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389

Strategies for an Improved Nitrogen Utilization of Organic Manures

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The return of organic wastes from agriculture to the natural cycle is a necessity in terms of both farm management and economics. When applied in normal amounts, they make an essential contribution to a sustained or increased soil fertility; however, when applied in excess or at the wrong time, they may result in pollution of soil, water or air. Consequently, an economically and ecologically justifiable use of residues from plant and animal production is a highly desirable but demanding aim.

1. In this Respect We Have to Focus on Two Important Processes:

a. Nitrate, the result of microbial decomposition of organic wastes can be utilized by crops directly; however this very mobile form of N can also be leached out or denitrified, hence polluting ground water or air.
The velocity of mineralization and nitrification depends mainly on the C/N ratio of the organic material and on the temperature, moisture, and biological activity of the soil.

b. Ammonia released from N-rich organic material (mainly slurry) can be volatilized, thus polluting the air. After incorporation of the wastes into the soil, ammonia will be fixed but later on nitrified with all the previously mentioned consequences.

The goal must be to optimize nitrogen utilization by crops and to minimize environmental pollution.

2. Strategies for Improved Nitrogen Utilization of Organic Manures:

a. The residues from *plant production* are mainly straw and green material.
Straw, rich in cellulose, pentosanes, and lignin, has a high C/N ratio (70–120). After incorporation into the soil, immobilization of soil N takes place, lasting for several months. Hence this biologically blocked nitrogen is prevented from being leached out in the fall and so it is not available to the following crop (Tab. 1). In the long run it will be utilized by plants at a rate of about 5–10% per year. Consequently, the main positive effect of straw manuring is the conservation of soil N or (see later) slurry N (AMBERGER 1987).
Green material, such as sugar beet leaves, catch crops etc. with a C/N ratio of 15–25, when incorporated into the soil undergoes a faster mineralization; the critical C/N ratio is between 25 and 30 (Fig. 1). Consequently, green material should be incorporated as late in fall as possible, or even better – if soil properties are favourable – not before spring. About 1/3 to 1/2 of total green manure N is available to the following crop (AMBERGER 1987).

Tab. 1 N leaching and N uptake after wheat straw manuring in pot trials (silty loam, pH 6.5, N appl.: 690 mg/pot)

Time of straw and N application	N leaching mg/pot without straw	with straw	N uptake by ryegrass mg/pot	
control (N_o)	160	6	49	36
August	564	164	68	67
September	434	280	64	58
October	264	109	82	74
LSD %	25			

