Organic amendments in horticultural production

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Abstract
Mineralization of organic amendments applied to soils in field conditions has been little studied in Uruguay. Ours objectives were: a) to document the amount of the most frequently organic amendments applied to soil for intensive productions; b) to know the range of N concentration in soils of commercial greenhouses at crop plantation; and c) to characterize in situ the nitrogen mineralization from organic amendments and their effects on tomato yield under greenhouse conditions. Dairy or poultry litters were applied to representative soils of the two horticultural zones in Uruguay, at the rate usually applied and at the half of that rate. Soil mineral N was monitored periodically and crop yield was measured. The organic amendment most frequently applied in the North Zone was dairy litter, at rates ranging from 30000 to 55000 kg/ha and in the South Zone, was poultry litter, at rates from 10000 to 31250 kg/ha. The mineral N in the soils ranged from 30 to 496 mg/kg. In the greenhouse experiments N mineralization was closely related to soil temperature and soil physical characteristics. Crop yields were higher in soils with lower amounts of organic amendments. More field studies are needed to improve organic amendment recommendations.

Key Words
Decomposition rate, mineralization, immobilization

Introduction
The incorporation of organic amendments to improve the physical properties of degraded soils is a common practice in intensive production in Uruguay. However, the application of organic amendments is performed regardless their chemical and physical characteristics or history of application of organic materials. In addition, inorganic fertilizers are also frequently applied. Improper use of amendments may limit the production of crops due to nutrient imbalances excessive amounts of some nutrients or deficiencies induced by others, disease problems arising from the risk of environmental pollution by excess nutrients accumulated in the soil may cause deterioration in soil quality.

The prediction of the amount nitrogen mineralized from organic amendment is necessary to improve N recommendations. The mineralization of organic amendments is a microbial process that depends on the nature of the amendment (C and N content, C/N ratio, and fiber, lignin and soluble C content) (Trinsoutrot *et al.* 2000; Calderón *et al.* 2004) as well as environmental factors (temperature and humidity) that promote increased microbial activity (Kowalenko *et al.* 1978; Kelley and Stevenson 1987; Paul and Beuchamp 1996). Soil characteristics (texture, pH) have been reported as other factors that affect the mineralization of organic materials (Hassin, 1994). These are factors determining the release or immobilization of N and other nutrients (Eghball 2000). Therefore the estimation of N mineralization, in order to adjust N availability for crops and requirements is important, not only in economic but also environmental terms Although incubation studies are normally used to estimate the mineralization rates from organic materials under laboratory conditions (del Pino *et al.* 2008), studies under field conditions need to be done. Therefore, the objectives of this study were: a) to document the amount of organic materials applied frequently to soils for intensive plant productions; b) to know the N concentration in soils in commercial greenhouses previously under crop plantations; c) to characterize the decomposition and release of nutrients from organic amendments in situ and their effect on yield in actual greenhouse tomato production.

Methods
Greenhouse survey
Twenty five greenhouses in the South Zone and twenty in the North Zone were surveyed during the spring of 2007 and 2008. The farmers were asked about the type of amendment used, amount, and time before planting crops. In the South Zone, composite soil samples from the 0-15 cm depth were taken and analyzed for NH_4^+ and NO_3^- (Table 1).

Greenhouse experiments
Two greenhouse experiments were conducted during 2007 and 2008 in the North Zone and during 2008 in the South Zone of Uruguay. The soils were a sandy soil and a clay soil, respectively, being representative of the horticultural zones of the country.

Three treatments were applied to plots arranged in a randomized complete block design with three replicates. The treatments were three rates equivalent to 0, 300, and 600 kg N/ha of poultry or dairy litter. The poultry litter was obtained from a local commercial farm and consisted of a mixture of poultry feces and rice hull bedding. The dairy litter compost was taken from an unsheltered pile and consisted of a mixture of relatively fresh and old feces and forest bedding, including soil. The organic amendments analyses are shown in Table 2. Two or three weeks after organic amendment application, the tomato crop was planted at a rate of 25,000 plant/ha. All culture practices, except organic amendment application were those conducted by the farmers. Crop harvests were made during May to Jun in the North, and from January to April in the South.
After treatment application, soil samples were taken at 1, 15, 30 days, and each month during the growing season, using plastic 5 cm diameter and 15 cm depth tubes inserted in each plot. For each sample, NH_4^+ and NO_3^- were determined. For all treatments soil temperature was maintained.

Table 1. Selected characteristics for soils used in the study.

	Sandy soil	Clay soil
Total sand (g/kg)	907	118
Total lime (g/kg)	5	591
Clay content (g/kg)	88	291
pH (H_2O)	7.3	7.7
Org. C (g/kg)	8.1	13.0
NO_3^- (mg/kg)	33.0	102.0
NH_4^+ (mg/kg)	6.0	7.0
K ($cmol_c$/kg)	0.34	0.52
Ca ($cmol_c$/kg)	6.23	9.8
Mg ($cmol_c$/kg)	1.36	4.5
Na ($cmol_c$/kg)	0.48	0.76
P-Bray-1 (mg/kg)	108	323

Table 2. Chemical and physical characteristics of the organic amendments used in the experiments.

