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# Abatement of gaseous nitrogen losses from surface-applied urea with a new urease inhibitor

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## Abstract

Ammonia ($NH_3$) emissions can occur especially after application of urea. Addition of urease inhibitors (UI) to urea is one possible way to abate $NH_3$ losses. In these experiments the newly developed UI P204/98 was tested for its reduction potential in $NH_3$ emission and its possible influence on nitric ($NO_x$) and nitrous oxide ($N_2O$) emissions. Granular urea was surface applied to winter wheat and emissions were measured during the growing period. With a modified instrumentation based on the dynamic chamber technique $NH_3$ and $NO_x$ emissions were measured. $N_2O$ losses were determined using the closed chamber technique. Generally ammonia emissions after application of urea mainly occurred within the first week following fertilizer application and could be reduced by 50% on average with UI P204/98. Emissions of $NO_x$ and $N_2O$ were not significantly influenced by the application of UI.

## Introduction

Around 75% of global 54 Mt $a^{-1}$ of ammonia ($NH_3$) volatilization is of anthropogenic origin. Agriculture is responsible for 80%-90% of these emissions. Next to animal manure as the dominant source (80%), losses from surface-applied mineral fertilizers – urea and especially ammonium bicarbonate – represent a major source for anthropogenic $NH_3$ losses (10%-15%) (Hofman and van Cleemput, 2004). On average $NH_3$ losses from surface-applied urea amount to 10%-20% of fertilizer N (Harrison and Webb, 2001). In southern Bavaria, Germany, Weber *et al.* (2001) determined losses from applied urea N up to only 0.5%-5%. The release of $NH_3$ from urea catalysed by the urease enzyme and subsequently the risk of $NH_3$ emissions is affected by soil properties (pH, soil texture) and environmental factors (temperature, rainfall). For the enhancement of nitrogen efficiency urease inhibitors have been developed (Watson, 1998). During nitrogen turnover in soils - nitrification and denitrification-up to 15% increased $N_2O$ emissions have been reported (Brink *et al.*, 2001).

The objective of this study was firstly to measure the reduction of $NH_3$ emissions in fields by the new developed UI P204/98 (phosphoric acid diamide) compared to the US approved NBTPT [N-(n-butyl)-thiophosphoric-triamide] after broadcasting urea to the soil surface. P204/98 offers advantages in formulation of granulated fertilizers. Secondly, possible consequences of UI application on $N_2O$ as well as on $NO_x$ emissions were determined.

## Materials and methods

The outdoor flux measurements were performed at the research station Duernast of the Chair of Plant Nutrition, located in the Tertiary hill landscape of Southern Bavaria, Germany, in the years 2002 to 2004. Annual precipitation is around 800 mm and mean annual air temperature is 7.4°C. The soil is characterized as a silty loam derived from loess with pH($CaCl_2$) 6.3.

For every application 80 kg N $ha^{-1}$ of mineral nitrogen fertilizer were surface-applied to winter wheat as granular urea with or without a urease inhibitor (UI).

$NH_3$ and $NO_x$ emissions were measured online with a modified instrumentation based on the dynamic chamber technique for two weeks following fertilization. Ambient air was continuously drawn through chambers (covering ¼ $m^2$ soil surface) with a constant flow rate. Sample air was collected and led to a $NH_3$/$NO_x$-analyzer. $NH_3$ and $NO_x$ fluxes were calculated from the difference of $NH_3$ and $NO_x$ concentration in ambient and sample air and from the airflow through the chamber. To minimize the influence of the artificial climate inside the chambers on the volatilization process, the chambers were moved to an undisturbed part of the plot every day. $N_2O$ fluxes were measured using the closed chamber technique (Hutchinson and Mosier, 1981). Climatic data were collected from a meteorological station close to the experimental area.

## Results

Urea led to $NH_3$ losses up to 2.6 kg $NH_3$-N $ha^{-1}$ representing 0-3% of the applied N (Table 1). Maximum losses were found in warm and dry periods within 3-6 days following fertilization. Lower temperature and rainfall significantly decreased $NH_3$ losses. The use of UI led to an average reduction in $NH_3$ volatilization by 50 % independent of the absolute level of $NH_3$ emissions. There was no significant difference between the effectiveness of both UI. Across all early spring seasons UI showed the best result eventually due to a prolonged urease inhibitor activity.

Figure 1 shows a typical course of $NH_3$ emissions following fertilization in May 2003. High temperatures accelerated while precipitations within the first days dramatically reduced further $NH_3$ volatilization. Losses are decreased by applied UI.

*Table 1.* $NH_3$ and $NO_x$ emissions following application of urea without or with urease inhibitor

