Potential substitution of mineral N fertilizers by organic residues at the territory scale.

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Abstract
The recycling of organic residues on cultivated soils could make possible the partial substitution of mineral nitrogen (N) fertilizers. An inventory of all organic residues available or potentially available was realized in a suburban territory where animal breeding is scarce and the availability of their N was assessed in laboratory controlled conditions. In this same territory, the major crop successions were determined and the total need for mineral N was calculated based on the fertilization practices of the farmers. The territory was located near Versailles (Ile-de-France) had a total surface of 178 km^2 from which 9900ha were cropped. The major crop successions included rapeseed and cereals and the total needs in mineral N represented 1300 tons of N each year. The total N present in the organic residues represented 808 tons of N from which only 185 tons were easily available, representing 14% of the total needs from crops. Thus, mineral N fertilization can be partly substituted by organic residues even where animal manures are poorly available. The increase of soil organic matter through regular organic amendments applications could constitute another way of mineral N fertilizer substitution.

Introduction

The recycling of organic residues on cultivated soils could make possible the partial substitution of mineral nitrogen (N) fertilizers [1]. The availability of N in organic residues must be known to adjust the applied doses to the crop needs and apply some additional mineral N fertilizer if necessary without excess N in soils leading to risk of nitrate leaching. Organic residues can also be applied to increase soil organic matter [2], thus indirectly increasing N availability for crops. To determine how fare such substitution of mineral N by organic residues is possible, a study was realized at the territory scale including 3 inventories: (i) of soil and crop distribution, (ii) of available organic residues, (iii) of farmers 'practices for N fertilization. The results were used to compare the needs in mineral N fertilizer with the available N in the organic residues.

Material and Methods

Characterization of the territory

The studied territory was the "Plaine de Versailles and Plateau des Alluets" (PVPA), located in Ile de France, west of Versailles. It represents 178km^2 from which 9900ha are cropped. There are 82 farmers from which 60 cultivate cereals and with very few animal breeding. The area is constituted by plateaux separated by river valleys and the most frequent soils are luvisols and cambisols.

Inventory of crop successions and mineral N fertilization practices

Representative farmers were interviewed to determine the main crop successions and practices of nitrogen fertilization. Based on these interviews and annual declaration of crop localization, a map of the main crop successions was realized.

Inventory and characterization of organic residues:

An inventory of all available or potentially available organic residues was realized and all residues were sampled and characterized for classical physic-chemical analysis (dry matter, total organic carbon, total N and mineral N). The N availability was assessed through potential organic N mineralization in laboratory controlled conditions during incubation of organic residue in soil and measurement of the dynamic of organic N mineralization (French standard XPU 44-163, [3]).

Results and discussion

Main crop successions and mineral N fertilization

By interviewing 15 among the 82 farmers present in the territory, the main crop successions were assessed and validated by the farmers' advisers. There were 3 or 4 years successions including rapeseed and cereals (Table 1). Based on the yearly declaration of the farmers concerning their use of the cropped surface, the distribution of the main crop successions in the territory was assessed (Figure 1) and their surface calculated (Table 1). The assessed surface represented 80% of the total cropped surface and was considered as representative of the major crop successions.

Still based on farmer interviews, the fertilization practices were assessed and are reported in table 1for each crop succession. The average mineral N fertilization was 170 kg N/ha. The total yearly needs for mineral N were calculated and represented 1300 tons N (Table 1).

