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DEEP LITTER MANURE TO SPRING CEREALS
- MANURE PROPERTIES AND AMMONIA EMISSIONS

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ABSTRACT

The study was designed to give information on certain effects of using deep litter manure in crop production. Fresh and stored deep litter manure from a dairy farm were investigated for chemical and physical properties as well as ammonia emissions following spreading in autumn and spring. Incorporation into the soil was made 4-7 days after spreading. Manure bulk density and comminution resistance were measured by means of a 'characterization box'. Ammonia emissions following spreading were measured using an equilibrium concentration method. Measuring equipment for both physical properties and ammonia emissions were earlier developed at JTI. The mean total ammoniacal nitrogen (TAN) share of total nitrogen was 23 % in fresh deep litter manure and 8 % in stored deep litter manure. Bulk densities in stored manure varied in the range 619-764 kg m^{-3}, compared with fresh deep litter manure where corresponding values were 345-402 kg m^{-3}. Measurements of the comminution resistance in the manures used in spring, showed that the mean value for fresh manure (51 Nm) was higher compared with the corresponding figure for stored manure (44 Nm). Ammonia emissions were higher when spreading in autumn compared with spreading in spring. It was estimated that almost all TAN (about 22 % of total nitrogen) seems to have been emitted as ammonia after spreading of fresh manure in autumn. The corresponding figure for spreading fresh manure in spring was measured to be about 15 % of total nitrogen. Emissions after spreading of decomposed and stored manure were 8 % of total nitrogen in the autumn and less than 1 % in spring.

Key words: Manure, deep-litter, properties, spreading, ammonia, emissions

INTRODUCTION

Livestock buildings designed for improved conditions according to animal health and animal behaviour are emphasised in the Swedish animal welfare law and within organic farming. Deep litter systems offer good possibilities for the natural behaviour of animals. Fresh deep litter, especially where large amounts of straw are used, is often heterogeneous. Today's spreading technology for field application often gives poor scattering and an uneven distribution of such manures. However, in stored deep litter manure the organic material is more or less decomposed which gives a product that is easier to scatter and spread evenly. One drawback is that during storage of deep litter manure, up to 50 % of the nitrogen can be lost. The aim in this project was to investigate both fresh and stored deep litter manure for manure properties and ammonia emissions following spreading in two different spreading seasons.

MATERIALS AND METHODS

In spring 1997 a batch of deep litter manure from cattle was put in a windrow for storage, decomposition and subsequent use as stored manure in a field application study. The windrow was approximately 2.5 m wide at ground level, 1.9 m high and 25 m long. A tractor with front loader was used on three different occasions during the summer to loosen and mix the windrow in order to encourage decomposition. Spreading of the stored deep litter manure was performed in late autumn in 1997 and at spring tillage in 1998. On both spreading occasions, fresh deep litter manure from the same dairy farm was also spread. The spreader used for both treatments was a JF ST 9500 equipped with a control system and a moveable front wall mounted on the bottom conveyor for improved longitudinal distribution pattern. Further, a hood was attached over the two horizontal beaters to ensure a controlled working width.

Spreading was performed on cereal stubble in the autumn, followed by ploughing 7 days later. Spreading in spring was performed on already ploughed and harrowed land prior to spring tillage. Incorporation into the soil was made by means of a rotary harrow 4 days after spreading. Spring barley crops were established in both cases. First and second year yield responses were measured as kg harvested grain per hectare, but will not be further discussed in this paper.

Manure samples were taken on the two spreading occasions from each one of the two treatments (manures) used. Analyses were made of chemical properties. Applied amounts of manure were adapted to the phosphorus concentration in the manures and the crop's needs of that nutrient. For measuring physical properties, a specially made 'characterization box' was used (Malgeryd, 1994). The box held 1.3 m^3 of manure. Bulk density was measured by weighing the whole box with three separate samples per treatment. To estimate comminution resistance in the manure, a desometer plate with spikes was forced down into the manure in the box. Then the plate was turned 90° at a constant low speed by an electric motor. The torque needed was measured. Measurements were made in all three boxes; four separate measurements when each box was half filled and four additional measurements when each box was full. That gave a total of 24 torque values from which the mean torque was calculated. Heterogeneity was calculated as the coefficient of variation for the torque values measured. Manure samples for chemical analyses were taken from the box with a pitchfork during loading. One subsample was taken when each box was half filled and one when it was completely filled.

Ammonia emissions following spreading were measured with an equilibrium concentration method, developed at JTI (Svensson & Ferm, 1993). The method is based on passive diffusion sampling close to the ground. Three replicate field plots were used for ammonia measurements within each treatment. Two dynamic chambers and one ambient condition meter were used in each plot. 3-5 separate measuring periods were used in each treatment, depending on estimated emission rates. During the ammonia measurements, air temperature, soil surface temperature and wind speed were continuously recorded by means of a Vicon WS 801 weather station (Vicon LTD., Ipswich, U.K.).

