Nitrogen effect of poultry manure

Sofia Delin, Swedish
University of Agricultural Sciences, Department of Soil Sciences, Division of Precision Agriculture
P.O. Box 234, SE-532 23 Skara, Sweden, sofia.delin@mv.slu.se

Abstract

The nitrogen (N) effect of laying hen and broiler manure on yield of spring barley was investigated in five field trials in Sweden during 2005-2007. To study the course of N mineralisation after fertilisation, manure was incubated with soil in plastic bottles placed in the topsoil at different times of the year, simulating times of fertilisation. The results indicate that the fertilisation effect was better estimated from total N content than mineral N content. Laying hen manure (24% DM with 67% of total N as NH_4-N) had net N immobilisation, while broiler manure (55% DM with 25% of total N as NH_4-N) had net N mineralisation. Both therefore contributed approximately equal amounts of mineral N to the crop and gave similar effects on yield in proportion to their total N content. The yield effect of total N corresponded to 30-40% effect compared with mineral fertilisers (ammonium nitrate) in 2005 and 2007, which could be considered normal years, but only 20-30% during 2006, which had a late spring and dry weather during June. The residual N effect on the following crop corresponded to 5-10% of total N in the manure. The best time for fertilisation varied between trials, presumably depending on the risk of ammonia volatilisation.

Introduction

Most knowledge about effective manure management for Swedish circumstances so far concerns cattle and pig manure. Poultry manure is a much more concentrated fertiliser and has different chemical and physical properties. More knowledge is therefore needed on how to handle different types of poultry manure for effective nutrient utilisation. The nitrogen effects of two types of poultry manure (laying hen or broiler chicken) on yield of spring barley and the course of nitrogen mineralisation after fertilisation were therefore investigated.

Materials and methods

Nitrogen effects of laying hen and broiler manure on yield of spring barley and residual effects on the following crop (oats or oilseed rape) were investigated in five field trials in Sweden during 2005-2007. Trials on clay soil in the province of Västergötland (58º12'N, 13º08'E) in 2005 and 2006 involved both laying hen and broiler manure and two times of application. In 2005 early spring application was compared with application at sowing. In 2006, when early sowing application was impossible due to snow, application at sowing was compared with application after crop emergence. Since the laying hen manure was too sticky to apply after crop emergence, only broiler manure was applied then. Instead, an extra treatment of broiler manure was added to the spring application, in order to compare the effect of soil incorporation versus no incorporation of manure into the soil. Two other trials in 2006 on sandy soil in Halland (56º35'N, 12º56'E) and Öland (56º31'N, 16º23'E) involved broiler manure at two different rates. The fifth trial (in Halland in 2007) involved both different rates and different times of application of broiler manure. In all trials the manure treatments were compared with four treatments with ammonium nitrate with doses ranging from 0 to 120 kg N ha^{-1}. The yields from the ammonia nitrate treatments were plotted against N dose and to this cubic polynominal functions were fitted. The yields from the manure treatments were compared with these yield response curves in order to estimate the mineral N fertiliser dose to which a certain total N manure dose corresponded.

To study the course of nitrogen mineralisation after fertilisation, manure was incubated under natural soil temperatures in conjunction with the trials in Västergötland. The manure was added to soil to a total of 400 g in 1-litre plastic bottles and placed in the topsoil at different times of the year, simulating different fertilisation times. The broiler manure used in the trials had approx. 55-60% DM, 28-31 kg tot-N ton^{-1} and 5-7 kg NH_4-N ton^{-1}, while the laying hen manure had approx. 23-24% DM, 15 kg tot-N ton^{-1} and 11 kg NH_4-N ton^{-1}.

Results and discussion

The results indicated that the fertilisation effect was better estimated from total N content than mineral N content. Laying hen manure (24% DM, with 67% of total N as NH_4-N) had net N immobilisation, while broiler manure (55% DM, with 25 % of total N as NH_4-N) had net N mineralisation (Figure 1). Both types of poultry manure therefore contributed approximately equal amounts of mineral N to the crop and gave similar effects on yield in proportion to their total N content.

