,2**	**109,6**	**19,6**	**12,1**
BREEDING PIGS	**170,0**	**13,3**	**33,9**	**21,9**	**9,5**

In TABLE 6 we show the comparison between three fertilizers options in order to evaluate the optimal decision. Thus, following the main objective of this study, an economic analysis was carried out taking into account equipment costs, in this case the tankers used for slurry transport and spreading, and potential savings in costs of N, P and K mineral fertilizer. The fertilizer's cost has been calculated according to crop requirements that make the Integrated

Production Technical Standards, published for these crops. The price for the tanker is the mean from different prices reported by farmers for several tanker capacities. On economic grounds, the use of tankers for surface spreading, could be justified in terms of fertilizer cost savings, because the additional costs of injection could be recouped in reduced fertilizer requirements, but comparing the results reported by others authors (McGechan and Wu, 1998) only half of the additional costs could be recovered in this way.

TABLE 6: **Economical data for three options of fertilizers evaluated.**

CROP	ONLY FERTILIZRERS (€)	ONLY PIG SLURRY (€)	PIG SLURRY AND SUPLEMENT (€)
BARLEY	210	200	207
LETTUCE ICEBERG	502	200	399
WATERMELON	708	200	507
BROCCOLI	783	200	570

Under the view of economic performance the most important objective is to convince farmers that this system is very suitable fertilization and is well supported by legislation. In addition the system is perfectly enhanced with the addition of suitable chemical fertilizers.

CONCLUSIONS:

The results of this study show that increasing rates of N applications (in the form of slurry and fertiliser) resulted in a non-linear increase before two years of study. And taking in account the economical conditions, we conclude that the mixed fertilizer option represented a saving of at least 50% compared to chemical fertilization, and taking advantage of liquid nutrients complement crop requirements that make the AIPG.
The repeated spreading of slurry on the same land area was shown to be a good practice from an economic standpoint, as well as being a sustainable option to manage the excess of manure. However, the economic and organisational feasibility of this system should be evaluated. Also, the content of others nutrients as a P, for example, should be further investigated.

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