MINERAL LOAD ON THE PADDOCK OF ORGANIC SOWS IN THE NETHERLANDS

Sonya Ivanova-Peneva (1,2), Andrè Aarnink (2), Martin Verstegen (3)

(1) Agricultural institut, 3 Simeon Veliki blvd., 9700, Shumen, Bulgaria, Tel. +359 (0) 54 83 04 48, sonia.ivanova@wur.nl, http://www.minedu.government.bg/NSFB/rtd/eng/index.htm

(2) Wageningen UR, Agrotechnology and Food Innovations, Bornsesteeg 59, 6708 PD, Wageningen, The Netherlands, Tel. +31 (0) 317 47 65 54, andre.aarnink@wur.nl, http://www.agrotechnologyandfood.wur.nl

(3) Wageningen University, Animal Nutrition Group, Marijkeweg 40, 6700 AH, Wageningen, The Netherlands, Tel. +31 (0) 317 48 29 82, martin.verstegen@wur.nl, http://www.zod.wau.nl/vv/index.html

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Abstract

The main aim of this study was to quantify nutrient deposition on the paddock in Dutch organic pig farms. Observations of excreting behaviour of grazing sows were carried out at three farms in each of two measuring seasons (spring/summer and autumn). The nutrient loads of N, P and K were calculated according to their content in urine and faeces, average weight of urine and faeces per excretion, and number of urinations and defecations done in the paddock. The N and P loads on the paddock varied greatly between the organic pig farms ($P<0.01$ for N, not significant for P and $P<0.05$ for K). The total amount of nutrients on two of the farms far exceeded the permitted levels (170 $kg.ha^{-1}year^{-1}$ for N and 44 $kg.ha^{-1}year^{-1}$ for P). On all three farms, faeces were unevenly distributed in the paddock. Regular rotation of paddocks resulted in a more uniform distribution.

Introduction/Problem

According to EC regulation No 2092/1991 (Council Regulation 2092/91) and supplementing No 1804/1999 (CEC, 1999), in organic pig production pregnant sows must have access to pasture, which allows the sows to express their natural rooting and grazing behaviour. However, this practice brings animal welfare into conflict with environmental issues, as the animals deposit a high nutrient load on the paddock from their excretions. As the manure deposited by grazing sows is difficult to utilise, the potential for nutrient loss is considerable (Eriksen and Kristensen, 2001). Overstocking with pigs for long periods on the same area may cause nitrate leaching (Worthington and Danks, 1992) and phosphorus accumulation in soils (Jongbloed, 1998). Moreover, soil nitrate leaching results in enhanced nitrate levels in groundwater and surface water.

Methodology

General description of the farms

The study was conducted on three organic pig farms in The Netherlands in three different provinces. On farms 1 and 2 the soil was sandy; on farm 3 clay soil was dominant. All three farms were organic farms with sows and fatteners. Pregnant sows were housed in closed buildings with access to an outside yard and a paddock used in the time of the year when the vegetation (clover grass) was present.

Management of the paddock

On farm 1 the sows had access to the paddock continuously from approximately mid-May until October-November, when almost all the vegetation of the paddock was gone. The practice on this farm at the beginning of the grazing period was to expand the paddock by 3 m every two or three weeks, until the sows had access to an area of 4,270 m^2 in total. On farm 2 the sows had access to the paddock from end of May - beginning of June onwards until November-December. They had access to an area of approximately 1 ha (10,200 m^2). There were three equal-sized paddocks available on this farm for rotation every year. On farm 3 there were three almost equal-sized paddocks, with a total area of approximately 25,00 m^2. Sows had daily access to one of these paddocks from 15.30-16.00 h until sunset; except when the meadow was too wet. This prevented the structure of the clay soil from being destroyed by poaching. Every two weeks the paddock was rotated.

Observations and measurements

The sows' behaviour on the paddock was observed by direct observations during one day in each of two seasons (in spring and in autumn) . From the observations on excreting behaviour recorded on paper, the number of urinations and defecations and the place they were made were determined and analysed.

