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N_2O-emissions from long-term different fertilized arable soil

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INTRODUCTION

N_2O is a very effective greenhouse gas and may support the partial destruction of the earth's stratospheric ozone layer. Gradual increase of the atmosphere's N_2O-content is evident. Increased use of nitrogen fertilizers during the last century should have substantially increased N_2O-emissions from arable soils. Both nitrification and denitrification occur as N_2O-sources, controlled by many factors (soil water content, aeration status, availability of nitrate and carbon sources, soil-pH, microbiological status, farming system...). This results in pronounced temporal and spatial variability. Therefore, short-term measurements or laboratory studies do not allow reliable conclusions about total N_2O-losses during year (**Granli and Bøckman, 1994**). Though technique of in-field measurement of N_2O-fluxes cannot be characterized as a serious problem, the expense for a complete season can. For this reason, there is still some lack in such extended reports on N_2O-emissions. So we conducted another one with emphasis on long-term effects of different fertilizing strategies.

METHODS

All N_2O-fluxes were measured using the closed-chamber technique according to **Hutchinson** and **Mosier (1981)**. To avoid spatial variation, chambers (eight replications per plot and date) were always placed on the same low plastic base fixed in the ground. Samples were analyzed within weeks by gas chromatography. Denitrifier activity was determined using a modified procedure described by **Tiedje (1994)**.

MATERIALS

Field experiment about different intensity of mineral, organic and combined fertilizing (situated near Freising, started in 1979); soil: Brown earth from loess; crop rotation: corn for silage - winter wheat (1995) - winter barley (1996); straw remains on field. Treatments:

1/1: unfertilized control plot, poor yield
3/1: slurry applications only, poor yield
3/3: mineral fertilization as 1/4, additional slurry applications
1/4: mineral fertilization

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Table 1: Attributes of the treatments (Ø 1990-1995; kg $N*ha^{-1}*a^{-1}$)

Treatment	1/1	1/4	3/3	3/1
N-input: fertilizer	0	170	128	0
slurry (total N)	0	0	155	155
N-output: crop-N	52	138	148	80
N-balance: input minus output	-52	+32	+135	+75
Total N in topsoil (0-30cm; VIII 1995; % of dry matter)	0,166	0,163	0,187	0,181
Total C in topsoil (0-30cm; VIII 1995; % of dry matter)	1,10	1,14	1,27	1,31

RESULTS AND DISCUSSION

The N_2O-flux measurements at our field experiment were conducted to find out about differences between pure mineral fertilization and a usual combination with slurry applications (high N-intensity).

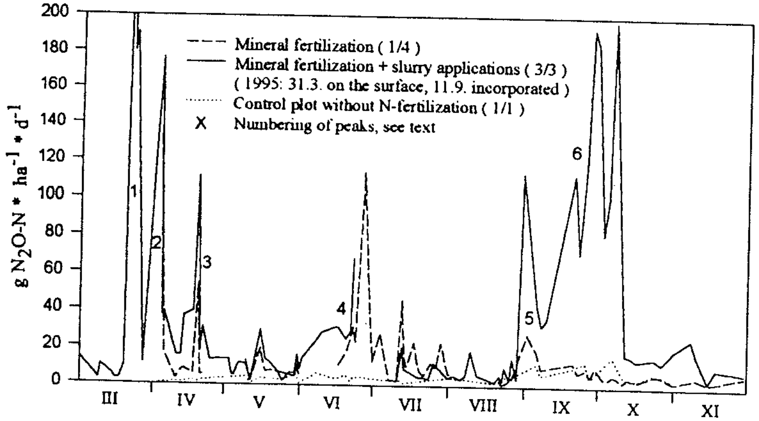

Figure 1: N_2O-emissions 1995 from long-term different fertilized arable soil

Figure 1 shows the N2O-emissions from the soil subdivided into two parts :

There is a base-line of emission with a mean of 5g (unfertilized control plot) to 10g N_2O-N $*ha^{-1}*d^{-1}$ (others). Peaks of varying size appear above the base-lines of fertilized plots. With the exception of peak No.6 they correspond to rainfall events or situations with high soil moisture content. Therefore, they probably represent denitrification, what also explains their absence at the control plot without N-fertilization, where nitrate content of the soil never exceeded 1,5mg NO_3-N *kg soil dry $matter^{-1}$. Such circumstances "force" denitrifiers to an effective use of the NO_3-oxygen, they reduce NO_3 to N_2 almost entirely.

