COMPOST, MANURE AND SEWAGE SLUDGE APPLIED TO A CROP ROTATION

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ABSTRACT

The disposal of organic wastes specially from urban origin is a very serious problem. The recycling through agriculture is certainly one of the best solutions but it means a thorough control of the composition and doses applied, as well as the response of the crops, in production and quality. In this paper we deal with compost of solid urban residues, sewage sludge, and cow manure as a known reference, on a crop rotation of barley, rape seed, wheat and sorghum. The experience is planned on the basis of N crop needs, considering that manure and compost mineralize 60% the first year and 40% the second after their application, while sewage sludge does it 75% and 25%. Crop composition has not shown any significant difference between treatments, and a rather high production increase comparing with the testimony plot.

INTRODUCTION

Within the frame of two CICYT research projects (AMB 92-0577 and AGF 06-0966) the Department of Agronomy of the Escola Superior d'Agricultura de Barcelona (ESAB), has done several experiences of comparative application of three organic wastes (manure, compost and sewage sludge) in horticultural and extensive crop rotations in order to detect behaviour differences and to be able to define how to use and dosify them.

There is, at this moment, an special interet in the application of organic wastes on soils in order to facilitate their management. It seems, again, necessary to recover old application and dosage systems, employed years ago, but taking into account their great variation in composition, and the present environmental legislation (BOE 262, 1990; ECC Directive, 91/676; Llei Reguladora de Residus, 1993; BOE 131, 1998)

MATERIALS AND METHODS

Experience design. The plot in which we have worked (875 m2) is located in the ESAB experimental farm, in a zone of alluvial indifferentiated terraces. Soil is sandy loam and belongs to a xerochreft (Josa et al., 1984). Table 1 shows the soil general characteristics at the beginning of the experience. 7 treatments were applied with 4 repetitions in a random blocks design. These treatments correspond to a testimony (T), a treatment with only a mineral fertilizer (M), two treatments with compost (HDC and LDC), two with cow manure (HDM and LDM) and one with sewage sludge (LDS).

The fertilization, for the different treatments, was planned on the following propositions and hypothesis:

- waste dosage would be calculated on the basis of crops N needs;
- some treatments, considered high dose (HD) would supply all N needed from the different organic wastes;
- other treatments, considered low dose (LD) would supply 50% of N from the wastes and the other half as a mineral fertilizer;

- the needed quantities of P and K not supplied by wastes would be completed with mineral fertilizer;
- we consider that manure and compost would mineralise 60% the first year and 40% the second while sewage sludge would do it 75% and 25%. Former experiences have detected a higher mineralisation of sewage sludge compared with manure and compost;
- to calculate the fertilizing dose of 2nd and 3rd crops we considered the residual effects of the former waste applications, as said in previous hypothesis;
- mineralised N in periods between crops is supposed to be lost by leaching;

These propositions and hypothesis might be disputable and too simple, but the idea was to plan experiences in order to facilitate comparisons and balances.

The crops on rotation are barley, rape seed, wheat and sorghum. The experience has been planned on the basis of N crop needs. The last crop (sorghum) did no receive any fertilization

Materials. Manure came from the cow shed of the ESAB experimental farm (cow manure, chosen as a positive and well known comparison material); the sewage sludge, from the residual urban waters depuration plant; and the compost from the two different composting plants (Mataró that works with non selected MSW and Torrelles de Llobregat which treats the organic fraction (OF) of municipal solid wastes (MSW) proceeding from selective collection). There are important differences between wastes in the following parameters: water content, electric conductivity, organic, ammoniacal and non hydrolyzable N, stability level, nutrients and heavy metal content. Regarding these, the levels are within acceptable limits according to the spanish present legislation (BOE 131, 1998 and 3rd draft of CEE working document on sludge). It is necesary to point out that the Mataró MSW compost besides being very little stabilized has a higher content of heavy metals. It presents, as well, lower contents of organic matter and plant nutrients.

