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Efficient and reliable utilisation of nutrients in animal manures

Members of the Project Team and International Steering Committee at the Project Conference held in Johnstown Castle Research Centre on 26 November 2009

Key external stakeholders:

Farmers, agricultural contractors, agricultural machinery manufacturers and retailers, fertilizer industry and policy makers.

Practical implications for stakeholders:

This research was conducted to investigate strategies for organic manure application that maximise their nitrogen fertilizer replacement value (NFRV). Application methods and timings for cattle and pig slurry were assessed in grassland and cereal crop systems. The research also studied the logistical issues associated with pig manure by calculating the transport distance required to locate arable spreadlands for pig manure application.

Main results:

- In grassland, cattle slurry application using trailing shoe under optimum weather conditions (spring application) achieved the highest NFRV. Optimising weather conditions through spring application is the most cost effective way to maximise NFRV.
- The target NFRV of 40% for cattle slurry is achievable on grassland, but only under optimal weather conditions and by using high-cost trailing shoe technology. The target of 40% is only achievable when the recovery of N in subsequent years following application is included.
- The target NFRV of 50% for pig manure in cereal crops is achievable where the manure is incorporated into the soil within hours of application.
- The transport distance required to utilise pig manure on tillage crops is highest in northern and western counties. The transport distance is dependent on the willingness of tillage farmers to take manure.

Opportunity / Benefit:

- The advice regarding the reliability and precision of using cattle and pig slurries to offset chemical fertilizer requirements has been improved.
- The fertilizer replacement potential of organic fertilizers will be incorporated into future editions of Teagasc's Nutrient Advice publications.
- Managing organic fertilizers more effectively can result in improved nutrient recycling on farms, potentially reducing both fertilizer costs and environmental impacts of nutrient surpluses on farms.
- The results of the project are also relevant to future manure management policy development, and to the development of landspreading methods and technologies.

Collaborating Institutions:

UCD

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1. Project background:

The Nitrates Directive regulations impose limits to nitrogen (N) and phosphorus (P) inputs onto livestock and tillage farms. This is having a large impact on both cattle/dairy farms and pig farms.

Cattle and dairy farming systems are required to make more efficient use of nutrients. International experience suggests that significant gains in nutrient efficiency can be made by increasing the utilisation of N in slurry. Data from Teagasc, Johnstown Castle, suggested N-utilisation efficiencies from slurry as low as 5% under existing practices, whereas international literature suggests that there is scope to raise efficiencies to 40-80%. Despite the relatively low utilisation in practice, the Nitrates regulations set an NFRV target of 40%, presenting a considerable challenge for the grassland sector.

In addition, the ceiling to nutrient inputs imposed under the Nitrates Directives made it difficult for many livestock farmers to continue to accept pig slurry as a fertilizer onto their farm. As a result, the potential for the traditional practice of spreading slurry on grasslands has been reduced significantly. Returning pig slurry to arable land allows a more closed nutrient cycle to operate, since cereal grains constitute a significant proportion of the diet of pigs. However, this creates a major logistic challenge where arable land and pig farms are not closely located.

2. Questions addressed by the project:

- What are strategies and methods for the application of cattle slurry to grassland that maximise the NFRV and reduce the variability associated with predicting the nutrient utilisation in the year of application?
- What is the residual effect of cattle slurry applications to grassland on the NFRV in subsequent years?
- What is the fertiliser replacement value of pig slurry applied to cereal crops?
- What are the transport distance implications at a national scale of transporting pig slurry to suitable tillage areas?

3. The experimental studies:

Four separate experimental studies were conducted to address the four project objectives.

A field study was carried out over 3 sites and 3 years to compare the effect application method (splashplate and trailing shoe) and application timing (April and June) on the NFRV of cattle slurry in grassland. This experiment was carried out on field plots using farm-scale slurry application machinery.

A similar study was also conducted to examine the long-term effects of the residual N release from cattle slurry in the years following application. This experiment was carried out on small scale plots and soil cores, and included ^{15}N stable isotope technology to trace the pathways of slurry-N in the soil and plant system over time.

The NFRV of pig manure applied to cereal crops was assessed in a total of 18 field experiments in five separate locations over four years. The field trials compared the grain yield and N uptake in spring barley between chemical N fertilizer and pig manure. Pig manure was applied and incorporated rapidly into the

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seedbed by ploughing. Yield response curves to fertilizer N with and without pig manure were used to calculate the NFRV of the pig manure.