RESULTS AND DISCUSSION

Chemical properties of the used manures are given in Table 1. Phosphorus (P) concentrations indicate that decomposition continued in the windrow manure storage between the two spreading seasons, since the concentration was higher in the spring season. The opposite trend was found for total nitrogen, where the concentration decreased during the same period, indicating that losses of nitrogen occurred during the winter and spring storage period. The mean total ammoniacal nitrogen (TAN) share of total nitrogen was 23 % in fresh deep litter manure and 8 % in stored deep litter manure, which corresponds with earlier findings (Kirchmann, 1985). Thus, the potential for ammonia release following spreading of stored manure was reduced.

Table 1. Chemical properties and application rates of used manures in autumn 1997 and spring 1998

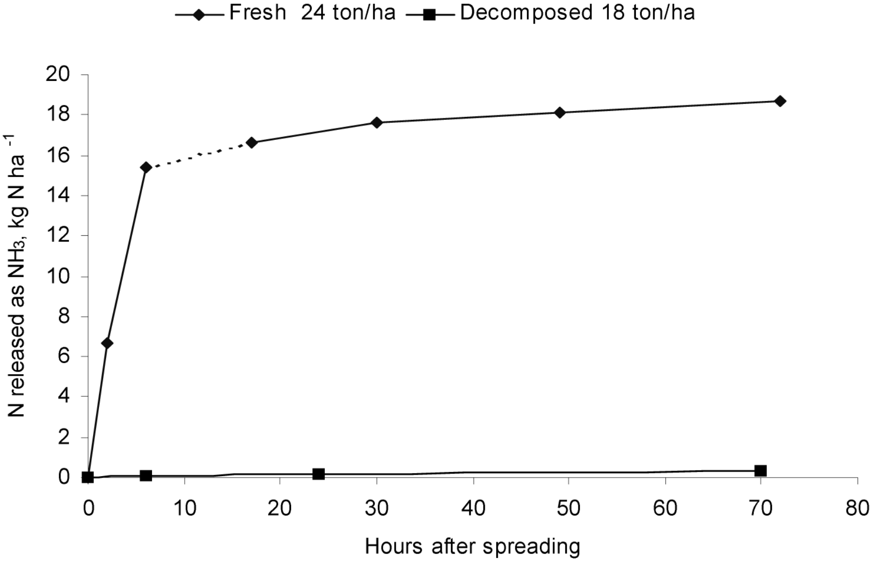
	Autumn 1997		Spring 1998	
	Fresh manure	Stored manure	Fresh manure	Stored manure
Dry matter, %	18.2	29.8	26.3	37.6
pH	9.0	9.1	9.2	8.9
Total-N, kg tonne^{-1}	3.2	9.5	5.3	5.9
TAN, kg tonne^{-1}	0.7	0.8	1.3	0.5
P, kg tonne^{-1}	0.6	1.5	1.7	2.2
K, kg tonne^{-1}	5.3	18.0	12.0	11.0
Application rate, kg [Total-N] ha^{-1}	96.0	42.8	127.0	106.0
Application rate, kg [TAN] ha^{-1}	22.2	3.6	31.2	9.5

Decomposition and storage of deep litter manure led to higher bulk densities than those found in the fresh manures. Bulk densities in stored manure varied in the range 619-764 kg m^{-3}, compared with fresh deep litter manure where corresponding values were 345-402 kg m^{-3}. Measurements of the comminution resistance in the manures, by means of the torque values, showed that the mean value for fresh manure (51 Nm) was higher compared with the corresponding figure for stored manure (44 Nm). However, the difference was not statistically significant. These comparative measurements were only made at the spreading occasion in the spring.

By calculating the coefficient of variation (CV) of the measured torque values, the results give an indication on the manure's heterogeneity. It was found that the CV was higher for fresh manure (36 %) than for stored manure (23 %), indicating that the decomposition process and other processes during the storage period lead to a more homogenous product compared with fresh manure.

Ammonia emission rates were higher after spreading of fresh manure compared with stored manure. When spreading in autumn the emission rate from fresh manure was so high that the samplers at the first measuring period, ranging over the first four hours after spreading, became saturated. However, considering also the results of the subsequent measuring periods, it was estimated that almost all TAN (about 22 % of total nitrogen) seems to have been emitted as ammonia after spreading. The corresponding figure for spreading fresh manure in spring was measured to be about 15 % of total nitrogen. Emissions after spreading of decomposed and stored manure were 8 % of total nitrogen in the autumn and less than 1 % in spring. According to spreading of fresh manure in autumn, it was found that the ammonia emission rate was still high the day after spreading. Figure 1 shows the cumulative ammonia release after spreading in spring. The curve representing release from fresh manure shows that it is only during the first 6-8 hours after spreading that the emission rate are high.

Fig. 1. Accumulated nitrogen losses as ammonia after spreading of deep litter manure to arable land prior to spring tillage



These facts indicate that rapid incorporation would be an effective measure to reduce ammonia emissions after spreading of fresh deep litter, especially when spreading in autumn.

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