Figure 1. Mineral N in field incubations at different dates after manure application

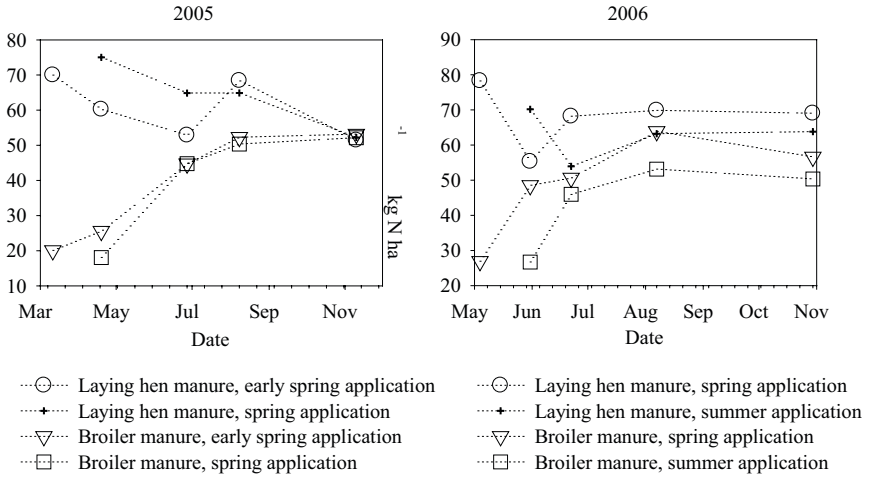
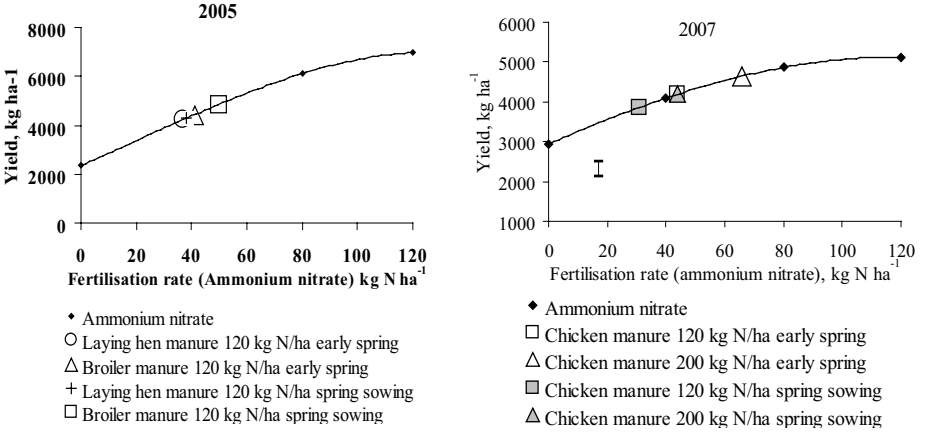


Figure 2. Barley grain yields at different application rates and times of manure application compared with yield response curve to ammonium nitrate



In Västergötland in 2005, 120 kg tot N ha^{-1} with manure corresponded to 40 kg N ha^{-1} with mineral fertiliser in three of the treatments. In one treatment (broiler manure at sowing) 120 kg tot N ha^{-1} with manure corresponded to 50 kg N ha^{-1} (Figure 2). This corresponds to effects of 33 and 41% from the total N compared with mineral fertiliser. The yield effect from broiler manure in Halland 2007 (Figure 2) was better after early spreading (March 23) than after application at sowing (April 4), possibly due to stronger sunlight at sowing causing ammonia volatilisation. The total N in early application corresponded to 33-37% as much mineral fertiliser N, whereas the later application only corresponded to 22-23%. There were no major differences in effect per kg total N between doses (Figure 2).

In 2006, spring sowing was later than usual in Sweden. This was followed by dry weather in June, which gave a low effect of both mineral N fertilisers and manures. The effect of total N in poultry manure in the three trials gave on average only 23% compared with mineral N when application after emergence was excluded. That gave no yield effect at all, due to weeks of no rain after application.

