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THE USE OF COVER CROPS AFTER A MAIZE CROP IN THE NORTH OF SPAIN

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Abstract

This work intends to study N leaching losses in a field assay when crimson clover (*Trifolium incarnatum*) and italian ryegrass (*Lolium multiflorum*) was incorporated into the soil and quantify the their effect on N_2O, N total gaseous losses under controlled soil moisture and temperature conditions. Field assay: A split-plot design where main plot was the cover crop and the subplot was the rate of fertilizer (0 and 150 kg N ha^{-1}) applied to the subsequent maize crop. Laboratory assay: Residues of italian ryegrass and crimson clover were mixed with soil in containers, leaving one set of unamended controls. Incubations of soil during 27 days with a 0, 5 or 0.01 % C_2H_2 atmosphere allow us to obtain potential N_2O and N total gaseous losses. In the field experiment crimson clover incorporation was better than ryegrass to resolve nitrate leaching losses due to 150 kg N ha^{-1} applied to maize although clover incorporation in the laboratory assay seemed to increase the risk of N_2O emissions despite most gaseous losses were in the form of N_2.

Keywords: Ryegrass, clover, maize, cover crops, nitrate leaching, N gaseous losses

Introduction

A maize crop requires high N inputs and residual amounts of soil mineral nitrogen at harvest being greater than values environmentally desirables (Vanotti and Bundy, 1994), with risk of nitrate leaching. The use of cover crops is a way to reduce this risk because they remove the nitrogen left in the soil by the summer crop and can be used as a green manure for the subsequent summer crop. However, an input of degradable organic material to soil provides reducing agents for denitrification, is a substrate for respiration and may induce O_2 limitation (Parkin, 1987) which are favourable conditions for N_2O formation, this gas is involved in the greenhouse effect and ozone layer depletion. Our objective was to study N leaching losses in a field assay when crimson clover and italian ryegrass were incorporated into the soil and quantify their potential effect on N_2O, N total gaseous losses under controlled soil moisture and temperature conditions.

Material and Methods

Field assay. A split-plot design with 4 replications was established at Derio (Northern Spain) in October 1996. The soil was a Gleyic Luvisol, silty clayed loam and initial values in the 0-25 cm layer were: pH=5.3, MO=1.6%, C/N=12, P=50.4 mg kg^{-1}, and K=135 mg kg^{-1}. Main plot (162 m^2) was the winter cover crop (Italian ryegrass -40 kg ha^{-1} seeding rate- and Crimson clover -35 kg ha^{-1} seeding rate-) whereas the subplot (81 m^2) were two rates of fertilizer (0 and 150 kg N ha^{-1}) applied to the subsequent maize crop. The cover crops were destroyed with herbicide on April and on May the plant residues were incorporated into the soil up to 15-20 cm depth. Maize was sown on May and harvested on October.

The apparent N recovery in maize (ANR) of the N incorporated into the soil with the cover crops was calculated by balance as a percentage, considering the N in the above ground cover crop and the N extracted by maize after cover crop or after fallow in the following way:

ANR (%) = 100 * (N in maize after clover – N in maize after fallow) / N in clover

To determinate nitrate leaching losses teflon cups were located at 90 cm depth on November 1997. During the drainage period they were sampled weekly or after 25 mm rain.

Laboratory assay. The soil used was collected from a grassland area nearby the field assay from the 15 cm soil surface layer. The soil was air-dried and passed through a 5 mm sieve. 1 kg of soil dry weight was placed into 1 l opened containers. Residues of italian ryegrass and crimson clover were collected from the experimental field. Fresh material was dried at 65 ^{o}C, chopped into 20 mm pieces and 15 g mixed with the soil in each container, leaving one set of soil containers as unamended controls. C/N ratios in crop residues are shown in Table 2. At the same time, 97.5 mg N kg^{-1} as potassium nitrate (13 %) was applied per container (150 kg N ha^{-1}) in half of the containers, being the other half (0 kg N ha^{-1}) as control. Three replicates were made for each N source, residue and sampling date. The moisture content was adjusted by weight to field capacity and was maintained along the experiment.

