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Project leader:	Dr Clive Rahn
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The results and conclusions in this report are based on an investigation conducted over one year. The conditions under which the experiment was carried out and the results obtained have been reported with detail and accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results especially if they are used as the basis for commercial product recommendations.

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Grower Summary

Headline

Whilst the research is not complete this report highlights key actions that growers should consider when assessing the soil nitrogen status of their fields in rotations of crops containing vegetable crops.

Background and expected deliverables

There is need to manage nitrogen application into the soil to maximise the efficiency in which nitrogen fertilisers are used, reduce nitrate leaching and to minimise the crops carbon footprint. N fertiliser commonly contributes 50-85% of this footprint.

Currently (Soil Nitrogen Supply) SNS Index is an integral part of decision making for fertiliser applications to all crops. The SNS Index, defined in 6 categories from low (Index 0) to high (Index 6), is a measure of the quantity of available nitrogen to a growing crop. It can be estimated from a series of tables in RB209 and the new Fertiliser Manual. For mineral soils, the highest indices are after intensive cultivation of Brassicas on silt soils in the driest parts of the country. The lowest indices are on shallow or light soils following cereals in the wettest parts of the country.

Crops grown on soils with an SNS Index of 6 will generally require little fertiliser. Over-fertilisation could lead to poor storage of produce whilst under-fertilisation could result in loss of yield. It is therefore important that the Index is assessed accurately. The tables in RB209 or the new Fertiliser Manual are a guide but where large amounts of leafy crop residue or manures have regularly been incorporated measurement of SMN is recommended.

Previous work in **FV17** (Prediction of Nitrogen Requirement for Vegetables) demonstrated the potential to reduce fertiliser applications in intensively managed Brassica rotations if soil mineral N levels were measured. SNS is defined as the N available to the crop, that is soil mineral nitrogen (SMN) plus any N in the crop at the time of measurement with an allowance made for N mineralising from soil organic matter.

Such measurements have been available to commercial growers since the eighties but are not always made in an appropriate way, so questions have been raised about their reliability. This project aims to address these concerns:

- when to take samples
- the correct sampling depth

- how to get samples to the laboratory
- analysis of the samples and
- consistency in lab results and how these results should be interpreted

All are equally relevant in rotations of vegetable crops so the topic is ideally suited as a cross-sector project.

This project aims to provide best practice guidelines as to how the assessment of SNS should be carried out.

Summary of the project and main conclusions

The main conclusions of the research in the context of what the growers need to know are presented in the following section.

Sampling time and depth

Soil and crop measurements have been made on 112 sites growing cereals in 2007/08 & 2008/09 seasons. These included 5 cereal sites following vegetables in 2008/9 (funded by HDC). At each site soil mineral N (SMN) was measured in autumn and spring to 60 and 90cm depth. Potentially mineralisable N was measured in spring on the 0-30cm layer. An area of crop was kept unfertilised by nitrogen so that crop nitrogen uptake from the soil could be measured at harvest; this nil-N crop N uptake is taken as the best estimate of SNS.

In 2008/9 the values of SNS measured following cauliflower and cabbage at 2 sites in Lincolnshire were SNS Index (2), much less than normally expected. The tables in RB209 would have suggested SNS Index 4/5. These may be explained by low rates of N being applied to the cauliflower crops and well grown cabbage leaving only small amounts of crop residue. Measurements of soil mineral N in this case would avoid under fertilisation of the following crops.

In general, across all previous crops, results have shown soil sampling to give a better prediction of SNS (ie that measured in the unfertilised crop at harvest), than using the tables in RB209, although there is still much variability.

For growing cereals:-

- autumn sampling for SMN was as effective as spring sampling in estimating SNS, especially for heavy and medium soils in low rainfall areas.
- sampling 0-60cm depth only in autumn on heavy and medium soils was as effective as sampling 0-90cm.
- autumn sampling on shallow and light soils, and in high rainfall areas, tended to over-estimate SNS as N was lost over-winter by leaching.
- in spring, sampling to 90cm was more effective than sampling to 60cm.
- when following Brassica crops do not sample too early

For growing field vegetables previous experience has shown that:-

- it is best to take samples as close to planting date as possible after N has mineralised from previously incorporated residues. (Measurements on sites after Brussels sprouts can have low mineral N in spite of large residues of leaf).
- sampling to 90cm is preferable but care is needed in interpreting results.
- the current RB209 makes poor allowance for rooting depth.
- WELL_N can be used as a tool to interpret mineral N data.
- the future Fertiliser Manual does provide a interpretation method for assessing N to rooting depth.

Taking soil samples

Whilst it is advantageous to measure soil mineral N in the field the results can be meaningless if the samples are not taken correctly. Sampling to 90cm is preferable but care needs to be taken that the samples are both representative and that the equipment used is appropriate. Spades and trowels are definitely not appropriate!

- For most crops sampling soils to three depths 0-30, 30-60 and 60-90cm is appropriate. Care needs to be taken to avoid contamination of samples from lower layers with soil from the surface. Research within the HGCA project has indicated that a minimum of 15 sampling points are needed.

