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Studies on the supply of nitrogen from soil to wheat

Key external stakeholders:
Cereal and crop growers; Advisers and crop consultants; Crop production industry; Other research teams.

Practical implications for stakeholders:

- The current soil N index, which relies principally on the previous crop grown, is a relatively poor indicator of soil nitrogen supply to crops
- Soil mineral N measurements made in the spring before significant crop growth, in association with information on cropping history and crop N uptake in the spring, can improve prediction of soil nitrogen supply.

Main results:

- While previous crop is a significant indicator of soil N supply to cereals it typically explains less than a third of the variation in soil N supply to crops between sites and seasons
- Soil mineral N measurements in spring, previously thought to be of little value in Irish conditions, can explain a similar amount of variation in soil N supply as previous crop when used on their own.
- Using a number of indicators in combination gives a better prediction of soil N supply than individual indicators.
- Two laboratory soil tests were of little value for indicating soil N supply.

Opportunity / Benefit:

The work, which used winter wheat as a test crop, indicated that measurements of soil mineral N could be used to improve estimation of soil N supply, defined as crop uptake at harvest where no fertilizer N has been applied. However more work is required to develop robust relationships between soil mineral N measurements, in association with other site information such as previous crop, and soil N supply across a range of crops.

Collaborating Institutions:

University College Dublin

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1. Project background:

A crops demand for nitrogen will be satisfied by a combination of nitrogen originating from the soil and fertiliser nitrogen. Therefore, estimating the supply of nitrogen from the soil is a key first step in determining the correct amount to fertiliser N to apply to a crop. Currently in Ireland an indication of the differences between soils in their ability to supply N to a crop is achieved using the soil N index system which uses previous cropping history as the main indicator of the supply of nitrogen from the soil (SNS). Given that it relies on only one indicator, this system is not very site specific. Work from abroad suggests that more site specific estimation of SNS is possible either by developing an index system that takes more variables, such as soil type and weather conditions, into account when determining the potential SNS or by using one or more laboratory tests on the soil.
This project aimed to relate soil N supply for a range of sites to factors such as previous cropping history, weather parameters and soil type and to the results of a range of laboratory measurements (e.g. organic matter levels, soil mineral N, amino sugar nitrogen, organic nitrogen) on soil samples taken from each site.

2. Questions addressed by the project:

- How well does the current N index system estimate soil N supply?
- Can the soil N index system be improved by including more variables such as soil type?
- Are measurements of soil N in spring of use in predicting SNS?

3. The experimental studies:

Areas within commercial winter wheat crops were maintained fertiliser N free, using plastic sheeting. A range of sites with different soil types and cropping histories were selected in the main winter wheat growing areas of Ireland. For each site cropping histories were recorded and weather data was obtained from the nearest weather station. Crop N uptake at harvest was determined by hand harvesting a small area at the center of the fertiliser N free area at each site and this was taken as the measure of soil N supply.
In early spring soil samples were collected from each site. Two types of soil sample were taken. The first involved taking soil cores to 90 cm depth and were used to determine mineral N (ammonium-N and nitrate-N) in the soil profile before significant crop uptake occurred. The second sample, taken to a depth of 20 cm, was used to perform a range of tests including organic matter levels, amino sugar nitrogen, total nitrogen and potentially mineralisable nitrogen. Crop N uptake was also determined at this stage.

Multiple regression procedures were used to establish relationships between SNS, as measured by crop N uptake at harvest, and both site characteristics (previous cropping history, soil type, weather) and laboratory measurements on the soil from each site to determine the best predictor or combination of predictors of SNS.

4. Main results:

When all variables were related individually to SNS, previous crop and soil mineral N, measured before significant growth in the spring, were the two variables explaining the most variation in SNS. Other factors such as soil organic matter content, total soil nitrogen content, soil type or overwinter rainfall were not well related to soil N supply.
There was large variation in SNS associated with individual previous crops. When previous cropping history was related to soil N supply according to the current soil N index system less than a third of variation in SNS, as indicated by crop N uptake where no fertiliser N had been applied, was accounted for. Including other site factors such as soil type, organic matter content and weather variables, in combination with previous crop gave relatively small improvements in the amount of variation explained.

Variation in soil mineral N to a depth of 90cm in spring before significant crop growth was able to explain approximately one third of variation in soil N supply. Sampling to shallower depths reduced the amount of variation in SNS that was explained.

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A model that included previous crop, soil mineral N measured in spring and crop N accumulation at the time of soil N measurements could explain over two thirds of variation in soil N supply.

Two laboratory tests, the amino sugar nitrogen test and a 7-day anaerobic incubation test, which have shown promise in other studies for indicating the amount of N provided by a soil to a crop were poorly related to soil N supply measured in the field in this study. They were of little added value, in terms of increasing the amount of variation in SNS that was accounted for, when used in combination with other indicators of soil N supply.

5. Opportunity/Benefit:

The work indicated that there is considerable scope for improvement of the current soil N index system used for estimation of SNS in Ireland. In particular the work highlighted the potential of measurements of soil mineral N in the spring, previously thought to be of little value under Irish conditions, to improve predictions of SNS. However more work is required to determine if mineral N needs to be measured in every field, a costly and laborious task, or if regional measurements would be sufficient to provide an indication of SNS.

6. Dissemination:

Walsh, S., Hackett, R., Wall, D. and McCabe, T. (2016) Investigating Soil Nitrogen Supply in Ireland. Poster presented at the National Tillage Conference, Kilkenny, Ireland. January 2016

Walsh, S., Wall, D. and McCabe, T., Hackett, R. (2015) Investigating the soil nitrogen supply from arable soils in Ireland. Teagasc Walsh Fellowship Seminar, Royal Dublin Society Showgrounds, Dublin, Ireland November 2015.

Walsh, S., Hackett, R., Wall, D. and McCabe, T. (2014). A study of soil nitrogen supply to winter wheat crops in contrasting rotations in Ireland.. Proceeding of the Agricultural Research Forum, Tullamore, Ireland, p 8.

Walsh, S., Hackett, R., Wall, D. and McCabe, T. (2013). Investigating Soil Nitrogen Supply in Ireland. Proceedings from the Teagasc National Crops Research Open Day 2013, Oak Park, Carlow.

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