Differences between individual treatments in residual effects on yield of the following oat crop in 2006 in Västergötland were not statistically significant. However, treatments with manure gave on average 150 kg more yield or 3.4 kg more N yield in oats in 2006 compared with treatments equivalent to 40 kg N ha^{-1} as mineral N in 2005 (Table 1). According to the yield response curve in barley in 2006 (Figure 3), this yield effect corresponds to about 7.5 kg mineral fertiliser N in this year.

Table 1. Residual effect of poultry manure type and timing on oat yield and oat N yield, Västergötland 2006

Treatment in 2005	Yield (kg ha^{-1})	N-yield (kg ha^{-1})
0 kg N ha^{-1}	4526	74
Laying hen manure, early spring	4590	75
Laying hen manure, spring	4571	77
Broiler manure, early spring	4645	77
Broiler manure, spring	4598	77
40 kg N ha^{-1}	4449	73
80 kg N ha^{-1}	4422	72
120 kg N ha^{-1}	4573	75
LSD	164	4

Table 2. Residual effect of poultry manure type and timing on oat yield and oat N yield, Västergötland 2007

Treatment in 2006	Yield 2007	N-yield 2007
0 kg N ha^{-1}	4744	61
30 kg N ha^{-1} + Laying hen manure, spring (soil incorporation)	5006	70
30 kg N ha^{-1} + Broiler manure, spring (soil incorporation)	5169	72
30 kg N ha^{-1} + Broiler manure, spring (no soil incorporation)	5220	70
30 kg N ha^{-1} + Broiler manure, summer	5323	76
30 kg N ha^{-1}	5086	65
80 kg N ha^{-1}	4946	65
120 kg N ha^{-1}	5129	73
LSD	346	7

Residual effects in 2007 were somewhat larger, probably due to low utilisation of the N during the unfavourable year 2006. There were significant effects between treatments.

The best residual effect was achieved in the treatment with the lowest N utilisation in 2006 (summer application of broiler manure), with 560 kg more yield or 12 kg more N yield compared with treatments that received 30 or 80 kg N ha^{-1} as mineral N in 2006 (Table 2). The other manure treatments gave on average 290 kg more yield or 6 kg more N yield compared with treatments that received 30 or 80 kg N ha^{-1} as mineral N in 2006 (Table 2).

There were no statistically significant differences in residual effects on the following oilseed rape crop between the different rates of broiler manure in 2006 in Halland and Öland (Table 3) or compared with the higher mineral fertilisation rates. However the differences (about 500 kg ha^{-1}higher yield) compared with treatments with 0 and 40 kg N ha^{-1} were significant (Table 3). The higher mineral N rates obviously also gave residual effects due to low utilisation in 2006.

Table 3. Residual effect of poultry manure on winter oilseed rape, Halland and Öland 2007

Treatment in 2006	Yield 2007, Halland	Yield 2007, Öland
0 kg N/ha	1731	1866
Broiler manure 120 kg tot N	2116	2231
Broiler manure 200 kg tot N	2344	2244
40 kg N/ha	1687	1938
80 kg N/ha	2222	2145
120 kg N/ha	2037	2288
LSD	470	253

On average, the residual nitrogen effect on the following crop corresponded to yield effects from mineral fertiliser N rates of 5-10% of the total N in the manure applied.

Conclusions

Fertilisation effect was better estimated from total N content than mineral N content. The yield effect of total N in laying hen and broiler manure corresponded to 30-40% effect compared with mineral fertilisers (20-30% under less favourable conditions). The best time of fertilisation varied between trials, presumably due to different weather conditions and thereby different risks for ammonia volatilisation during application. The residual nitrogen effect on the following crop corresponded to 5-10% of the total N in the manure applied.

Acknowledgements

The investigations were financed by Foundation for Agricultural Research. The author also wishes to thank Rolf Tunared and Johan Fredriksson at Lanna Experimental Station in Västergötland and Erik Ekre, Klas Eriksson and Magnus Håkansson at Hushållningssällskapet in Halland and Kalmar for management of the field trials.