| Year | Date of Appl | NH₃- emissions after application of | | | | | NOₓ- emissions after application of | | | | | Temp. | Rainfall (day 1-5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Urea | Urea+P204/38 | | Urea+NBTPT | | Urea | Urea+P204/38 | | Urea+NBTPT | | | |
| | | g $NH_3$-N $ha^{-1}$ | g $NH_3$-N $ha^{-1}$ | % of urea | g $NH_3$-N $ha^{-1}$ | % of urea | g $NO_x$-N $ha^{-1}$ | g $NO_x$-N $ha^{-1}$ | % of urea | g $NO_x$-N $ha^{-1}$ | % of urea | °C | (mm) |
| 2002 | 12 Apr | 518 | 11 | 2 | 32 | 6 | 62 | 93 | 150 | 78 | 126 | 8.1 | 0.9 |
| | 26 Apr | 230 | 191 | 83 | 44 | 19 | 258 | 208 | 81 | 154 | 59 | 10.7 | 6.5 |
| | 08 Mav | 223 | 131 | 59 | 113 | 51 | 273 | 264 | 97 | 295 | 108 | 15.0 | 21.1 |
| | 23 Mav | 168 | 118 | 70 | 109 | 65 | 45 | 36 | 80 | 39 | 87 | 13.2 | 20.3 |
| 2003 | 27 Mar | 192 | 45 | 23 | 23 | 12 | 124 | 133 | 107 | 117 | 94 | 5.2 | 1.7 |
| | 08 Mav | 109 | 105 | 96 | 73 | 67 | 132 | 176 | 133 | 235 | 178 | 11.9 | 33.1 |
| | 26 Mav | 2598 | 1978 | 76 | 7984 | 76 | 117 | 61 | 52 | 148 | 126 | 18.9 | 0.3 |
| | 11 Jun 6 | 592 | 507 | 86 | 565 | 95 | 279 | 197 | 71 | 158 | 57 | 19.6 | 13.6 |
| 2004 | 18 Mar | 1593 | 265 | 17 | | | -4 | 0 | -8 | | | 5.0 | 3.2 |
| | 31 Mav | 229 | 177 | 77 | | | 52 | 48 | 92 | | | 6.5 | 1.0 |
| | 04 Mar | 64 | 56 | 88 | 39 | 61 | -6 | -10 | 161 | -35 | 540 | 9.8 | 11.5 |
| | 27 Mav | 110 | 47 | 43 | 73 | 66 | 14 | 5 | 36 | 13 | 94 | 13.2 | 16.7 |
| average 2002 to 2004 | | | | 60 | | 52 | | | 88 | | 147 | | |

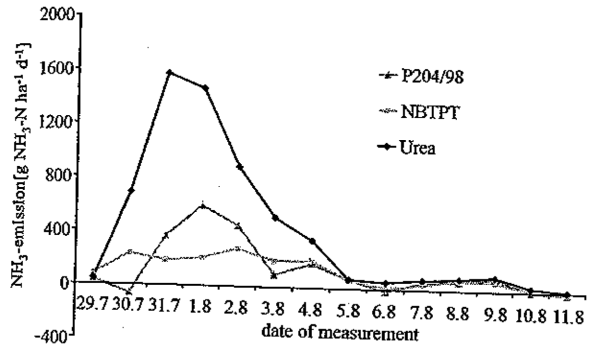


*Figure1.* Course of $NH_3$ emissions following application of urea with and without UI on 11.06.2003.

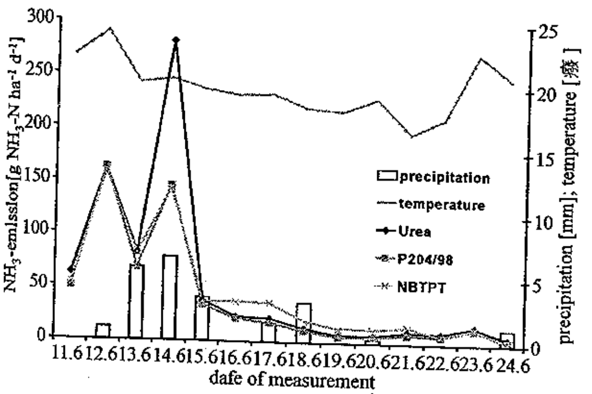


*Figure2.* Course of $NH_3$ emissions following application of urea with and without UI on 29.07.2004.

The experimental site conditions imply a small risk for $NH_3$ losses due to the soil characteristics, frequent rainfalls and temperate climatic conditions. In a further experiment (Fig. 2) $NH_3$ emissions were measured under elevated conditions for gaseous N losses [higher air temperature (average of 19.9°C), no precipitation, no plant coverage]. The majority of $NH_3$ emissions resulted within the first 7 days after fertilization. Owing to UI relatively high $NH_3$ volatilization of 5.8 kg $NH_3$-N ha$^{-1}$ 0–% of fertilizer N could be reduced by 75%.

A further aim of the project was to investigate possible consequences in the reduction of $NH_3$ losses due to UI with respect to the emissions of $NO_x$ and $N_2O$.

$NO_x$ losses were continuously low for all measurements (Table 1). A maximum of 400 g $NO_x$-N ha$^{-1}$ was emitted within the measuring period which corresponds to 0.5% of the applied N. The reduction of $NH_3$ losses by means of UI did not alter $NO_x$ emissions.

Emissions of $N_2O$ were measured during the whole growing period. Application of urea led to $N_2O$ emissions up to 3.7 kg $N_2O$-N ha$^{-1}$ representing 0-2.2% of the applied N. In contrast to results published by Brink *et al.* (2001) UIs did not significantly influence the emissions of $N_2O$.

## Conclusion

The majority of $NH_3$ emissions occur within the first week following application of urea. Precipitations and low temperatures within this period severely reduce potential losses. An addition of urease inhibitors P204/98 and NBTPT to urea granules led to an average reduction of $NH_3$ losses by 50%. Especially following the first fertilization in spring a high reduction potential could be detected. Because of site-specific low $NH_3$ losses of less than 3 kg N ha$^{-1}$ no effect on emissions of $NO_x$ or $N_2O$ were to be expected.

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## References

Brink C, *et al.* 2001. Atmos. Environm. 35, 6313-6325.

Harrison R Webb J 2001 Adv. Agron. 73, 65-108.

Hofman G, van Cleemput O 2004 *In:* Soil and Plant Nitrogen. IFA, Paris, ISBN 2 9506299 9 7.

Hutchinson GL, Mosier AR 1981 Soil Sci. Soc. Am. J. 45, 311-316.

Watson CJ, Poland P and Allen MBD 1998 Grass For. Sci. 53, 137-145.

Weber A, Gutser R and Schmidhalter U 2001 Proceedings of the IPNC 2001, Hannover, 884-885.