Figure 1 shows the applied dose of organic wastes. The total amount of residues to supply depends on their N content and their humidity. The manure amounts have been bigger because of their higher water content. This affects the transport and the spreading.

Figure 2 shows the total amount of heavy metals applied along the rotation. The treatments HDC and SSLD supply the higher quantities. Figure 3 shows the amounts of heavy metals applied along the rotation in HDC treatment; it is clearly seen that the higher supply corresponds to barley for two reasons: in the first crop, the supply was higher and it had a worse quality because the compost applied was from Mataró.

Methods. Residues were weighted in the field and hand spread, and buried with a rotary cultivator. We must point out the greater facility of compost spreading due to its granulometry and low water content.

Representative samples of soil were taken before wastes applications and at the end of the crops to analyze the general characteristics and total contents of heavy metals. Samples of the crops were taken in order to determine the production and to make the corresponding analysis.

RESULTS

Regarding soil. The soil initial and final general characteristics are shown in table 1. Figure 4, shows the changes in organic matter content of the soils of different treatments. We must point out the small differences in the final content of OM, and that this content is significantly higher in the MHD treatment. As we thought treatments M and T present lower values. A significative increase has appeared in the assimilable P levels in the MHD treatment, but no in the K levels, even if there are important increases in MHD and M treatments.

Table 2 illustrates the heavy metals contents at the end of the rotation compared with the mean values of the soil at the beginning. No significative differences have been found.

Regarding crop production. In figure 5 we find the grain production results of the first three crops. Shorgum is not included as we controlled the whole plant production, which oscilated between 21 (T treatment) and 29 ton/ha (MLD and CHD). Such a high production seems due to irrigation.

Differences in production have been very much related to climate conditions, and to the fact of having had, or not, irrigation. The testimony, as it was thought, has had a clearly decreasing production. The mineral fertilizer application, in the correct moment, has had a great influence in the rape seed, in which the higher production corresponds to treatment M.

In this study we have had a special interest in the behaviour of the N coming from the different wastes, and how to calculate doses. For this, we have taken into account the residual effect of each application and its influence in future crops. Figure 6 shows, as an example, the origin of N received by wheat; we must point out the important amounts from the preceding crop (rape seed) in treatments CHD and MHD.

Regarding grain composition. Due to length limitations Table 3 shows only the grain composition of the rape seed. For wheat, little differences have been found in N content, with higher values in treatments M and SSLD, which we relate with the more assimilable forms of the applied N. For rape seed the differences found between treatments are smaller, being specially low the value of the grain of T treatment. In wheat significative differences have appeared amongst which the higher values for treatments SSLD and lower values for treatments T y CHD. We suppose that CHD treatment has mineralized less N than expected. No differences have been found for P and K contents. For rape seed we studied the oil content in seeds, founding differences significatively higher for the T and MHD treatments which we relate with the lower N contents.

Table 4 shows the heavy metals levels in the grain of the same crop and it is possible to observe no significant differences. From grain analysis and production we made the extractions calculations to estimate their relation with the hypothesis of mineralization.

Figures 7a, b, and c, compare the extractions of Nitrogen of the first three crops with organic and mineral nitrogen applied or estimated for three treatments.

TRANSPORT, HANDLING AND SPREADING

The great problem is, now, if the farmers, in general, will accept the use of these residues as a normal part of their agronomic practice. On one hand, we know it is more “easy” to rely on chemical fertilizer; we have mentioned, also, the normal scarcity of organic matter in most of our soils and there is no doubt about the need of O.M. for the correct management of a soil.
At this moment we know several examples of modified manure spreaders (with four, or even six, vertical axis distributors at the far end of the box, two rotating plates of large diameter at

the bottom of those and a good hydraulically driven transportation chain) which are doing a quite satisfactory job.