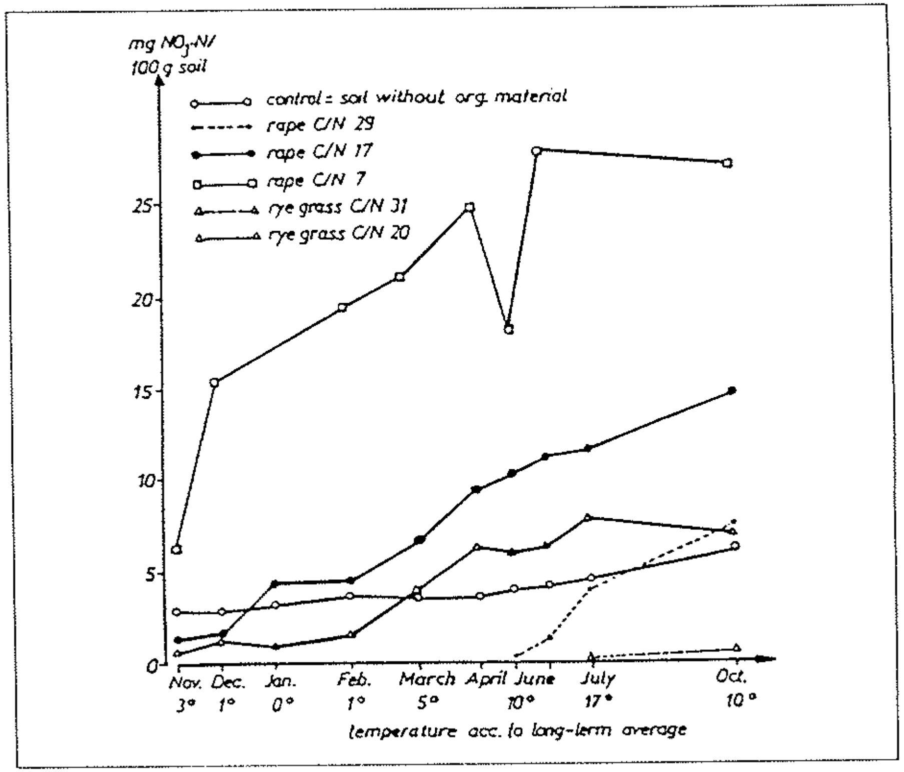

Fig. 1 N mineralization from catch crops (incl. roots), incorporated in November (VILSMEIER and GUTSER 1988).

b. Wastes from animal production are stable manure, liquid manure and semi-liquid slurry.
Stable manure, a mixture of dung, urine, and straw, left to decompose for several months, finally reaches a C/N ratio of 20–20. It is generally applied in autumn in quantities up to 30 t/ha, equal to 150 kg total N/ha. However only 1/10 is ammonium- and nitrate-N. Therefore, scarcely any environmental problems arise concerning ground water pollution.
Liquid manure, a mixture of urine and water is still applied seldom directly to main and catch crops.
Semi-liquid slurry, a mixture of dung and urine without straw, is produced in large quantities (Tab. 2) in intensive livestock farming (80 kg total N, resp. 40 kg ammonium-N per life unit and year). It undergoes anaerobic fermentation and has a C/N ratio of 7–12. 50–60% of total N is ammonium, which can be volatilized as ammonia to a great extent already in the first hours after spreading, unless it is immediately incorporated into the soil (Fig. 2). The remaining amount of organic N enters the large nitrogen pool of the soil with an initial availability of 5–10%. The main factors increasing volatilization are: high temperature (Fig. 3), compacted soil with stubble and straw (Fig. 4) or grassland and a high dry matter content of slurry (Fig. 3, difference between cattle and pig slurry) which impairs penetration into the soil (AMBERGER and HUBER 1988, HUBER 1993, in press).

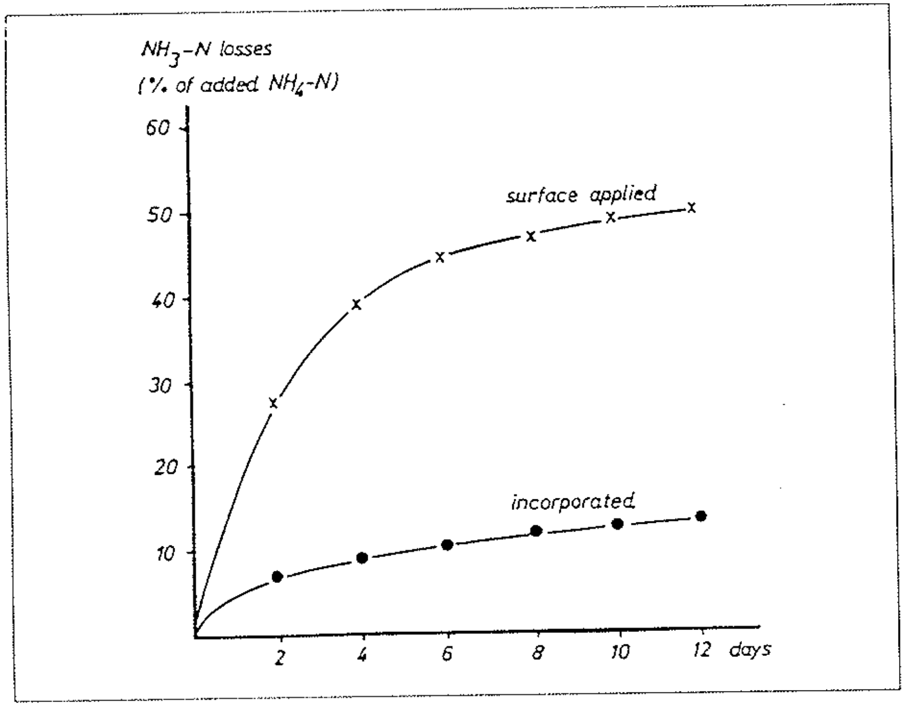

Fig. 2 NH_3 losses from slurry as dependent on mode of application (AMBERGER and HUBER 1988).

