Investigating the efficacy of soil nitrogen tests to predict soil nitrogen supply across a range of Irish soil types under controlled environmental conditions.

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1. Background & Objectives

Nitrogen (N) fertiliser usage on Irish farms is constrained under the European Union (EU) Nitrates Directive (S.I.610, 2010) which is part of the larger EU Water Framework Directive aimed at improving water quality. These constraints and increasing fertiliser prices at farm level coupled with concerns over food security and climate change at international level have placed N use efficiency high up the agri-environmental agenda.

In order to maximise the recovery and yield potential derived from N fertiliser, these inputs must be balanced with mineralised N (N_o) from soil reserves. The potential N_o may vary considerably between different soil types, and in Ireland N_o recovery over a range of grassland soils was shown to range from 74 to 212 kg N ha^{-1} yr^{-1} (Humphreys, 2007). However, the variability in soil N supply between soils is not reflected in current N recommendations in Ireland and in many fields N fertilisers are either under- or over-supplied compared to requirements for crop growth.

The objective of this study was to evaluate soil N tests for predicting soil N supply, grass DM yield and grass N uptake for a range of Irish soil types. This research aims to develop a soil N testing system for Ireland, as a basis for new soil specific N fertiliser advice to help farmers achieve grass production targets while conserving N fertiliser resources, and minimising N losses to the environment.

2. Materials & Methods

A soil microcosm experiment was established to compare grass growth across 28 different soil types. Soils were collected throughout Ireland to a depth of 10cm, potted in 11.3 L pots, optimised with key macronutrients (i.e. P, K & S) and seeded with ryegrass *(Lolium perenne* L.*).* No N fertiliser was added to these soils over the duration of the experiment. Four replications of each soil type were placed into a controlled environment facility in randomised blocks (where shelf position was the blocking factor). The temperature was fixed at $15^{o}C$, relative humidity at 80%, soil water maintained at 65% field capacity, and day-length at 16 hours light per day. Four grass harvests from each pot were taken at five week growth intervals and the grass DM yield, N content and N uptake were determined. The soils were also sampled to a depth of 10cm at each harvest time and analysed within 24 hours for mineral N (Total Oxidized N (TON= NO_3-N + NO_2-N) & NH_4^+-N) using 2M KCl extraction. The remainder of the soil (approx 40g) was dried at $40^{o}C$ and sieved to 2mm. The N_o potential was analysed using a standard seven-day anaerobic incubation method (AI-7) (Waring & Bremner, 1964) and the Illinois soil N test (ISNT) (Khan et al., 2001). Soils were analysed for a range of physical, chemical and biological properties, e.g. Total C and N, texture, pH and soil organic matter levels. Regression and stepwise regression analysis was performed on these data in SAS. JMP. version 9, to model the relationships between AI-7 and ISNT, and between mineral N, ISNT and grass DM yield and grass N uptake across the 28 soil types.

3. Results & Discussion

There was a large range in N_o potential (73 to 396 mg NH_4^+-N kg^{-1}) over the 28 different soil types in this study as measured by AI-7. This shows that some soil types have the capacity to supply more of the grass N requirement than others. Therefore less N fertiliser may be required to reach optimum grass growth on these soils. Illinois soil N test (ISNT) values were correlated with AI-7 values across all soils (r^2 = 0.68). This result supports previous laboratory studies where six rapid chemical N tests were compared to the time consuming AI-7 method across 35 similar soil types. Here the ISNT was found to be the best rapid soil test for predicting of N_o (McDonald et al., 2011). However, ISNT does not measure TON and by itself was a poor predictor of grass yield across all 28 soil types (Figure 1)**.** Thirteen out of 28 soils had high residual TON levels (>6 mg kg^{-1}) after harvest (Figure 2.). These soils produced higher grass DM yields and grass N uptake compared to the soils with low residual N levels. Total Oxidised N was a poor predictor of grass yield for sites with low residual N reserves, as these sites relied on the supply of N through N_o. However, when both ISNT and TON were combined to predict grass DM yield and grass N uptake across these soil types, the r^2 for these prediction models were 0.78 and 0.87 respectively.

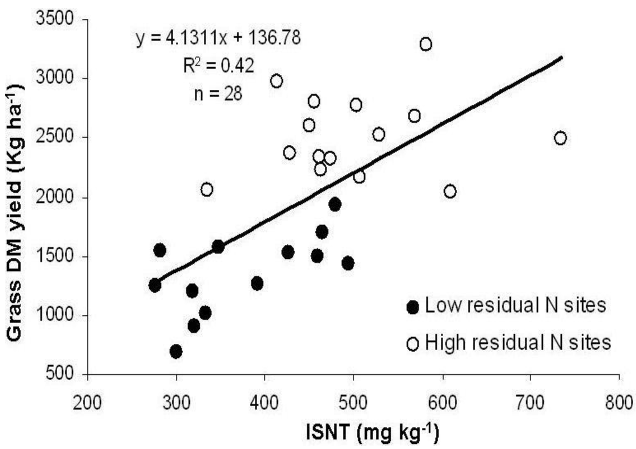

Figure 1. Illinois soil N test (ISNT) versus grass DM yield for 28 soil types.

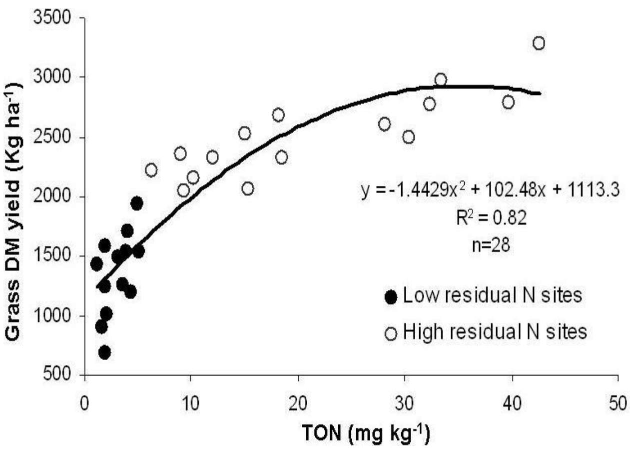

Figure 2. Residual Total Oxidised N (TON) versus grass DM yield for 28 soil types.

4. Conclusion

Irish soil types have the capacity to supply high levels of N through N_o. This shows that there is scope to reduce N fertiliser application rates on some soils without compromising grass DM yields. The ISNT was correlated with AI-7 and is suitable for routine soil analysis to predict N_o. Where high levels of residual TON was present in some soils, this contributed to higher grass DM yield and grass N uptake above what would have been achieved from N_o alone. When combined in a model, ISNT and TON were able to predict both grass DM yield and grass N uptake with a high degree of accuracy. This work shows the potential to better manage N fertiliser inputs based on soil N supply potential in order to increase N use efficiency.

References

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