Sample handling

A sample handling exercise on top-soils from 4 sites in spring 2009 assessed the effect of storage temperature and duration on measured SMN. There was a large increase in SMN with the time between sampling and extraction, by up to 10% per day, whether or not the sample was kept cool. Freezing samples gave variable results in measured SMN due to

increases in the amount of ammonium present. Comparisons designed to show variability arising from inappropriate sub-sampling method showed surprisingly little difference between thorough mixing and no-mixing; a further study is planned.

- The practice recommended for sample handling in the 2010 season is that the samples are chilled to between 2-4 ^{o}C as soon as possible after sampling and are analysed fresh within 48 hours.

Laboratory analysis

Soil samples have been taken and spit between three laboratories. Standardisation exercises have shown that labs are now producing comparable results from SMN analysis. The labs will continue to conduct their own ring tests to ensure that consistent results are given. Further information relating to best practices in analysing for nitrate and ammonium will be available later.

Interpretation of results

Most results will come back from the laboratory as mg/kg $NO3^{-}$ and $NH4^{+}$ on a dry soil basis. These need to be adjusted for the dry bulk density of the soil and be converted to kg/ha before they can be interpreted in the SNS tables in RB209. Attempts were made to develop a method to assess bulk density in the field while sampling but these failed to provide any advantage over an assumption that the density over the profile is 1.33g/cm^3. This is likely not to be the case for peaty, compacted or very stony soils and it is hoped that the final best practice guidelines will deliver more specific guidance.

- In the absence of properly conducted assessments of soil bulk density the mineral N (nitrate and ammonium) figures expressed as mg/kg on a dry basis for a 30 cm thick sample can be converted to kg/ha for that depth by multiplying by 4. This would not apply to peaty, compacted or very stony soils which are likely to have a different density.

Whilst autumn planted cereal crops have roots to at least 60cm for the spring period field vegetables do not and some crops such as salad onions rarely root below 30cm. In such cases SNS to 90cm is irrelevant though its value has to be determined to assess the appropriate SNS index. The appropriate fertiliser recommendation will be affected by the distribution of N within the profile. Even if SNS Index is high, if limited N is available in the topsoil, fertiliser may still be required. WELL_N can be used to interpret such results.

- For field vegetable crops it is important to ensure that N is available to rooting depth especially with young or shallow rooted crops. Table 1 presents 2 examples with the same SNS but completely different fertiliser

recommendations. Consider using the WELL_N computer decision support system as a tool in these situations.

Table 1: Demonstration of the effect of distribution of mineral N on fertiliser recommendation for Cauliflowers following Brussels Sprouts

	Field 1	Field 2
SNS(Index)	**6**	**6**
	kg/ha N	
0-30cm	150	25
30 – 60cm	100	100
60-90cm	25	150
0-90cm	**275**	**275**
RB209 (2000) recommendation	0	0
WELL_N recommendation	25	125

Both fields have the same SNS Index but in the second very little of the N is immediately available.

Final year research – HGCA Project

Assessments will be made at more than 70 sites growing cereals which will include a further 5 sites after cauliflowers and calabrese in the final measurement season 2009/10. SMN and various measures of soil properties will be made in autumn and spring, along with measurements of potential mineralisation by anaerobic incubation in spring and measures of yield and crop N uptake in fertilised and unfertilised cereal crops at harvest. At some sites repeated monthly sampling will be carried out to show how SMN varies over the winter.

Data will be combined and compared with data from previous years to allow conclusions to be drawn on the value of SMN sampling in autumn and spring across the range of soil types, seasons and geographic locations.

Further investigations will be made of the effects of sample storage and sample handling on analysis of soils for mineral N, focusing on the impact of between 0 and 7 days duration between sampling and extraction. Best practice guidelines will be provided in the final report due in 2011.

Financial Benefits

In intensive rotations of field vegetable crops assessing soil nitrogen supply with measurements of soil mineral N can save substantial amounts fertiliser N.

Action points for growers

Previous work in **FV17** (Prediction of Nitrogen Requirement for Vegetables) demonstrated the potential to reduce fertiliser applications in intensively managed Brassica rotations if soil mineral N levels were measured.

Which fields to sample

Consider sampling fields with high residues such as those in intensively cropped Brassica rotations or in fields where regular inputs of organic manures have been made.

Time to take samples

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Sampling and handling of samples

- For most crops sampling soils to three depths 0-30, 30-60 and 60-90cm is appropriate. Care needs to be taken to avoid contamination of samples

from lower layers with soil from the surface. Research within the HGCA project has indicated that a minimum of 15 sampling points are needed.

- The practice recommended for sample handling in the 2010 season is that the samples are chilled to between 2-4 ^{o}C as soon as possible after sampling and are analysed fresh within 48 hours.

Interpretation of results

- Overwinter rainfall 2009/10 has been higher than average which means that some nitrogen may be out of root range of young or shallow rooted vegetable crops.
- Consider using the WELL_N computer decision support system as a tool to interpret the results of the soil analysis when mineral N is not evenly distributed to 90 cm.