	Unit	Broiler litter	Dairy litter compost
Dry matter	%	70	47
Density	g/cm^3	0.24	0.70
pH^A		7.73	6.29
Total C	g/kg	283	178
Soluble C	g/kg	50	16
Total N	g/kg	17.7	8.8
C/N		16	20
NO_3^- -N	mg/kg	131	36
NH_4^+ -N	mg/kg	77	14
Total P	g/kg	14.5	1.5
K	g/kg	7.8	2.9
S	g/kg	2.65	0.91
Ca	g/kg	23.0	7.9
Mg	g/kg	3.2	2.5
Na	g/kg	1.6	0.2
Lignin	g/kg	166	109
Polyphenols	g/kg	253	29
Ash	g/kg	178	727

^{A}pH was determined on 1:1 water to dry organic amendment ratio

Results

Greenhouse survey
The type of organic amendment most frequently applied in greenhouses in the North Zone was dairy litter, in amounts ranged from 25 to 55000 kg/ha. In the South Zone, the most frequently used organic amendment was poultry litter, and the amount usually applied ranged from 10000 to 31250 kg/ha. Other sources of

organic amendments were poultry manure, which amount ranged from 5500 to 26000 kg/ha. Other organic amendments applied were poultry feathers, horse manure, or composts from different origin. The average application rates of those materials were 60000, 25000, and 17000 kg/ha, respectively.
The mineral N in the soils for the South Zone ranged from 30 to 496 mg/kg (Figure 1). This amount of N is greater than the amount that can be removed by a tomato crop, assuming a N concentration in tomato fruit of 16 g/kg and 5.6% dry matter.

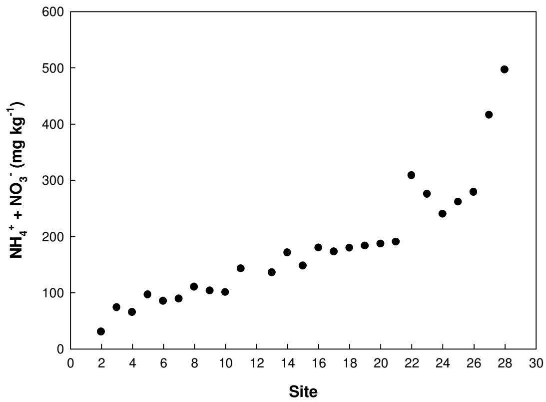

Figure 1. Mineral nitrogen in 0-20 cm soils from greenhouses, before planting crop.

Greenhouse experiments-Nitrogen mineralization
Soil temperature ranged from 10 to 45ºC during the field study. Nitrogen mineralization was closely related to soil temperature (Figure 2) or sampling date (Figure 3). There was a trend for amended soils to present greater amount of mineral N than control soils, especially in the period following the application. Net N mineralization was determined by subtracting the N mineralized in the control plots from the amended soils and dividing the difference by the total amount of N applied. About 20% of applied total dairy litter N and 30% of the poultry litter were mineralized in 2007 and 2008. The low N mineralization of the dairy litter may be explained by the relatively high C/N ratio, and the low N content of the material. This determined the net immobilization of N during the growing season.

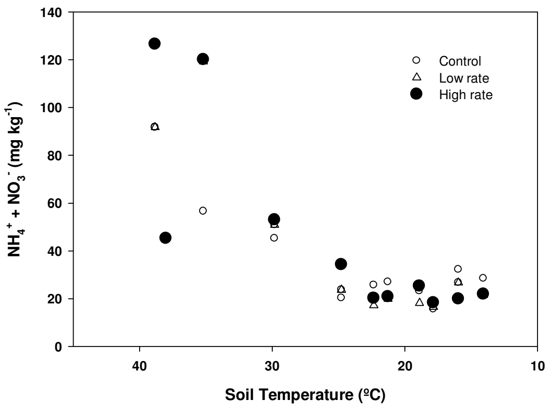

Figure 2. Relationship between nitrogen mineralization and soil temperature in soils receiving dairy litter in rates of zero, half rate (300 kg N/ha) and full rate (600 kg N/ha).

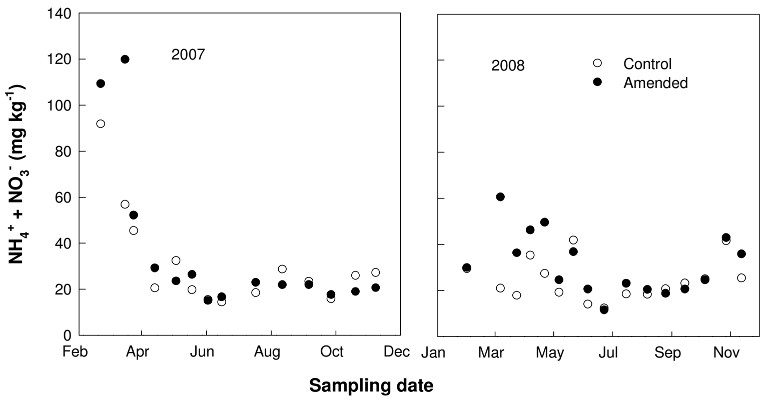

Figure 3. Relationship between nitrogen mineralization in amended and unamended soils and sampling date for the Sandy Soil in 2007 and 2008.

Tomato Yield

Tomato yield was similar for both zones and there were significant differences between treatments (Table 3). In the North Zone experiment, tomato yields for the control or the full rates were lower than half rate. At the SouthZone, the yield was higher in the control or half rate, comparing with the full rate. These results may indicate that the organic amendments applied in full rate may supply excessive nutrients to the crop.

Table 3. Tomato yield for North Zone and South Zone.

Organic N amendment rate kg/ha	North	South Mg/ha
Control	74b	77a
Half	79a	81a
Full	76b	69b

Conclusion

Our results show that reduced organic amendment application may produce best yields and decrease the risk of excess of nutrients. More studies are needed to develop organic amendment recommendations.

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