On the day after the behavioural observations, representative samples of urine and faeces were taken. The samples were analysed for total-N, total-P, total-K, NH_4^+-N, pH, dry matter and ash. Nutrient load of N, P and K was calculated according to their content in urine and faeces, average volume of urine and average weight of faeces, and number of urinations and defecations done in the paddock. The data on nutrient output were analysed by ANOVA using the Genstat program 7.1, including farm and period (spring-summer and autumn) as factors in the model without interaction effect.

The distribution of the faeces on the paddock was recorded once on farms 1 and 2 and twice on farm 3, simultaneously with direct behavioural observations. The location of visually fresh faeces was mapped on a plan of the paddock on millimetre paper. The spread of faeces on every farm was estimated according to the distance from the entrance and was calculated in number of droppings per square metre.

Results and brief discussion

EU regulations for organic farming (Council Regulation No 2092/91) stipulate that the amount of manure applied to a farmer's arable land may not exceed the equivalent of 170 kg N ha^{-1} yr^{-1}. The European Commission has not specified exactly how this application rate (including N excreted during grazing) should be converted into an acceptable excretion rate (Schröder et al., 2004). The Dutch authorities have reasoned that an effective application rate (i.e. *onto* the soil) of 170 kg N ha^{-1} is equal to an excretion rate of circa 200 kg N ha^{-1} (Oenema et al., 2000).

In our study there was great between-farm variation in the N, P, and K loads on the paddock: the effect of farm was statistically significant for N ($P<0.05$), but not significant for P and K. The effect of period (spring-summer, or autumn) was not significant. On farms 1 and 2 with paddock areas of 89 m^2 per sow, the nutrient output of nitrogen on the paddock was much higher than permissible standards (420 kg N ha^{-1} yr^{-1} for farm 1 and 2, respectively). On these farms, the big excess of nutrients means there is a real risk of environmental pollution. On farm 2, where the paddock area per sow was bigger (289 m^2 per sow) compared with the other two farms, nutrient output of nitrogen was below maximum permissible levels. Furthermore, the whole system was different: the sows had access to a sandy yard and a long sandy path to the paddock. This explains why faeces and urine were more evenly spread through the whole system. Although the urine of sows on this farm contained larger amounts of N, P, K compared with the other two farms, relatively little of the nutrients were deposited on the paddock. On farm 3 the N output was 523 kg ha^{-1} yr^{-1}, which is more than treble the permitted standard. On this farm the sows' access to the paddock was limited: from 15.00-15.30 h in the afternoon until sunset. The soil on this farm was clay and the meadow was generally too wet in the morning, or when it was raining. But on this farm the sows had a preference to urinate (45.8% of total urinations) and defecate (59.5% of total defecations) on the paddock in the afternoon hours, when they were released. This pattern of excretion behaviour contributed greatly to the higher nutrient load on the paddock.

With respect to phosphorus output on the paddock, on two of the farms the permissible level of 100 kg P_2O_5, which is equivalent to 44 kg P per ha per year, was exceeded (2.5 times on farm 1 and approx. 4 times on farm 3). On farm 2 the estimated value of 20 kg P $ha^{-1}year^{-1}$ was much less than the permissible level. There is no standard for comparing the load of K.

The main reason for the higher nutrient load on farms 3 and 1 is the higher number of animals per hectare. As reported by Eriksen and Kristensen (2001), increases in both soil nitrates and phosphorus were related to increased stocking rates. In most of the available literature the appropriate stocking density mentioned in relation to minimising environmental problems assumes outdoor pig production, where all the excretions are done on the paddock. We cannot simply compare our data with such a system, because of the different distribution of urinations and defecations between the different farm compartments in our study. But it is clear that the stocking rate on the paddock on two of the farms (128 animals per ha on farm 1 and as many as 172 animals per ha on farm 3) is too high. In order to prevent environmental pollution, either the size of the paddock should be increased or the number of sows should be diminished. Further research on different management practices in organic pig farms in The Netherlands must be done to determine the optimum number of sows per ha grazing area.