An important part of the job is handling the material: discharging, keeping it for a time without generating problems, charging the spreader. It is not very complicate but it needs a certain amount of space for maneuvers, a consistent pavement and an efficient system for effluent recovery, and this, of course, has a cost.

For transportation the cost is, mainly, a matter of distance, but also, if the most appropriate lorries are used, for quite a number of hours or kilometers per year, the cost can be kept "reasonable". If we consider the general structure of most, or many, of our farms, their size or conditions do not allow them to consider, on their own, to have the appropriate material for this operation. The ones that could do it, or that have the materials needed, are the dairy farms, for example, and they have their own OM. If the farm has to set the premises and buy the machinery, in most cases, the cost would be too high. An if they try to save on machinery or installations their rate of work will be much lower thus increasing the operation cost.

The only, or one of the possible, solutions seems to be to offer the farmers the product "spread on field". There are some contractors, and some composting plants directly, that offer this service. They can have a certain amount of help from administrations and can reach low enough prices by means of scale economy.

CONCLUSIONS

The different characteristics presented by the wastes employed do affect the application doses and the velocity of nitrogen mineralization

The behaviour detected for the different treatments seems to confirm different mineralization velocities for the three materials and certainly different of the one estimated for compost.

The effects on soil appear in parameters such as OM, P and K content, mainly in the manure treatments. There are no significative differences in heavy metals content.

The differences found in production are more due to the crop conditions than to the different treatments. No important differences in grain composition have been detected, mainly in heavy metal content.

In order to facilitate the correct use of this kind of materials more should be studied of their characteristics and their behaviour, besides the possibility to keep their composition within a reasonable rank.

The interest for the farmers to apply these wastes will depend greatly on their being offered at a reasonable cost, considering transport, handling and spreading.

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Table 1. General characteristics of initial and final soil of different treatments.

Treatments	pH	EC, dS/M	% OM	ppm P Olsen	ppm K Soluble
Initial soil	8,1-8,2	101-109	1,9-2.0	22-27	50-65
CHD	8,17 a	115 b	2,06 ab	38,0 b	82 a
CLD	8,14 a	115 b	2,17 ab	36,2 b	84 a
MHD	8,13 a	122 ab	2,28 a	54,9 a	109 a
MLD	8,19 a	135 a	2,00 ab	38,6 b	96 a
SSLD	8,01 a	127 ab	1,98 ab	39,9 b	94 a
M	8,15 a	127 ab	1,85 b	35,9 b	112 a
T	8,20 a	98 c	1,82 b	27,5 c	54 b

Table 2. Heavy metals level (ppm) in the soils of different treatments at the end of the extensive crop rotation.

Treatments	Cu	Cr	ppb Cd	Ni	Zn	Pb
CHD	19 a	7 b	139 a	6 a	59 a	12 a
CLD	19 ab	7 b	125 b	6 a	55 a	12 a
MHD	18 ab	7 b	125 b	6 a	54 a	12 a
MLD	18 ab	7 b	117 b	6 a	53 a	12 a
SSLD	19 ab	9 a	148 a	6 a	54 a	12 a
M	18 ab	8 b	123 b	6 a	53 a	11 a
T	17 b	7 b	121 b	6 a	52 a	11 a
Initial soil	17	7	140	6	44	12

Table 3. Macronutrients content in rape seed oil.

Treatments	% N	% P	% K	% Oil
CHD	2,97 ab	0,71 ab	0,75 a	39,6 b
CLD	2,96 ab	0,69 ab	0,68 a	40,1 b
MHD	2,74 b	0,73 a	0,73 a	43,8 a
MLD	3,17 a	0,71 ab	0,75 a	40,7 ab
SSLD	3,15 a	0,70 ab	0,71 a	40,9 ab
M	3,16 a	0,66 b	0,71 a	38,2 b
T	2,62 b	0,72 ab	0,69 a	44,1 a

Table 4. Heavy metal content (ppm on dry matter) in wheat grain.