Tab. 2 Nutrient content of semi-liquid manure (»slurry«)

slurry	production m^3/LU	dry matter %	N(NH_4-N)	P_2O_5 kg/m^3	K_2O
dairy cows	20	7.5	4 (2)	2	6
feeder cattle	20	7.5	4 (2)	2	3
pigs	15	7.5	6 (4)	5	3
poultry	6	15	10 (7)	9	5

Consequently, broadcasting at low temperatures or in rainy weather, immediate incorporation or injection into the soil, or dilution with water on grassland can minimize both N losses and odour impact.

After proper incorporation the nitrification of slurry ammonium is completed in some weeks, depending mainly on temperature (Fig. 5).

A further hazard is the leaching of nitrate and ground water pollution after early autumn or early spring application especially on light soils and in rainy weather. This danger exists as long as crops with slow onset and initial growth (maize, sugar beets etc.) have not covered the soil (mid/end June), whereas a fairly well developed root system of winter wheat prevents nitrate translocation and leaching (Fig. 6).

Therefore, slurry should be applied as near as possible to the onset of or into the growing crop in quantities targeted to the expected yield level and the actual nitrogen requirement, avoiding overfertilization.

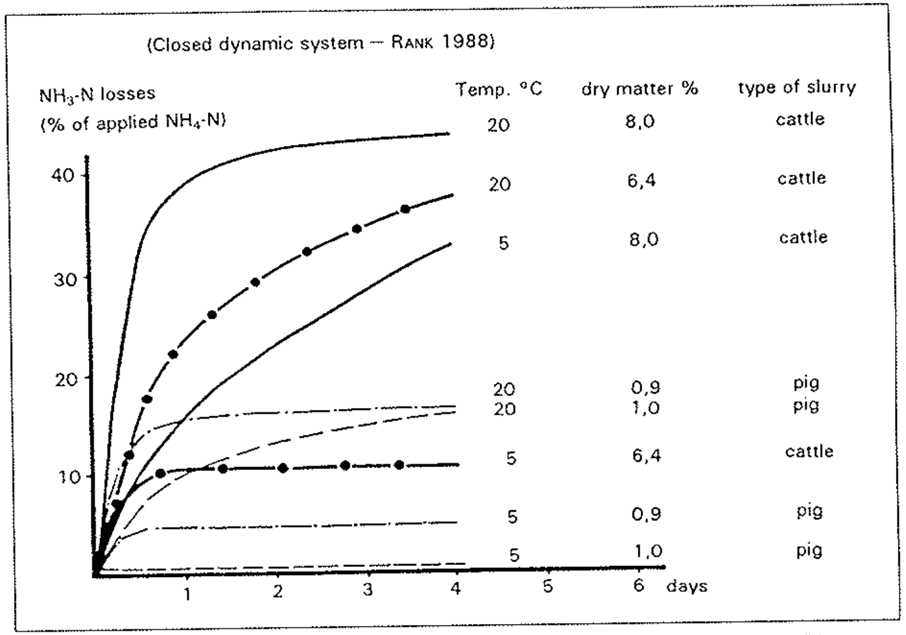

Fig. 3 Ammonia losses from slurry depending on dry matter content and temperature (RANK 1988).