The current practice in organic pig farms in terms of diet and stocking density results in substantial nutrient deposition in the paddock (Watson and Edwards, 1997), which is in agreement with our results. However, even with moderate stocking densities the excretory behaviour of pigs may create nutrient 'hot spots' in the paddock (Zihlmann et al., 1997). We observed differences in the number of droppings per surface area on the three farms. The sows on farm 3 had the smallest area available (65 m^2 per sow), and on this farm the number of visible droppings was the highest (respectively 0.222 and 0.224 droppings m^{-2} in the first and second observations). The difference compared with the other two farms was highly significant ($P<0.001$). On farm 2, the number of visible droppings was the smallest: 0.012 droppings per m^{-2} on farm 1 the average number was 0.072 m^{-2}.

In all three farms the faeces were not spread evenly over the paddock, especially on farm 2. On that farm the sows had a large area available for grazing. The skewness in distribution on that farm was very big - about 5 times higher per m^2 in the first quarter of the area than the average for the paddock. On farm 1 the first quarter of the paddock (where it was bare) was favoured for defecation (41.6 \%). In the second and third quarters the excretions were almost equally spread, but in the last quarter only a small number of excretions were observed (10.2%). On farm 3, during the first observation the faeces were better distributed than during the second observation and in comparison with the other two farms. The second observation was characterised by a more uneven distribution of faeces. The favoured area for excretion was between 12 and 16 m from the entrance, where the average load of faeces was more than double the average for the whole paddock.

As a result of this uneven distribution of excretion, in certain areas the deposition of nutrients may be much higher than the average for the whole paddock. In accordance with other authors (Sommer et al., 2001; Eriksen and Kristensen, 2001), we would argue that a surplus of N could be source of emissions to the air and nitrate leaching. The distribution of N surplus between plant uptake, losses, and soil organic matter depends on soil type and climatic conditions. However, in temperate regions the combination of sandy soils and high rainfall may lead to a relatively large proportion being lost through leaching. This is very likely in The Netherlands, where most organic pig farms are on sandy soils. Furthermore, on most Dutch farms, clover/grass is the dominant pasture. Generally, clover grass ley elements are the most susceptible to nitrate leaching (Stolze et al., 2000) and that increases the risk of environmental pollution on organic pig farms in The Netherlands.

In addition to the type of soil and the distribution of nutrients, the vegetation cover of the pasture is important in terms of risk of environmental pollution of pasturages. In a study by Williams et al. (2000), the nitrate concentrations increased towards the end of the grazing season as the grass cover became more damaged, and the lack of vegetative cover during the second winter of the study had a large influence on leaching losses. We may expect leaching losses to be higher on farm 1 than on the other two farms because during the second observations (in autumn), the grass cover had disappeared as a result of the sows' grazing, trampling, and rooting. Bearing in mind that this farm had a high load of nutrients, was on sandy soil, and had a skewed distribution of excretions, we can expect a considerable amount of nitrogen to be leached to the groundwater and a considerable amount of phosphorus to accumulate in the soil, which will ultimately become saturated.

The distribution of nutrients was more even on farm 3, where sows had access to three small paddocks and paddocks were rotated very three weeks. But from the direct observations of the behaviour we found that when sows had limited access to the paddock, they excreted frequently in the first hour of grazing. Other authors (Eriksen and Kristensen, 2001) have argued that a uniform distribution of nutrients should be obtained by keeping sows in smaller groups instead of in a large communal paddock, and also by manipulating the excretory behaviour of sows. Our findings support this conclusion. We suggest that the excretory behaviour be manipulated by offering sows first a small paved yard for urination and defecation for one hour and then giving them access to the paddock. In this way most urine and faeces should be produced on the paved yard, where it could be easily collected and distributed evenly on the field in the right amount.

Conclusions

Nutrient load of N and P on the paddock of sows is varies a lot among organic farms. In two of the three studied farms, standards were considerably exceeded. Unequal distribution of excretions was found in all the studied farms. Rotation of paddocks resulted in a more uniform distribution on the paddock.

In order to prevent environmental pollution, the area of the paddock should be matched to the number of sows. Manipulating the excretory behaviour of sows also may decrease nutrient load on the paddock.

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