The containers were incubated at 25 ^{o}C. Soil was sampled 1, 2, 3, 7, 10, 13, 16, 20, 23 and 27 days after residue incorporation. 300 g of soil were taken from each container (27 containers per sampling date) and incubated in 1L jars with a 0, 5 or 0.01 % C_2H_2 atmosphere to distinguish between N_2O coming from denitrification or nitrification. After 24 hours incubation, 8 mL of gas were stored for N_2O analysis by gas chromatography. NH_4^+-N and NO_3^--N contents were determined from soil in 0 % C_2H_2 incubations, 100 g wet soil were extracted with 200 ml KCl 1 M and analysed using a flow injection analyser. The ANR was derived from balance calculations accounting for the initial and final soil mineral N contents, the N applied and the accumulated N gaseous losses in the residue applied and in the unamended containers.

Results and Discussion

In year 1, the ANR of the aboveground N content of clover was 18.7 % (33.9 kg N ha^{-1}) (Table 1). In year 2, the ANR was 27.3 % due to better climatic conditions that improved N mineralization of residues and N maize uptake. For the ryegrass this figure was negative in both years due to its high C to N ratio at incorporation time. Fertilizer application to maize resulted in a decrease of ANR from clover and in negative values in year 2. Clover incorporation increased maize yield with respect to fallow, whereas ryegrass incorporation produced a decrease (Table 1).

Related to nitrate leaching the higher losses occurred after maize fertilised with 150 kg N ha^{-1} preceded by fallow in year 1 and after maize preceded by clover in year 2 (Table 1). This residual effect, after clover incorporation in year 2, explained the negative ANR. Clover followed by unfertilized maize was the best alternative not decreasing maize yield that reduced the leaching losses produced after the application of 150 kg N ha^{-1} to maize followed by fallow.

In the laboratory assay clover incorporation resulted in a net positive mineralization with respect to the unamended containers. Comparing mineral N content in soil plus gaseous losses in clover related to those in unamended control, N recovered from clover was calculated to be 27.8 % (Table 2), 18.2 % was recovered as mineral N and 9.6 % as gaseous losses. For ryegrass, 1.1 % of the N was recovered in gaseous plus N mineral related to unamended control. This low recovery was due to the less total gaseous losses occurring related to clover and the unamended soil (Table 2). The incorporation of plant residues with a high C/N ratio enhances microbial biomass growth, resulting in CO_2 emission and mineral N immobilisation during the initial phase. A C/N ratio about 25-30 has been suggested as the threshold, so that net mineralisation occurs when the C/N ratio is lower and, however, net immobilisation is observed when the C/N ratio is higher.

Ryegrass incorporation decreased the total gaseous N losses with respect to unamended containers, whereas clover caused a 10-fold increase (Table 2). Thus, clover incorporation seemed to increase the risk of N_2O emissions from soils despite mostly as N_2.

References

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Table 1 - N uptake (N), ANR, maize dry matter (DM) and NO_3^--N leached (autumn-winter after cover crops incorporation.)

	Year 1				Year 2			
	N	ANR	DM	Leached	N	ANR	DM	Leached
Treatment	(kgNha^{-1})	(%)	(tDMha^{-1})	(kgNha^{-1})	(kgNha^{-1})	(%)	(tDMha^{-1})	(kgNha^{-1})
Unfertilized								
Ryegrass	63.8		7.6	15.3	40.6		7.3	15.1
Clover	181.1	18.7	12.2	33.6	228.4	27.3	13.9	54.4
Fallow			10.7	53.8			9.4	24.5
Fertilized								
Ryegrass	63.8		9.9	24.7	49.2		11.7	67.7
Clover	181.8	11.1	13.6	67.5	226.1		12.3	165.1
Fallow			12.5	123.5			13.3	116.7

Table 2 - (C/N), N incorporated into the soil , ANR and N_2O and ($N_2 + N_2O$), after 27 days.

Treatment	0-27 days				
	C/N	N (mg kg^{-1})	ANR (%)	N_2O total (mg kg^{-1})	$N_2 + N_2O$ (mg kg^{-1})
Unfertilized					
Unamended		0		0.68	4.32
Ryegrass	29	202	1.1	0.63	1.02
Clover	14	373	27.8	2.64	40.26
Fertilized					
Unamended		0		1.85	85.68
Ryegrass	29	202		1.03	18.65
Clover	14	373	5.8	4.11	62.17