Treatments	Zn	Cu	Cr	Ni	Pb	Cd (ppb)
CHD	21 a	5 a	<0.5 a	0.9 a	0.5 a	<50 a
CLD	22 a	5 a	<0.5 a	0.7 a	0.5 a	<50 a
MHD	22 a	5 a	<0.5 a	0.8 a	0.5 a	<50 a
MLD	24 a	5 a	<0.5 a	0.8 a	0.5 a	<50 a
SSLD	23 a	5 a	<0.5 a	0.9 a	0.5 a	<53 a
M	21 a	5 a	<0.5 a	0.9 a	0.5 a	<50 a
T	18 a	5 a	<0.5 a	0.9 a	0.5 a	<50 a

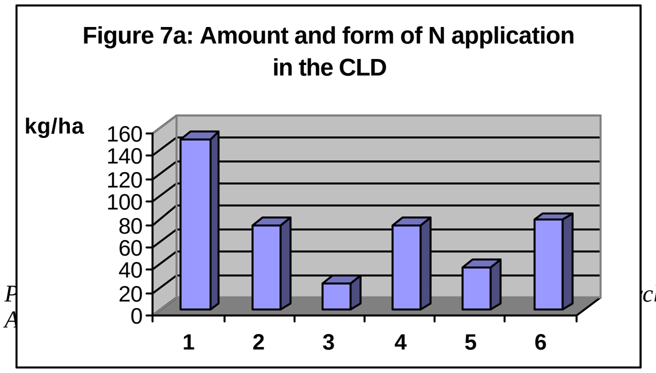

Figure 7a: Amount and form of N application in the CLD

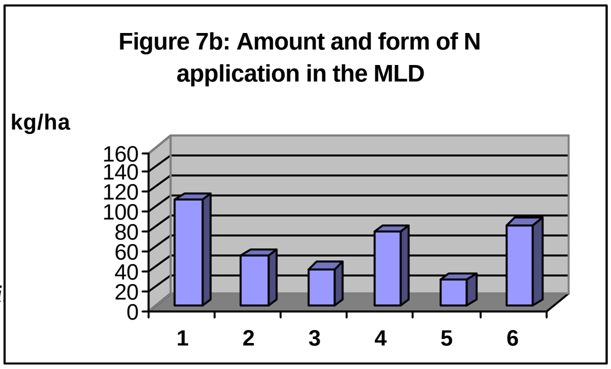

Figure 7b: Amount and form of N application in the MLD

6. N extracted. **CLD**; Compost Low Dose**. MLD**; Manure Low Dose; **SSLD**; Sewage Sludge Low Dose.

1. Total organic N **2**. Organic hydrolysable N

3. Mineral N applied with residue **4**. Mineral fertilizer N

5. Organic N we estimated to have been mineralized

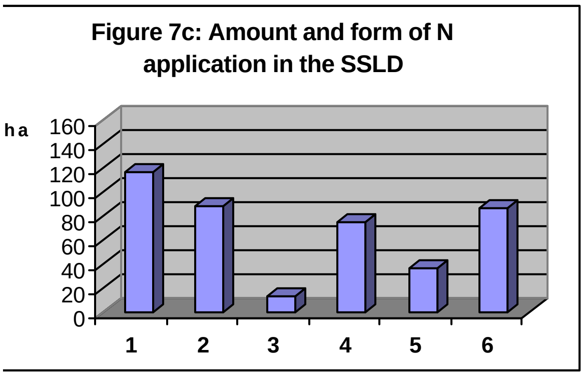

Figure 1. Supply of residues along the rotation, expressed in terms of fresh and dry matter.

