W. J. Horst et al., Plant nutrition – Food security and sustainability of agro-ecosystems. 702~703, 2001

The new nitrification inhibitor DMPP (ENTEC®) – Comparisons with DCD in model studies and field applications

A. H. Wissemeier[1)], W. Linzmeier[2)], R. Gutser[2)], W. Weigelt[1)] and U. Schmidhalter[2)]
[1)] *BASF AG, Agricultural Center Limburgerhof, D-67114 Limburgerhof, Germany, alexander.wissemeier@basf-ag.de*
[2)] *Chair of Plant Nutrition, Department of Plant Science, Technical University of Munich, Am Hochanger 2, D-85350 Freising, Germany*

Key words: dicyandiamide, DCD, 3,4-dimethylpyrazole phosphate, DMPP, nitrification inhibitor

Abstract

DMPP (3,4-dimethylpyrazole phosphate (ENTEC®) is a new nitrification inhibitor (NI), the use of which is likely to advantage the environment and farmers. Comparisons with DCD (dicyandiamide) show that more than an order of magnitude less DMPP than DCD is needed to inhibit nitrification. Further features of DMPP are a soil – specific longer time period of efficacy and a substantial higher plant compatibility than DCD. Due to sorption DMPP is less mobile than DCD in soils and inhibits nitrification in the top soil even after simulation of heavy rainfall. Hence, NO_3^- leaching is more efficiently restricted by DMPP than by DCD under leaching conditions. Field experiments indicate reduced N losses due to N_2O volatilisation after DMPP or DCD application and no increase of NH_3 volatilisation from ammonium containing fertilisers stabilised with DMPP .

Introduction

The new nitrification inhibitor (NI) 3,4-dimethylpyrazole phosphate (DMPP) has been registered in Germany under the Chemical Act, and under fertiliser legislation in Austria, Belgium, France, Germany, Italy, Spain and The Netherlands. The present paper compares DMPP with the well established NI dicyandiamide (DCD), both in model studies and for selected aspects of field application. Crop yield responses following use of DMPP are reported elsewhere (Pasda *et al.*, 2001)

Materials and methods

Soil incubation experiments were conducted at 20°C at about 60% water holding capacity. 10 mg N as ammonium sulphate nitrate (ASN) was added to 100 g soil. Limburgerhof soil is a loamy sand and Ruchheim soil a loam with pH($CaCl_2$) 6.8 and 7.3, respectively. If not otherwise stated, application rate of DMPP and DCD were 1% and 10% (w/w) from NH_4-N, respectively (standard rate). 1% (w/v) K_2SO_4 solution was used to extract NH_4^+ and NO_3^- for analysis. The field experiments were conducted near Munich in 1998 (for details see text).

Results and discussion

The efficiency of DMPP in comparison to DCD in inhibiting nitrification was tested in an incubation experiment with slurry using different application rates of the 2 NI (Fig. 1). After 3 weeks of incubation, more than an order of magnitude less DMPP than DCD is needed to recover fertilised NH_4^+ in Ruchheim soil. In Limburgerhof soil, DCD even failed to stabilise NH_4^+ for 3 weeks, while small amounts of DMPP were highly effective. Comparing different soils and periods of time DMPP is 15 to 30 times more efficient than DCD (data not shown).

To test the longevity of DMPP in comparison to DCD soil was sampled from a pot experiment with mustard grown either on Ruchheim or Limburgerhof soils for 37 d during summer (June – July). In an incubation test with these soils the residual effect of the NI applied with ASN at the start of the pot trial was in focus. Therefore additional ASN was applied and after 14 d the recovery of ammonium was determined. DCD had lost any effectiveness in preventing NH_4^+ oxidation in these soils, while for the DMPP treated soils about 25% of the ammonium was recovered (Tab. 1).

Table 1. Residual effect of DMPP and DCD in a 14 d incubation experiment at 20°C using soils where ASN had been applied without extra NI (n = 4, ±SD, controls without ASN subtracted)

Fertiliser history	% NH_4^+ recovery Ruchheim soil	Limburgerhof soil
ASN	0 ± 0	0 ± 0
ASN/DCD	-0.6 ± 1.7	0 ± 2.5
ASN/DMPP	22.8 ± 6.5	25.4 ± 3.1

Plant compatibility is another feature where DMPP outperforms DCD. Hardly any leaf edge burn on lettuce leaves after DMPP application at 2.6 times the standard application rate could be observed, while DCD caused massive leaf burn at doses as low as 1.1 times the standard application rate (Tab. 2).

A major task of a NI is to keep NH_4^+ in the rooting zone and to prevent N leaching. Model studies in soil columns show indirectly that also in this important respect DMPP outperforms DCD. After leaching with 48 mm water, no residual DCD effect in preventing nitrification could be observed, while DMPP still inhibited nitrification as high NH_4^+ and low NO_3^- contents indicate (Tab. 3). Furthermore the low mobility of DMPP in soil has been shown in a lysimeter study by Fettweis *et al.* (1999), where no DMPP could be detected in the leaching water (limit of detection of 0.05 µg L^{-1}).