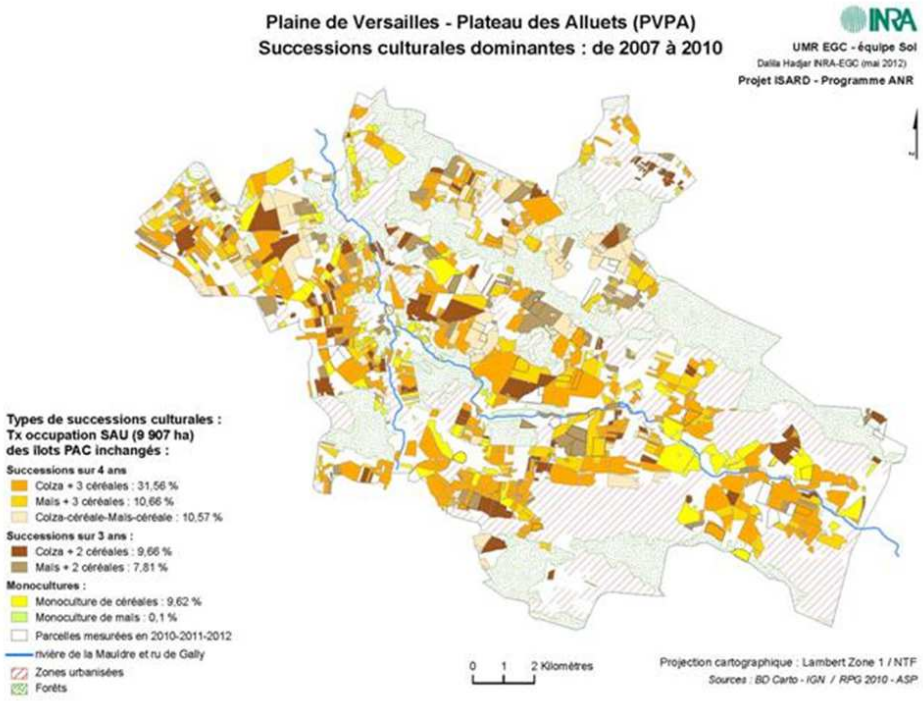

Figure 1: Map of the PVPA territory with the distribution of the main crop successions

Table 1: Main crop successions in the PVPA territory, average mineral N fertilization of the crop succession and total mineral N needed for the fertilization of the total surface of the successions

	% cropped surface	Average Mineral N kgN/an	Total need tons N/an
Rapeseed +3 cereals	31.6	158	492
Maize+3 cereals	10.7	131	139
Rapeseed/wheat/maize/wheat	10.6	168	176
Rapeseed+2 cereals	9.7	172	164
Maize +2 cereals	7.8	176	136
Continuous wheat	9.6	210	200
Continuous maize	0.1	150	1
Total	**80.0**		**1308 tN**

Inventory and characterization of organic residues:

The organic residues were split into (i) organic amendments (26870 tons DM and 435 tons N) characterized by stabilized organic matter, high potential efficiency at increasing soil organic matter and (ii) organic fertilizers with high availability of their N (6455 tons DM and 374 tons of total N). The most abundant residues were organic amendments including greenwaste composts and horse manures (Table 2). The potentially available biowaste composts represented 15% of the organic amendments.

Table 2: Total organic residues available or potentially available* in the PVPA territory. Total N contents in these organic residues.

	Quantités T MS	Ntot %MS	N total tons N
Organic amendments			
Greenwaste compost	10520	1.5	161
Biowaste compost*	4079	1.7	71
Horse manure	4140	1.4	56
Farmyard manure	1050	3.1	32
Other manures	600	3.0	18
Fertilys (Greenwaste compost+animal flour)	6480	1.5	97
Fertilizer organic residues			
Cow slurry	400	3.1	13
Dried poultry manure	200	3.8	8
Composted poultry manure	210	1.8	4
Humival (dried pig slurry)	700	5.3	37
Dried sewage sludge	3515	7.0	247
Limed sewage sludge	1430	4.5	65
Total			**808 t N**

*All municipal wastes are incinerated by now. The potential amount of biowaste compost was calculated based on 30% of the total municipal waste potentially treated by composting, and a yield of 30% of compost produced from the fresh mass of treated fermentescible biomass.