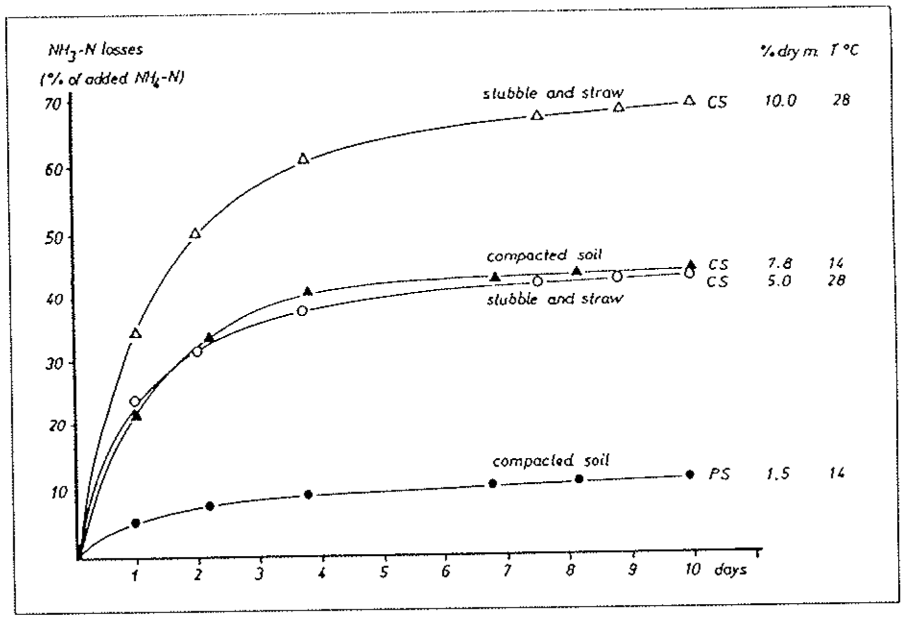

Fig. 4 NH_3 losses after surface application of cattle (CS) and pig (PS) slurry on stubble and straw (August) or compacted soil (November) (AMBERGER and HUBER 1988).

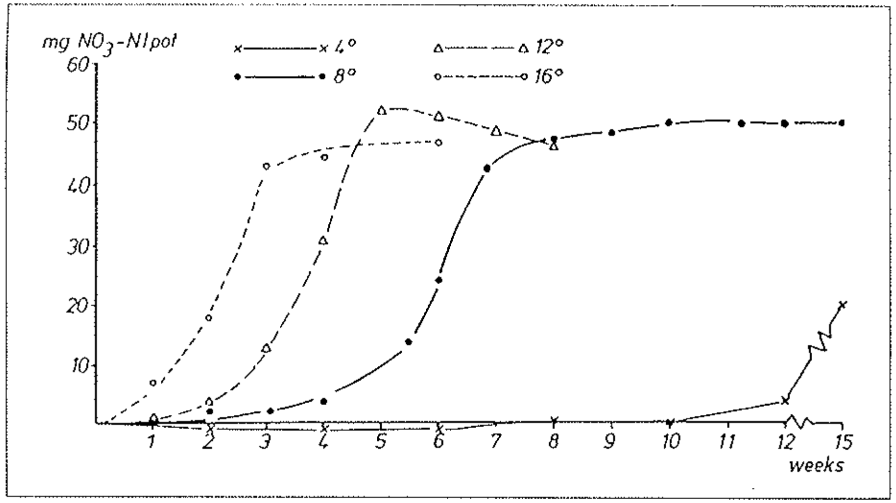

Fig. 5 Nitrification of cattle slurry as dependent on temperature (AMBERGER 1984).

