Grower Summary

FV 345b

Establishing Best Practice for determining Soil Nitrogen Supply (HGCA 3425) – Reporting and Technology Transfer (Post Warwick HRI)

Final 2012

Disclaimer

The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of the full report, please email the HDC office (hdc@hdc.ahdb.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

HDC
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

HDC is a division of the Agriculture and Horticulture Development Board.

Project Number:	FV 345b
Project Title:	Establishing Best Practice for determining Soil Nitrogen Supply (HGCA 3425) – Reporting and Technology Transfer (Post Warwick HRI)
Project Leader:	Dr Clive Rahn
Contractor:	PlantNutrition Consulting
Industry Representative:	David Norman
Report:	Final Report 2012
Publication Date:	21/11/2012
Previous report/(s):	None
Start Date:	01 October 2011
End Date:	31 July 2012
Project Cost:	£6,225

Headline

- Fields following Brassicas can contain large but variable reserves of nitrogen.
- Consider sampling Soil Mineral Nitrogen (SMN) in fields with high or uncertain amounts of residues such as in intensively cropped Brassica rotations or in fields where there is a past history of grass or regular inputs of organic manures.
- Interpretation of mineral N needs to be careful especially with shallow rooted crops.

Background

A project investigating the best practice for predicting soil nitrogen supply managed by HGCA - has been running since November 2007 and aimed to achieve consensus across the industry on best practice for estimation of Soil N Supply (SNS).

Specifically:

- To consider stakeholder concerns
- To collate unpublished data on SNS measurement
- To conduct new measurement to develop best practice for interpretation of Soil mineral N (SMN) analysis
- To evaluate uncertainties in SMN measurements
- To understand the importance of over-winter crop N in the interpretation of SNS in Oil seed rape

With needs to maximise the efficiency in which nitrogen fertilisers are used, reduce nitrate leaching and to minimise the crops carbon footprint (N fertiliser commonly contributing 50-85% of the footprint) the application of nitrogen has to be managed.

Currently SNS Index is an integral part of decision making for fertiliser applications to all crops. 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. For mineral soils, the highest indices are after intensive cultivation of Brassicas on silt soils in the driest parts of the country and the lowest 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 (Factsheet FV 17). Over-fertilisation could lead to poor storage of produce whilst under-fertilisation could result in loss of yield. It is therefore important that Index is assessed accurately. The tables in the Fertiliser Manual (RB209) are a guide but where large amounts of leafy crop residue or manures have regularly been incorporated measurement of SMN should be considered.

HDC funded 10 field sites within the overall scheme to test the value of SMN measurements on fields after Brassica crops. The results from these sites are reported here.

The interpretation of soil mineral N measurements for field vegetable crops is more complex than for cereals as they generally have a different cropping period, have variable rooting depths and can be in complex and intensive rotations with high and variable amounts of N from crop residues.

This project aimed to address

- which assessment methods to use
- when to take samples
- sampling depth
- sample handling and analysis
- interpretation of the results

All are equally relevant in rotations of arable and vegetable crops so the topic was ideally suited as a cross-sector project with HDC and HGCA funding.

Summary

This summary specifically relates to field vegetable crops. The summary for the full HGCA report is appended to this project report – Appendix 1.

Measurements of Soil mineral nitrogen were made at 10 cereal sites following Brassica vegetables. An area of wheat 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.

The values of SNS measured following cauliflower were variable, and much lower than expected (SNS Index 2 rather than index 3/4 by the Fertiliser Manual (RB209) at three of the sites, Table 1. This was explained by conservative amounts of N being applied to the previous crops. The levels of soil mineral N were very low after the cabbage crops

suggesting low amounts of soil N and crop residues. Soil mineral N levels were very large after calabrese crops reflecting the large amounts of residue left behind (average measured SNS = 5).

These figures suggest that the assessments of SNS Index using the Fertiliser Manual (RB209) can be in error and measurements of soil mineral N would avoid errors in under or over fertilisation of subsequent crops.

Table 1. Assessments of SNS Index on silt soils by the Field Assessment method (FAM) using the Fertiliser Manual (RB209) and by direct measurement at HDC funded sites after Brassica vegetables.

