A. Weiske: Greenhouse Gas Emissions from Agriculture – Mitigation Options and Strategies, Proceedings of the int. Conference, February 10-12, 2004 Leipzig, Germany, p. 273-275

Dicyandiamide and 1H-1,2,4-Triazole – a new effective nitrification inhibitor for reducing nitrous oxide emissions from cultivated land

A. Weber[a], R. Gutser[a], H.-J. Michel[b], H. Wozniak[b], G. X. Chen[c] , H. Xu[c] and H.-J. Niclas[b]

[a] Technical University Munich, Chair of Plant Nutrition, Freising-Weihenstephan

[b] SKW Stickstoffwerke Piesteritz GmbH, Lutherstadt Wittenberg

[c] Chinese Academy of Sciences, Institute of Applied Ecology, Shenyang

1. Introduction

Nitrogen losses as nitrous oxide (N_2O) from soil and water are unavoidable due to the nitrogen turnover by microorganisms. The most important processes for N_2O release into the atmosphere are nitrification and denitrification. Nitrous oxide is a greenhouse gas with a very high impact to global warming as a result of its long half-life period in the atmosphere connected with ozone degradation. Nitrogen fertilisation of arable land may lead to a short term increase of N_2O emission. In general the potential of nitrification inhibitors (NI) to reduce N_2O emissions especially in combination with adapted fertilisation strategies (less dressings) is well known.

The aim of these investigations was to evaluate the potential of the new nitrification inhibitor dicyandiamide + 1H-1,2,4-triazole (DCD + TZ) for minimizing N_2O emissions from soil in connection with urea fertilization.

2. Methods

N_2O emissions were determined by laboratory and field experiments. For laboratory experiments in a flask 81 g soil adjusted to various water holding capacities are incubated at 25 °C after adding a fertilizer solution (300 µg N g^{-1} soil) with and without NI (2% (w/w) of DCD + TZ related to the fertilizer nitrogen content). For N_2O sampling the flasks were scavenged with air, then sealed and gas samples were taken after twelve hours. N_2O analysis was performed by means of gas chromatography with ECD detector.

Field experiments were carried out at the Weihenstephan experimental station. Urea stabilised by DCD + TZ was given to wheat separated in two dressings (120 kg N ha^{-1} with NI and 60 kg N ha^{-1} without NI). Without NI three dressings (80-40-60) were applied. N_2O measurements were done by the static chamber method during the vegetation period up to three times a week from the first N application until heading.

3. Results

The obtained laboratory results demonstrated a significant effect of DCD + TZ on the nitrous oxide emission from paddy as well as upland soils. The rates of N_2O emission from paddy soil were reduced by 60% at a soil moisture content of 22%, by 95% at a soil moisture content of 30% and by 73% at a soil moisture content of 57%. In the case of upland soils no significant differences in the nitrous oxide emission rate between the different humidity levels were found. The reduction of N_2O emission by DCD + TZ ranged from 70% to 83%. These findings were proved in parallel incubation experiments. In this trial urea lead to a high nitrate and to a low ammonium level in the soil. In contrast the combination of urea with DCD + TZ induced low nitrate but high ammonium contents as a result of inhibited nitrification.

Field experiments at the location "Dürnast/Weihenstephan" confirmed the potential of DCD + TZ for reducing N_2O-emissions (Tab. 1).

Tab. 1: Yield, N efficiency and N_2O emissions of urea and urea-ammoniumsulfate with (+) and without (-) the nitrification inhibitor DCD + TZ – winter wheat – measuring period from the first N application until heading

	DCD+TZ	grain yield	nitrogen uptake*	N_2O-emissions			
				overall		fertilizer related	
					reduction		reduction
		dt ha^{-1}	kg N ha^{-1}	g N ha^{-1}	%	g N ha^{-1}	%
urea	-	83	179	275		187	
	+	84	184	163	41	75	60
urea + ammonium-sulfate	-	83	187	238		150	
	+	86	193	188	21	100	33
control		39	52	88		-	

* grain and straw

All fertiliser treatments showed the same yields and nitrogen use efficiency. But the total N_2O emissions could be reduced by the nitrification inhibitor by about 20 % in the case of urea-ammoniumsulfate and by 40 % in the case of urea. Related to the fertiliser induced emissions only, the decrease was 60 % for urea and 33 % for urea-ammoniumsulfate.

The new nitrification inhibitor dicyandiamide + 1H-1,2,4-triazole in a mixing ratio of 10:1 (w/w) demonstrates the same reduction potential as usually observed for other nitrification inhibitors. It is well suited to contribute to a significant reduction of nitrous oxide emissions in combination with ammonium based nitrogen fertilisers. The use of stabilised N fertilisers could be an effective strategy for reducing the emission of the greenhouse gas nitrous oxide from arable soil.