Starting events of the huge peaks numbered in figure 1 shall be shortly characterized:

Application of mineral fertilizer onto water-saturated soil resulted in peak No.1, which continued as peak No.2 after a short interruption during a frost-period. Heavy rainfall on soil of still high nitrate content produced peak No.3. Peak No.4 was again the reverse: fertilizer application on water-saturated soil. Rewetting of dried up soil caused peak No.5 at plots with former slurry applications only. Peak No.6 is an immediate result of slurry incorporation in the soil. All these monitored events causing high N_2O-emissions are well reported in literature. As a summary shall be mentioned **Granli** and **Bøckman** (1994) vicariously.

The table 2 shows an estimate of total N_2O-losses from soil based on the measured N_2O-fluxes.

Tab. 2: Total N_2O-losses of the field experiment from March to November 1995 **(kg $N*ha^{-1}$)**

	Base-line	Huge peaks	Total loss
1/1	1,3	-	1,3
1/4	2,3	2,8	5,1
3/3	3,2	7,3	10,5

These estimates characterize the additional slurry applications beside mineral fertilization (necessary for profitable yields) as an effective source to enhance N_2O-emissions. Apart from the N_2O-losses after slurry incorporation in September (mostly by nitrification, probably), there is a continous promoting effect from April to June (see figure 1). This appears due to the permanently enhanced microbial activity of long-term slurry-treated plots (see figure 2).

The preliminary gap in our experiment between December and February cannot be neglected to get a complete estimate of N_2O-losses for one year. High emissions of N_2O must be expected during thawing (**Christensen** and **Tiedje** 1990). Our own results from February and March 1996, yet incomplete, suggest additional losses of 1,5kg N_2O-N approximately at all plots.

To quantify the activity of microorganisms and the potential for denitrification in the topsoil of the field plots, denitrifier enzyme activity was measured (slightly modified according to **Tiedje, 1994**) throughout the year using soil samples fresh from the field. Results permit rating the mineralizable carbon source of the samples indirectly, because this carbon source determines the microbial population mainly (and most soil microorganisms are optional denitrifiers), subordinated only the annual course of soil temperature. The method delievers a clear annual course of the microbial activity in soil parallel to soil temperature. Influence of tillage (August) and slurry incorporation (September) are represented (see figure 2).

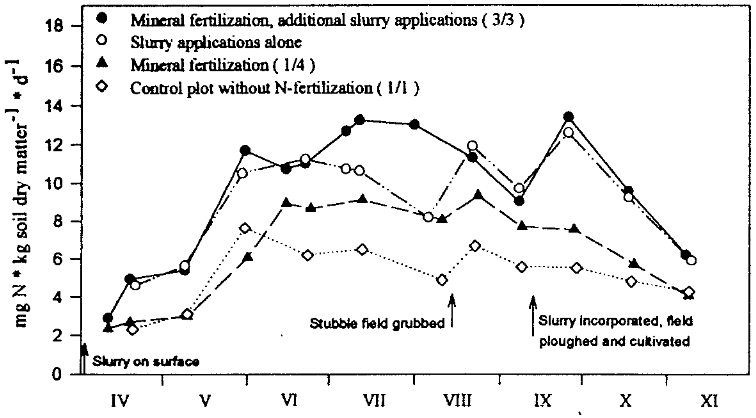

Figure 2: Potential for denitrification of the field plots throughout the year

Different treatments are subdivided significantly. Their levels support our presume, that long-term organic fertilizing increases microbial activity of soils permanently by elevating the pool of oxidizable carbon (see enrichment of total C and N in the soil of the slurry-treated plots - table 1). If other conditions for high denitrification rates are fulfilled, this will be the decisive control variable, as probably from April to June and again in October / November at our fertilized plots (see figure 1). Long-term enhancement of microbial activity by organic fertilizing is obviously not dependent on additional mineral fertilizing to reach maximum yields - see variant 3/1 in figure 2 (breaking-in of the curve in summer may be due to an absolute lack of nitrate, finished with the end of N-uptake by plants). But according to the very low nitrate content (measured in three-week intervalls) in the soil of this field plot apart from actual slurry applications, its N_2O-emissions looked like those from the unfertilized control.

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