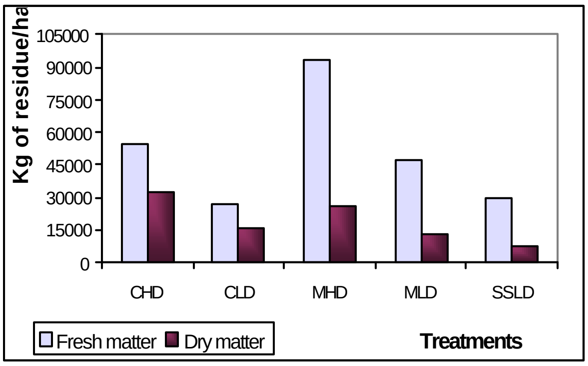

Figure 2. Total estimated supply of heavy metals along the extensive crops rotation.

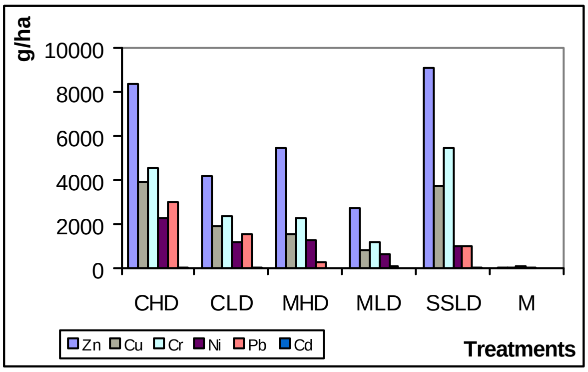

Figure 3. Total estimated supply of heavy metals along the extensive crops rotation in the CHD treatment.

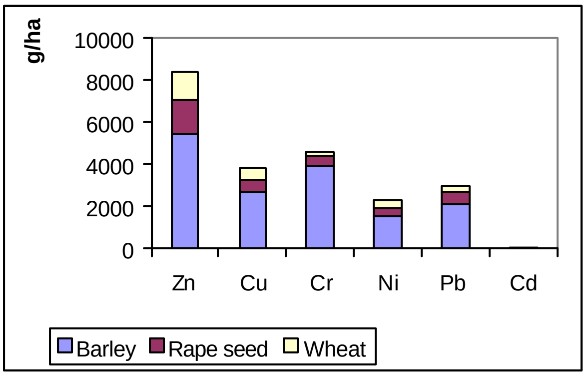

Figure 4. Evolution of OM content along the extensive crops rotation

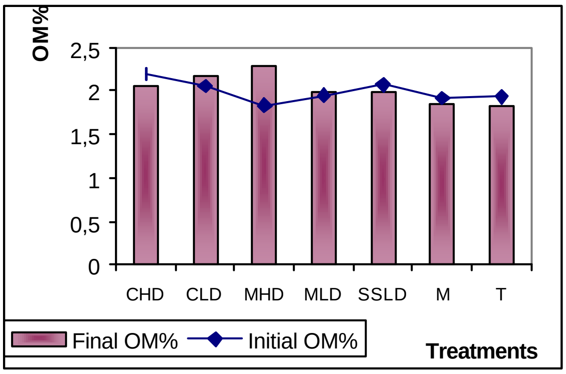

Figure 5. Grain production for the different studied crops, in kg per ha.

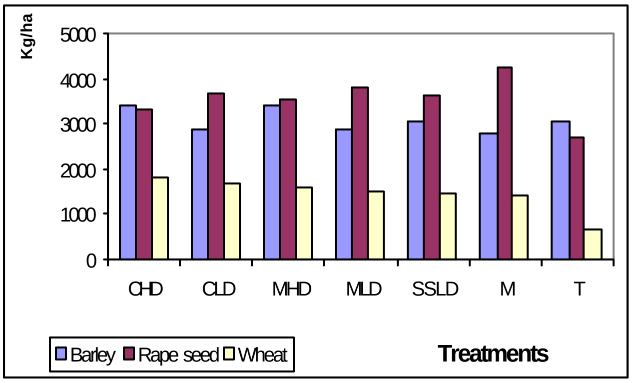

Figure 6. Origin of the organic N supplied to wheat, in %.