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Nitrification inhibitor decreases N_2O emission from soils amended with fertilizer N and sugarcane trash

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Sugarcane ethanol represents almost half of the fuel used in light vehicles in Brazil. One reason for replacing biofuels for fossil fuels is to reduce greenhouse gases (GHG) emissions. N fertilizers account for 23 to 40% of the GHG emissions and about 25% of the fossil fuel energy associated with sugarcane production. Nowadays, most of the sugarcane is not burned before harvest, which leaves a thick mulch on the field which affects GHGs emissions. Two studies were conducted to evaluate the effect of two nitrification inhibitors (NI), DCD and DMPP, on GHG emissions: a) under controlled conditions in which N fertilizer (ammonium sulfate, 100 kg ha^{-1} N, with or without dicyandiamide - DCD) was applied to soils covered with 8 and 16 t/ha of sugarcane straw, plus a control with no plant residue; b) under field conditions, where 120 kg N/ha was applied as urea with or without DCD (10% of N rate) or DMPP (1% of total fertilizer N), plus the controlled-release fertilizer PSCU (polymer and sulfur coated urea[5], containing 39% N and 11% S). In the field experiment sugarcane straw was removed. GHGs (N_2O, CO_2, and CH_4) were measured during 120 days in the laboratory experiment and 45 days in the field experiment.

In the laboratory study CO_2 emission from the soil increased with increasing straw rates as it was expected. The addition of N fertilizer caused an increase in CO_2 emission probably because of stimulation of straw decomposition. The soil, with or without straw, was a net sink for CH_4. The straw mulch significantly increased N_2O emission from soils treated with N fertilizer: +46% and +194% for treatments with 8 and 16 t/ha of straw respectively. Carmo et al (2012) also observed increased GHGs emission when sugarcane fields were covered with sugarcane trash. However, in the present study, the NI caused a sharp reduction of N_2O emission from fertilized soils: 65%, 62% and 73% when straw rates were 0, 8, and 16 t/ha (Table 1).

In the field, the reduction of N_2O emissions due to the use of enhanced-efficiency fertilizers was higher than the average values reported in the literature, especially for the treatments with the NIs. The average default N_2O emission reduction due to NI in IPCC models is 30% (IPCC, 2001). However, the data herein reported refer to a period of only 45 days. Data compiled by Snyder et al. (2009) indicated a reduction of 40-96% in N_2O emissions by the addition of NIs.

The controlled release fertilizer PSCU also showed great reduction in N_2O emission. In the present study the N fertilizer treatments were applied in a period in which the sugarcane plants were actively growing. Franco et al. (2011) showed that most N

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fertilizer is absorbed in this early stage of growth of sugarcane ratoon crops. These conditions may favor the lower N_2O emission not only from the conventional urea fertilizer, but also from the enhanced-efficiency formulations.

It was concluded that formulations or additives that reduce the rate of release of nitrate or soluble N into the soil, especially the NIs, may help decrease the environmental impact of sugarcane production associated with N fertilizer use.

Table 1. Cumulative emission of N_2O after 120 days in soil covered with sugarcane straw and treated with 100 kg/ha of N as ammonium nitrate, with or without DCD

Sugarcane straw cover	N_2O emission from soil		Reduction due to DCD
	Without DCD	With DCD	
t/ha	---------- mg N/m^2 ----------		%
0	10,894 b	3,847 a	64.7
8	15,917 b	5,914 a	62.8
16	32,044 a	8,441 a	73.7
Average	19,618	6,067	69.1

Tukey ($p < 0.05$) comparing results in rows

Table 2. Cumulative emission of N_2O from incorporated urea (UR) with or without nitrification inhibitors (DCD and DMPP) and polymer and sulfur coated urea (PSCU) applied to a sugarcane field. N rate: 120 kg/ha. Experimental period: 45 days.

Treatment	N-N_2O emission		
	(g ha^{-1})	% of N applied	Difference from urea (%)
No N	312 b[#]		-
UR	700 a	0.32	-
UR+DCD	316 b	0.00	- 99
UR+DMPP	331 b	0.02	- 95
PSCU	438 b	0.10	- 68

[#] Result from unfertilized control was subtracted for calculations of N_2O emissions. Means followed by same letter do not differ (Tukey, $p \leq 0.05$).

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