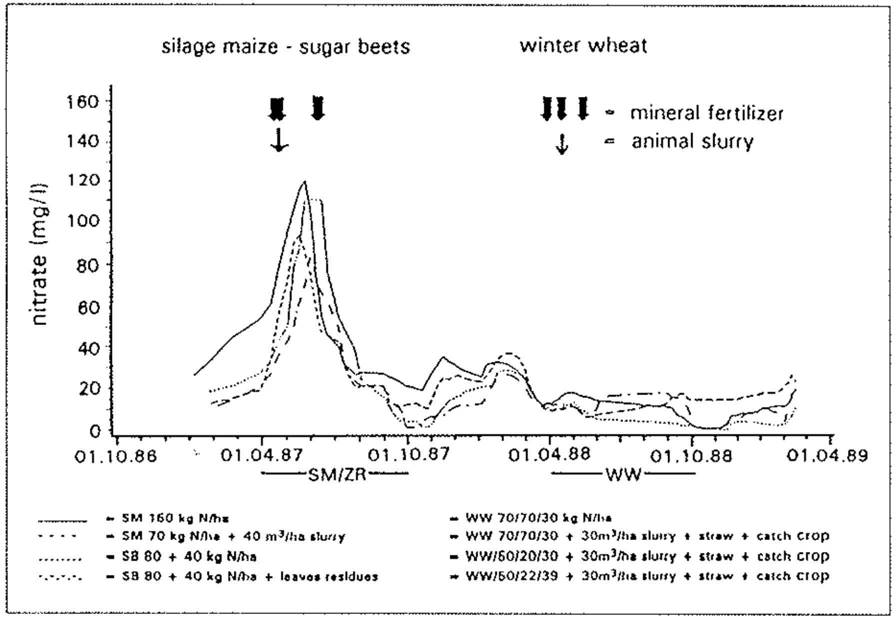

Fig. 6 Nitrate concentration in soil solution (60 and 130 cm depth) (RIESS 1993).

In case of early autumn application a highly appropriate measure is to combine slurry with green manure and/or straw, which conserves the slurry ammonium at least till the middle of the following year. In late autumn or winter, with shortage of storage capacity, the addition of the nitrification inhibitor dicyandiamide (a non toxic compound) to slurry (AMBERGER 1986) prolongs the ammonium phase of slurry-N at low

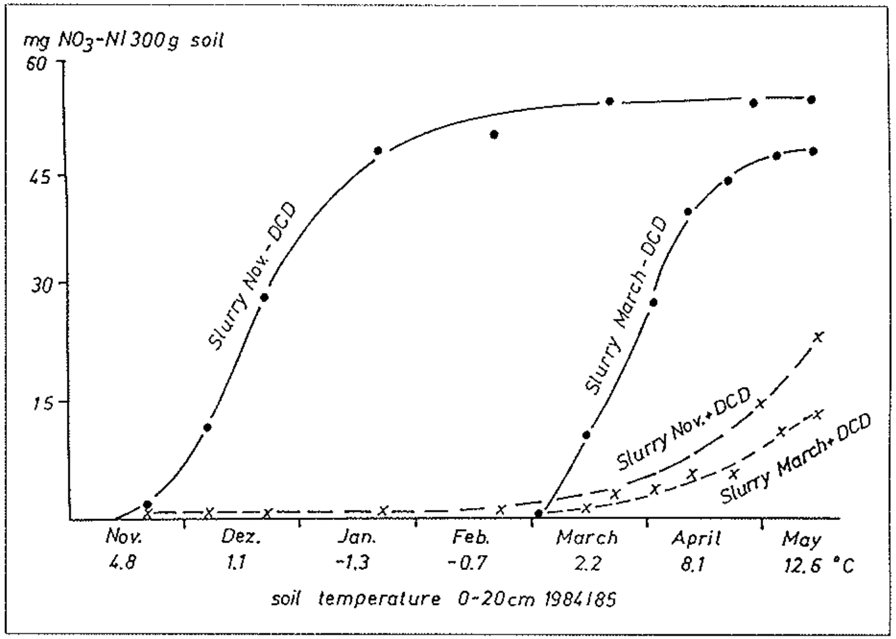

Fig. 7 Nitrification of cattle slurry (with simulated outdoor temperatures November-May) (VILSMEIER and AMBERGER 1987).

temperatures for several weeks, which is fully available to the following crop (Fig. 7).

Finally, slurry must never be applied in winter on slopes or soils with high snow cover or strong frost, in order to avoid erosion.

3. *Conclusion*

Considering these recommendations carefully, the utilization of nitrogen from organic manures can be very much improved and environmental pollution consequently minimized.

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