The fourth part of the project was a desk study of the transport distances required to find arable spreadlands for pig manure. Datasets of land use, road networks and pig farm locations were analysed to calculate the average travel distance required in order for pig manure to be applied to arable land. The analysis facilitated regional comparisons of the average travel distances required.

4. Main results:

The experiments with cattle slurry application on grassland show that the NFRV in the year of application was affected by application method and timing. Cattle slurry applied with splashplate had an NFRV of 21% in April and 12 % in June. Application using trailing shoe increased the NFRV to 30% in April and 22% in June. Changing application timing from summer to spring with existing splashplate machinery is the most cost effective strategy for improving NFRV.

Approximately 4% of the total slurry N applied was recovered in the second year after application. For repeated applications over a number of years, models indicate that the maximum cumulative residual recovery would be 12-14% of the annual slurry N application rate. It would take approximately 10 years of repeated slurry applications for the residual N release to reach this maximum level.

The NFRV target of 40% set in the Nitrates regulations was only achieved when the residual N release was included, and when best practice strategy of trailing shoe application in April was adopted. Spring application of slurry is often restricted by soil trafficability, particularly on poorly drained soils. The trailing shoe application method can provide more flexibility for spring application as grass contamination is reduced compared to splashplate.

The NFRV of pig manure on cereal crops was 50% on average. This is in agreement with the target in the nitrates regulations. However, the NFRV of 50% is only achievable under best practice whereby the manure is incorporated into the soil immediately (< 2 hours) after application. The NFRV of 50% refers to the actual total N content of the pig manure being applied. This can differ from the total N content assumed in the Nitrates regulations. There can be considerable variation in the total N content of all manure types.

In a best case scenario where all arable spreadland was available to receive pig manure, the national per-parcel manure transport distances from pig farms to arable farms was 22 km. This transport distance was increased when the willingness of farmers to use pig manure, and the variation in the P requirements of soils and crops was taken into account. The transport distance varied considerably between regions, and results confirmed expectations concerning counties in the south east and east of Ireland with the average distance to parcel by county well below the modelled national average of 22 km, while counties in the north and west had average travel distances that were far higher.

5. Opportunity/Benefit:

The findings of this project have substantially increased the reliability and precision of using cattle and pig slurries to offset chemical fertilizer requirements and costs in grassland and arable systems. The information generated regarding the fertilizer replacement potential of organic fertilizers has been widely publicised, and will be incorporated into future editions of Teagasc's Nutrient Advice publications. The use of this information in managing organic fertilizers more effectively can result in improved nutrient recycling on farms, potentially reducing both fertilizer costs and environmental impacts of nutrient surpluses on farms. The results of the project are also relevant to future manure management policy development, and to the development of landspreading methods and technologies.

6. Dissemination:

Main publications:

Lalor, S.T.J., Schröder, J.J., Lantinga, E.A., Oenema, O., Kirwan, L. and Schulte, R.P.O. (2011). 'Nitrogen fertilizer replacement value of cattle slurry in grassland as affected by method and timing of application.' *Journal of Environmental Quality*, 40(2): 362-373.

Hoekstra, N.J., Lalor, S.T.J., Richards, K.G., O'Hea, N., Dungait, J.A.J., Schulte, R.P.O. and Schmidt, O.

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(2011). 'The fate of slurry-N fractions in herbage and soil during two growing seasons following application.' *Plant and Soil,* 342: 83-96.

Hoekstra, N.J., Lalor, S.T.J., Richards, K.G., O'Hea, N., Lanigan, G.J., Dyckmans, J., Schulte, R.P.O. and Schmidt, O. (2010). 'Slurry (NH_4)-N-^{15}N recovery in herbage and soil: effects of application method and timing.' *Plant and Soil,* 330 (1-2): 357-368.

Selected Popular publication:

Lalor, S.T.J. and Schulte, R.P.O., 2008a. Slurry application using trailing shoe - potential benefits come at a price, TResearch, pp. 35-37.

Hoekstra, N.J., Richards, K., Schmidt, O., Lalor, S.T.J. and Schulte, R.P.O., 2010a. The fate of slurry nitrogen in grassland, TResearch 5:1, pp. 28-29.

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