Table 2. Leaf edge burn of mature lettuce heads (cv 'Nadine') in pot experiments fertilised with ASN and extra doses of DMPP or DCD (n = 3, ±SD)

NI compared to standard rate	Percentages of affected leaf margin per leaf summed up over individual leaves per head	
Control (without NI)	24	± 9
1.1 x DCP	440	±178
2.2 x DCP	753	± 51
5.6 x DCD	1198	±120
2.6 x DMPP	96	± 41
5.2 x DMPP	149	± 37

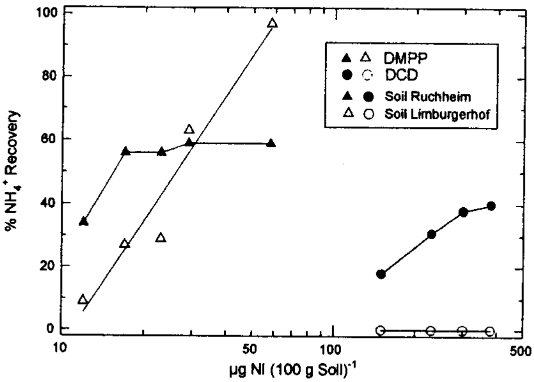

Figure 1. NH_4^+ recovery from liquid manure in two soils incubated for 3 weeks at 20°C either with DMPP or DCD at different concentrations

Table 3. N_{min} of 100 g Limburgerhof soil in columns (Ø 4 cm) together with 3 granules of ASN, ASN/DCD or ASN/DMPP embedded into the soil surface before and after leaching with 48 mm water and a subsequent incubation (14 d, 20°C, at 60% water holding capacity (n = 6, ±SD, controls without fertiliser subtracted)

	N_{min} in 100 g soil	
	mg NH_4-N	mg NO_3-N
Before leaching:		
ASN, ASN/DCD, ASN/DMPP	~ 16	~ 5
After leaching and subsequent incubation for 14 d:		
ASN	0.2 ± 0.03	6.9 ± 0.7
ASN/DCD	0.2 ± 0.02	10.0 ± 0.7
ASN/DMPP	7.5 ± 1.10	2.0 ± 0.8

An environmental concern is the emission of both N_2O and NH_3 after nitrogen fertiliser application. Field studies with the closed chamber technique on a brown earth with a silty loam texture, [pH($CaCl_2$) 6.4], show that N_2O emission derived from both soil-N as well as fertiliser-N is reduced by stabilised fertilisers as compared to ASN alone. This effect is particularly pronounced shortly after fertiliser application (Table 4). ^{15}N studies showed that the fertiliser derived N_2O emission (about 10-40% of total N_2O) was markedly reduced by stabilised fertilisers and further reduced by the granular form as compared to liquid application (data not shown). A significantly higher reduction of N_2O emission after fertilisation with ASN/DMPP compared to ASN/DCD or ASN without NI in a field experiment over three years is reported by Weiske *et al.* (2001).

Table 4. N_2O emission during 2 sampling periods in the field after soil surface application of liquid ASN (160 kg N ha^{-1}) on 27.03.98 (mean over 5 and 15 measurement dates, respectively, with n = 2–8 per treatment and date)

	N_2O [g ha^{-1} d^{-1}]	
	02.04.-17.04.98	22.04.–14.07.98
no N	6.0 (28)	5.2 (48)
ASN	21.8 (100)	10.8 (100)
ASN/DCD	17.3 (79)	10.7 (99)
ASN/DMPP	15.6 (72)	10.2 (94)

To estimate volatile NH_3 losses from fertilisers containing NI, a wind tunnel experiment was conducted. Calcium ammonium nitrate (CAN) was used as control (Table 5). After 25 d cumulativ NH_4-N losses from the ASN/DCD treatment was slightly higher compared to the control, while the losses from the ASN/DMPP treatment were even lower than from CAN.

Table 5. Loss of N as NH_3 after fertilisation with 160 kg N ha^{-1} to wheat (81 and 117 kg NH_4-N ha^{-1} as CAN and ASN, respectively) in a wind tunnel experiment for 25 d with one simulated rainfall event

	NH_3-N loss [kg ha^{-1}] cumulative for 25 d
no N (17 d only)	3.6
CAN	15.4 (100)
ASN/DCD	18.0 (117)
ASN/DMPP	14.2 (92)

In summary DMPP proved to be a highly efficient NI with several advantages compared to DCD.

References

Fettweis U, Mittelstaedt W, Führ F, and Schimansky C 1999. VDLUFA-Schriftenreihe 52 (Kongressband 1999), 457-460.

Pasda G, Hähndel, R, and Zerulla W 2001. IPNC Proceed., (this volume).

Weiske A, Benckiser G, and Ottow JCG 2001. IPNC Proceed., (this volume).