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The new nitrification inhibitor DMPP (ENTEC ®) allows increased N-efficiency with simplified fertilizing strategies

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Abstract

In short-term field trials and a long-term lysimeter experiment simplified fertilizing strategies with stabilized fertilizers were tested and yield and N-losses (leaching, N_2O-emissions) were measured. Compared to conventional fertilizer practice, strategies with stabilized fertilizers resulted in higher yields together with lower gaseous N-losses in field trials. In the long-term lysimeter study, stabilized fertilizers showed also higher yields and a reduction of NO_3^--leaching. Simplified fertilization strategies with stabilized fertilizers (fewer applications, enhanced fertilization in earlier growth stage) lead to the dual benefits of increased yield and a reduced risk of N-losses.

Introduction

An optimized nitrogen fertilization strategy aims to combine high yield and good quality of product with minimized risks of nitrate leaching and gaseous N-losses. The form of applied mineral N-fertilizer (NH_4^+ or NO_3^-) influences nitrogen utilization and efficiency (Trenkel, 1997). With 3,4-dimethylpyrazole phosphate (DMPP) a new nitrification inhibitor is available - ENTEC®. Stabilized fertilizers enable the development of new specific application strategies with fewer applications and an enhanced N-fertilization in earlier growth stages. These strategies have the benefits of improved yield and reduced N-losses by nitrate leaching, compared to conventional fertilization practice (Gutser, 1999; Linzmeier *et al.*, 1999). In this paper, we compare simplified fertilizing strategies with stabilized fertilizers with a conventional strategy (i.e. non-stabilized fertilizer in three split applications) regarding yield, N-uptake, and N-losses determined in short-term field experiments and long-term lysimeter studies. Differences are due to the fertilizer system and not to the fertilizer alone.

Materials and methods

The field trials were conducted on two locations near Freising, Germany, brown earth soils with silty loam (10 % clay, 26 % silt) or loamy sand (24 % clay, 51 % silt) (annual precipitation 800 mm, mean annual air temperature 7.4°C).

For winter wheat (Triticum aestivum cv. Astron) 3 simplified fertilizing strategies with stabilized ammonium sulfate nitrate (ASN; NH_4-N 75 %, NO_3-N 25% of total N, addition of DMPP 0,3 %) surface broadcast as granules were compared with a conventional fertilizing strategy with calcium ammonium nitrate (CAN, NH_4-N 50 %; NO_3-N 50%). All treatments received a total of 160 kg N ha^{-1} (Table 1), applied on the soil surface. In 1999, N_2O-emissions (closed-chamber technique) were determined for the treatments II and IV with ^{15}N-labelled fertilizers applied in liquid form (Linzmeier *et al.*, 2001). NH_3-losses after N-fertilization were studied in a wind tunnel system. The data are presented by Linzmeier *et al.* (1999) and in this issue by Wissemeier *et al.* (2001).

Table 1. N-fertilization and splitting of tested strategies.

	Treatment	early spring	30/31	32	49/51
		Growth stages[1] (kg N ha^{-1})			
I	no N	-	-	-	-
II	CAN	70	40	-	50
III	ASN/DMPP	160	-	-	-
IV	ASN/DMPP	110	-	50	-
V	ASN/DMPP	70	90	-	-

[1] according to Federal Biological Research Center for Agriculture and Forestry (1997)

In a long-term lysimeter study in Freising (1982 – 1998, silty loam, pH 6.4) CAN was compared to the stabilized fertilizer ASN/DCD (3 % Dicyandiamide) at two N-levels. The number of applications for ASN/DCD was fewer than for CAN. Yield, N-removal of plants, and nitrate leaching were measured. Crop rotation was sugar beet, winter wheat, winter barley, from 1994 with catch crops after winter barley (Gutser, 1999).

Results and discussion

Yield and quality

At both locations, the stabilized ASN resulted in higher yields compared to CAN (1997: treatment V, high N-contribution during shooting; 1998: treatments III and IV, high N-contribution at early spring) (Table 2). These results were influenced by the occurrence and quantity of rain in both years (data not shown).

However, crude protein contents in grain were reduced by stabilized fertilizers (Table 2). In order to achieve high grain crude protein levels a late N application with a conventional fertilizer (e.g. CAN) is recommended.

Table 2. Grain yield (Y) and crude protein content (P)[1] of winter wheat receiving DMPP-fertilizers compared to CAN (=100) on two locations and three years. Significant differences are indicated by an asterisk.