Year	Previous crop and residue group	Rainfall category	Soil Type	FAM SNS	Spring SMN 0-90	SNS Index Measured
2009		Low	Deep silt	4/5	156	4
2009	Calabrese	Low	Deep silt	4/5	128	4
2010	High N Veg	Low	Deep silt	4	173	5
2010		Moderate	Deep silt	4	310	6
	Average				**192**	**5**
2009	Cabbage	Low	Deep silt	3	10	0
2010	Medium N Veg	Low	Deep silt	3	52	0
	Average				**31**	**0**
2009		Low	Deep silt	3/4	65	1
2009	Cauliflower	Low	Deep silt	3/4	71	1
2010	Med/High N Veg	Low	Medium	3/4	104	3
2010		Low	Deep silt	3/4	150	4
	Average				**97**	**2**

Value of high soil supply to subsequent crops

On retentive silt soils larger levels of soil mineral N in the spring and autumn are closely associated with larger yields and N uptakes of unfertilised cereal crops at harvest. Figure 1 shows the close relationship between Spring SNS and N harvested in unfertilised wheat crops at harvest. This confirms the assessments that useful levels of mineral N are left behind after Brassica crops.

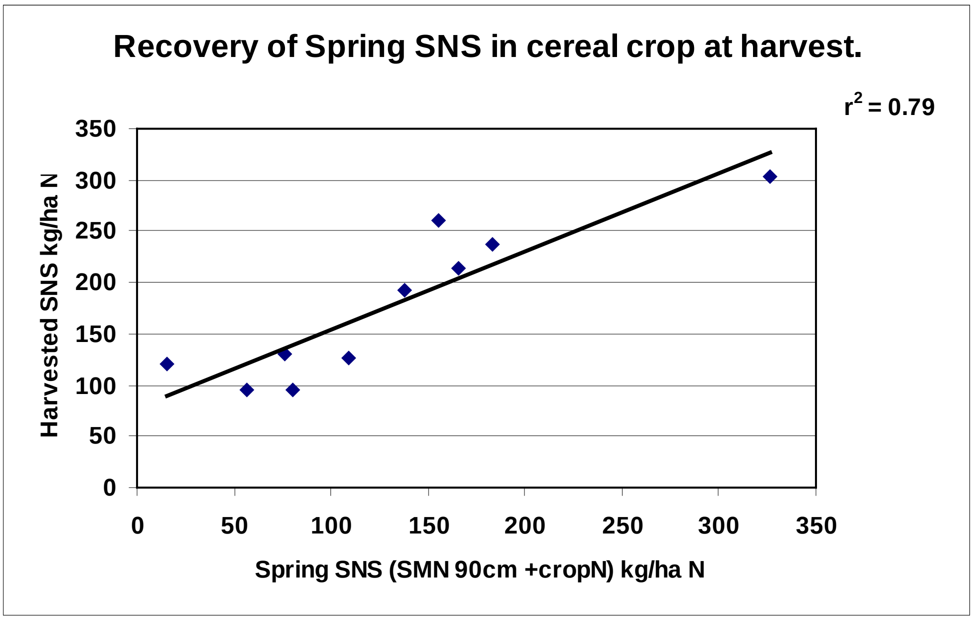

Figure 1. Close relationship between spring SNS and N harvested in unfertilised wheat crops.

Field vegetable crops can also make use of this nitrogen but there is an additional complication for field vegetables which have much shallower rooting than cereals. Crops such as salad onions will only be able to take up N from the top 30 - 45 cm of soil. In such cases SNS to 90 cm is irrelevant though its value has to be estimated to assess the appropriate SNS index in the Fertiliser Manual (RB209).

The appropriate fertiliser recommendation will be affected by the distribution of N within the profile. For field vegetable crops it is important to ensure that N is available to rooting depth especially with young or shallow rooted crops. Even for deep rooted crops like Brussels spouts sufficient N needs to be near the surface to promote early growth. Consider using the WELL_N computer decision support system as a tool in these situations.

In all situations good soil conditions are assumed – poor soil structure can restrict root growth which will reduce further the amount of N that can be taken up.

Appropriate sampling

Whilst measured values of SNS are valuable they have to be carefully measured. There is little room for poor sampling practices or delayed analysis.