The major part of N was present as organic N in the organic residues and needed to get mineralized in order to be used by the crops. The dynamics of organic N mineralization was assessed during incubation of soil-residue in laboratory controlled conditions. The initial mineral N present in the residues was added to the potentially mineralized organic N to determine the potentially available N (Figure 2).

The sewage sludges (dried and limed), the poultry manure and Humival (commercialized product corresponding to dried pig slurry coming from Brittany where animal breeding is largely present) were the organic residues presenting the largest availability of their total N. The sludges represented 54% of the residues characterized by a large availability of N. Based on the results of organic N mineralization during incubation, the easily available N was calculated for each organic residues. For all residues, the total available N was calculated as equivalent to 185 tons each year (Table 3). Thus the total N potentially present in organic residues in the territory represented 62% of the total needs but decreased to 14% when only the easily available N was considered.

Table 3: Proportion of easily available N in the organic residues characterized by a large availability of their N for crops.

	Total N tons N	Available N % totN	Available N tons N
Cow slurry	13	64	8
Dried poultry manure	8	39	3
Composted poultry manure	4	28	1
Humival (dried pig slurry)	37	47	18
Dried sludge	247	51	127
Limed sludge	65	44	29
Total			**185 t N**

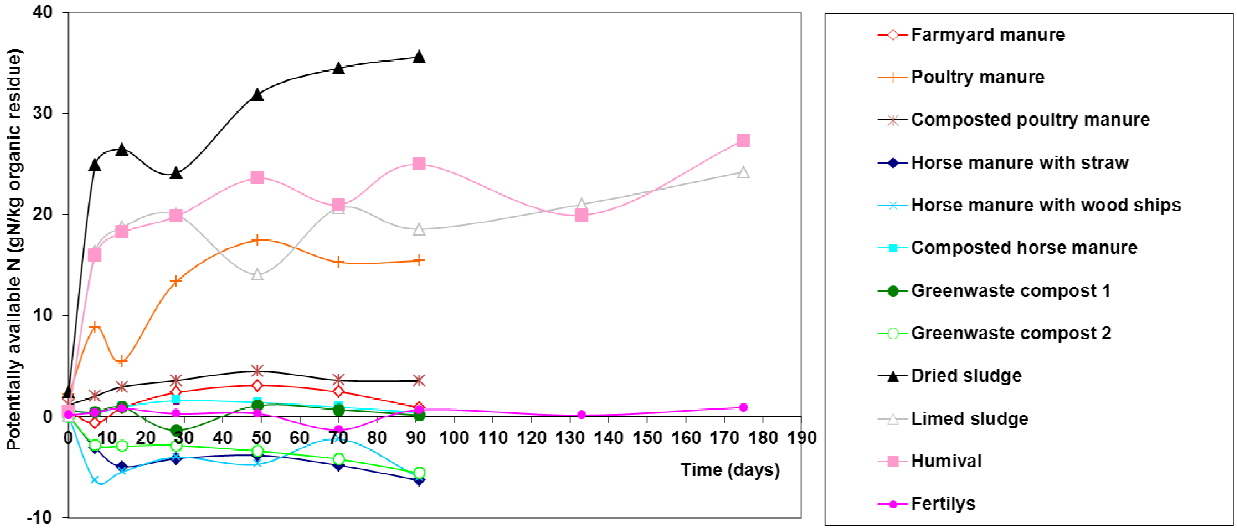

Figure 2: Assessment of potentially available N in the organic residues based on results of organic N mineralization during incubation of soil-organic residues in laboratory controlled conditions.

Conclusion and perspectives

The recycling of organic residues represent important sources of organic matter that can be used in substitution of mineral fertilizer, even where animal breeding is scarce in suburban areas. The substitution can be yearly made using residues characterized by high availability of their organic N but also via the increase in soil organic matter generated by regular applications of organic amendments. Further simulation of the scenarios of application will conclude on the benefits or environmental impacts of both ways of substitutions.

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