		Treatment					
		II	I	III	IV	V	LSD 5%
fertilization		CAN	no N	ASN/DMPP			
silty loam		% of treatment II					
1997	Y	69,3[2]	46	106	106	113*	13
	P	11,2[2]	80	89	92	92	-
1998	Y	78,7	40	110	102	96	12
	P	12,5	78	88	93	96	-
1999	Y	78,4	48	99	110*	104	8
	P	12,3	82	86	90	93	-
loamy sand							
1997	Y	69,2	55	101	112*	118*	11
	P	13,3	88	88	84	88	-
1998	Y	74,7	64	115*	111*	95	11
	P	14,6	70	95	97	102	-
1999	Y	82,1	50	101	105*	103	5
	P	12,9	86	87	86	85	-

[1] N content in grain x 5,7
[2] absolute: yield (dt/ha) and crude protein (% of dry matter), resp.

Gaseous losses

The short term N_2O-emission after N-application was determined for a simplified (ASN/DMPP, 2 applications) and a conventional strategy (CAN, 3 applications) (Fig.1).

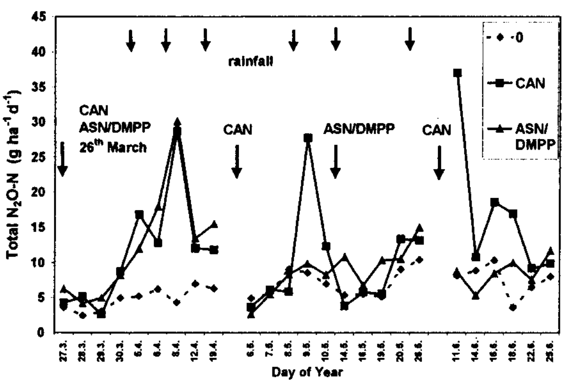

Figure 1. Total N_2O emission of treatments I, II, and IV on a silty loam soil in 1999.

For the stabilized fertilizer, the N_2O-emission was decreased by 20 % (Figure 1). ^{15}N labelling of the N-fertilizers showed that 10-40 % of the total N_2O-emission was attributed to fertilizer-N and 60-90% originated from soil-N (Linzmeier *et al.*, 2001). The N-pool of the soil represents an important source for N_2O-losses. The influence of fertilizers on the microbial N-turnover is likely to depend on the form of application (liquid or granules) (Gutser, 1999) and the chemical form of applied N (NO_3^- or NH_4^+) (Jenkinson *et al.*, 1985). Due to high mobility of nitrate, a larger area in the soil is probably influenced by nitrate-fertilization than by ammonium, which is easily adsorbed to clay minerals (Linzmeier *et al.*, 2001). For fertilizers with nitrification inhibitors, the reduced N_2O-emissions (see Figure 1) are probably mainly due to their lower NO_3^--N content, the inhibition of nitrification leading to longer persistence of ammonium and the reduced number of applications.

Long-term lysimeter studies

In the long-term lysimeter study particularly at high N-application stabilized fertilizers increased yield compared to the conventional fertilizer CAN (Table 3). Furthermore, for stabilized fertilizers nitrate-leaching was reduced. Yield increases were dependent on the crop (winter barley 12%; winter wheat 7%, sugar beet 3% (n.s.)) (Gutser, 1999). No differences in N-removal were determined at equal N-levels (Table 3). Comparable N-removals are due to lower N-contents in grain for the stabilized fertilizer treatment. Furthermore, this fertilizer shows a slightly higher N-immobilisation than conventional NH_4-fertilizer.

Table 3. Efficiency of NH_4^+-stabilized N-fertilizer in a lysimeter experiment from 1982 to 1998 at 0, 117, and 168 kg N ha^{-1}. Different letters within rows indicate significant differences.

N-fertilization		yield (grain/ beet)	removal	leaching	leaching water
			kg N $ha^{-1}a^{-1}$		mg NO_3^- l^{-1}
N_0	Control	61	44	30	37
N_{117}	CAN	=100 a[2]	97	29 a[2]	47
	ASN/NI[1]	101 a	97	27 a	46
N_{168}	CAN	106 b	121	35 b	59
	ASN/NI[1]	111 c	121	29 a	52

[1] NI = DCD   [2] homogeneous groups (Duncan-test)

According to our results, simplified strategies of stabilized fertilizer (fewer applications, enhanced fertilization in earlier growth stage) decrease N-losses and increase yield compared to conventional fertilizers.

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