Appropriate sampling equipment must be used. It is important to avoid cross-contamination of samples from different depths. Using a mechanised 1 metre long gouge auger (2.5 cm diameter) is a satisfactory and efficient method but care must be taken to avoid excessive soil compaction and contamination between soil layers. If each depth layer is to be sampled individually by hand, a series of screw or gouge augers should be used where the auger diameter becomes progressively narrower as the sampling depth increases. For most crops sampling soils to three depths 0-30, 30-60 and 60-90 cm is appropriate. Shallower sampling is acceptable for shallower rooted crops such as onions and lettuce but soil mineral N does need to be scaled to 90 cm to allow an index to be assigned, Table 2.

Table 2. Scaling up the SNS Index to take into account shallow rooting depth (assumes uniform distribution of N)

Crop	**Rooting Depth**	**Mineral N To rooting depth**[1]	**Estimate of SMN Index to 90cm**	**Scaled SNS Index**
Salad onions	30 cm	100	300	6
Crisp lettuce	45 cm	100	200	5
Cabbage	90 cm	100	100	2

[1] **From Appendix 10 of the Fertiliser Manual (RB209).**

At least 15 cores will be needed to represent a uniformly managed block of up to 20 ha. Five to 10 further sampling points may be necessary where SNS levels are expected to be very high or variable, after uneven amounts of leafy residues have been incorporated. It is very important that areas of the field with widely differing texture, cropping or fertilisation history are sampled separately.

Sampling in a W pattern (as opposed to more complex arrangements) is adequate to give representative samples. The ‘W’ design is the design recommended in the Fertiliser Manual (RB209). It requires the sampler to walk in a ‘W’ pattern across the field and extract soil cores at regular distance. The ‘W’ should cover as much of the field as is possible. Avoid sampling headlands or other obviously variable patches. Whilst walking in a “W” shape is adequate in most circumstances, the use of GPS techniques to both measure fields and generate sampling grids can be beneficial in large scale sampling campaigns, or for mapping purposes.

Appropriate sampling equipment must be used for assessing SNS. It is important to avoid cross-contamination of samples from different depths. Using a mechanised 1 metre long gouge auger (2.5 cm diameter) is a satisfactory and efficient method but care must be taken to avoid excessive soil compaction and contamination between soil layers.

If each depth layer is to be sampled individually by hand, a series of screw or gouge augers should be used where the auger diameter becomes progressively narrower as the sampling depth increases.

Sample handling and storage

If sub-sampling is required before the samples are sent to the laboratory it is important that the sub-sample obtained is representative. Take many small representative portions but avoid excessive mixing as this may stimulate mineralisation and over-estimation of the available nitrate-N.

It is vital to keep the interval between sampling and analysis for SMN as short as possible. The effects of sample storage were tested in two seasons. The average increase in topsoil SMN was 1.5 kg/ha per day of storage at 2-4°C, compared to 2 kg/ha per day of storage at ambient temperatures. On average SMN in a 90 cm profile increases by ~5 kg/ha per day of delay, even when samples are kept refrigerated (2-4°C).

However this is not always the case. Figure 2 shows an example of the effect of interval between sampling and extraction on measured SMN for soil samples taken in spring 2009 from four fields stored at two temperatures, Ambient and chilled to between 2 and 4 degrees C. Abbreviations are site codes; TT= Terrington, EF= Lincs site, Mo = Morley, Be = Beccles, BX = Boxworth. This shows that the effects of storage can be variable. On the clayey arable site in Lincolnshire mineral N actually fell. The difference was attributed to its previous history of grass and occurrence of immobilisation or denitrification rather than mineralisation.

It is concluded that samples should be kept as cool as possible after sampling (ideally between 2 and 4 ^{0}C placing samples in a cool box) and stored for less than 3 days before analysis.

