Optimal cattle manure application rate to maximise crop yield and minimise risk of N loss to the environment in a wheat-maize rotation cropping system

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Introduction

- Application of a large amount of livestock manure can be an important part of agricultural non-point source pollution.
- Excessive application of manures can result in nitrate (NO_3−) accumulation in soil.
- Nitrate (NO_3^-) accumulation could lead to NO_3^- pollution to surface water and groundwater.

Objective

- To examine the effects of cattle manure application rates on nitrate nitrogen (NO_3^--N) migration and accumulation in a farmland soil.
- To examine the effects of different application rates, on vertical distribution of soil NO_3^--N, crop yields, and nitrogen use efficiency.

Method

- The field experiment, conducted in the North China Plain, consisted of six treatments which included 0 (T1), 15000 (T2), 30000 (T3), 45000 (T4), 60000 (T5) and 75000 (T6) kg/ha/year, corresponding to N rates of 0, 75, 450, 675, 900 and 1125 kg/ha/year.
- Half of the manure was applied to the wheat and the other half to the maize. Total precipitation during the wheat growth season was 179 mm and 468 mm during the maize growth season.

Results

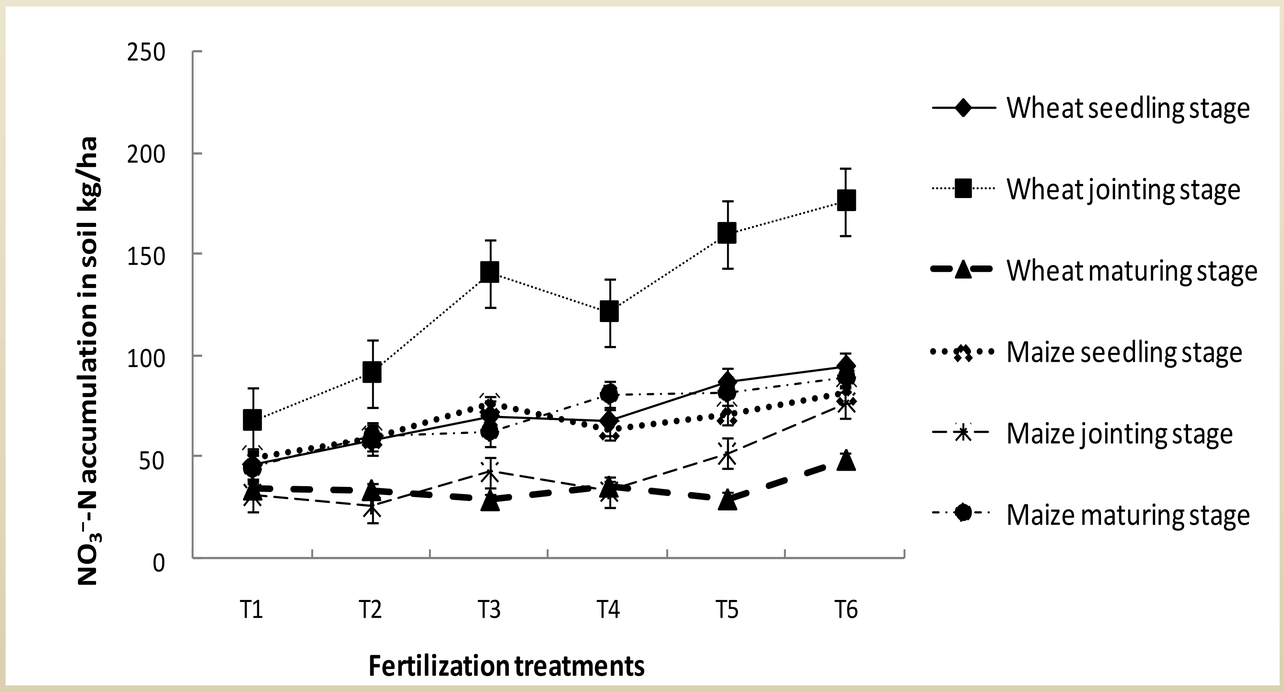

Figure. 1 Changing pattern of NO_3^--N accumulation in 0–100 cm soil over time after cattle manure addition

- At the wheat, maize growth, NO_3^--N concentration for soil layers in 0–100 cm increased with increasing cattle manure application rate.
- The highest NO_3^--N accumulation occurred at the wheat heading stage for each treatment, with NO_3^--N accumulation of up to 176 kg/ha.
- The relationship between the wheat, maize yield (kg/ha) and manure application rate (kg/ha) can be described by a quadratic function ($y = -4\times10^{-5}x^2 + 0.1232x + 279.42$, $R^2 = 0.92$) and linear relationship ($y = 0.0006x + 3.3249$, $R^2 = 0.8827$), respectively.
- The optimum cattle manure application rate would be 45000 kg/ha/year in the wheat-maize rotation cropping system in the test area.

Table 1. Wheat and maize silage yields and N efficiency of treatments with different application rates.

	Wheat			Maize		
Total manure application rate (kg/ha)	Yield (kg/ha)	N agronomic efficiency (kg wheat/kg applied N)	N use efficiency (%)	Yield (ton/ha)	N agronomic efficiency (kg wheat/kg applied N)	N use efficiency (%)
0	4134 c			45b		
15000	5034 b	8.0	125	59 ab	12.0	120
30000	5424 ab	5.7	76	60 ab	6.5	71
45000	5704a	4.7	52	65 a	5.8	50
60000	5136 b	2.2	33	68a	5.1	43
75000	5072 b	1.7	25	71 a	4.5	32

Note: In each column of data, different letters represent a significant difference among treatments, $P< 0.05$; N agronomic efficiency (kg yield/kg N) = (crop yield in N application area − crop yield control) /Manure N application rate. N use efficiency was calculated as the percentage of applied cattle manure N which was uptaken by crops.

Conclusions

- Wheat and maize silage yields were highest when cattle manure application rate was 45000 kg/ha/year, with the N use efficiencies of wheat and maize silage both being about 50%.
- Manure application rate with 45000 kg/ha/year (equivalent to 675 kg N/ha/year) is optimal for this wheat-maize rotation cropping system in the North China Plain.

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