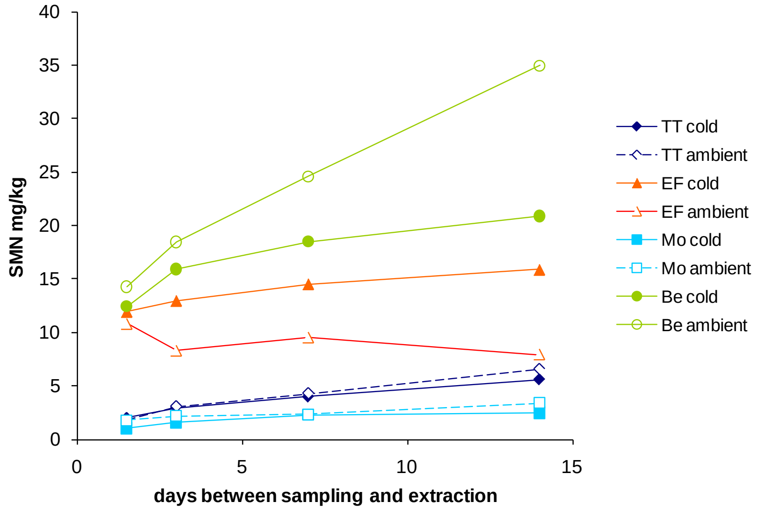

Figure 2. An example of the effect of interval between sampling and extraction on measured soil mineral N.

Financial Benefits

The main HGCA project identified that the financial benefits for cereal crops from measurement of soil mineral N could be largest on retentive silt soils and this was confirmed for the 10 sites sampled in the HDC project.

Savings in fertiliser were possible on sites following high residue crops such as calabrese. The amounts of residue nitrogen remaining after cauliflower crops were variable especially where conservative amounts of fertiliser had been applied.

Where field vegetable crops were likely to follow after cabbage and cauliflower crops measuring soil mineral N could avoid the risk of under fertilising and losses in yield. The benefits of soil samplings are obviously larger where the risk of under fertilising can be avoided. The cost savings are based on nitrogen fertiliser costing £1 per kg N and the price of cauliflower curds being set at £0.40 per curd. The response curve to N is taken for the first cauliflower crops in FV17.

Example 1 – Savings in fertiliser N

If a measurement of Soil Mineral N identifies a large reserve of available soil mineral N large savings of fertiliser are possible.

If 200 kg/ha N fertiliser is saved a possible £200/ha can be saved in fertiliser/ha.

Example 2 – Avoidance of error in fertiliser application

Where there is an overestimation of the residue contribution. For instance where conservative amounts of fertiliser N were applied to a previous crop, less residue N was incorporated than normal, and more overwinter rainfall than expected leached N out of the profile. Where a measurement of SNS Index might have been SNS Index 1 instead of 3 from tables in the Fertiliser Manual (RB209) – an extra 50 kg/ha N fertiliser would have been justified saving £400/ha in lost yield.

SNS Estimated	SNS Actual	N Fertiliser	Curds/ha	Output £/ha
3	1	210	31,000	12,190
3	3	210	32,000	12,590

Action Points for Growers

Which fields to sample

- The contribution from vegetable crop residues needs to be carefully determined - in some cases the SNS Index can be much lower than expected.
- Consider sampling Soil Mineral Nitrogen (SMN) in fields with high or uncertain amounts of residues such as in intensively cropped Brassica rotations or in fields where there is a past history of grass or regular inputs of organic manures.
- Measurements of SMN on peat and peaty soils can be unreliable.
- Choose the Field Assessment Method described in the Fertiliser Manual (RB 209) for soils where mineral N status is expected to be SNS Index 3 or less.

Time to take samples

For growing field vegetables, previous experience has shown:

- Take samples as close to planting date as possible after N has mineralised from previously incorporated residues. N release from winter incorporated residues (sprouts) can be slow.
- Introduce soil sampling for assessment of soil mineral N over a number of seasons so that experience can be gained in its use.
- Avoid sampling within two months after applications of nitrogen fertiliser or organic manures

Sampling and handling of samples

- For most crops sampling soils to three depths 0-30, 30-60 and 60-90 cm is appropriate.
- Sampling can be shallower for shallow rooted crops.
- Care needs to be taken to avoid contamination of samples from lower layers with soil from the surface.
- At least 15 sampling points are needed in a W pattern where previous crop management was uniform.
- Avoid excessive mixing when sub-sampling
- It is important that samples are chilled to between 2-4 ^{o}C as soon as possible after sampling and are analysed fresh within 72 hours.

Interpretation of results

- For most soils a conversion factor of 4 can be used to convert mg/kg to kg/ha for each 30 cm layer of soil.
- When sampling shallower than 90 cm depth, mineral N has to be scaled to 90 cm for assessment of SNS index.
- 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.
- If SMN measurements indicate that large changes in N use are required crops should be monitored for signs of deficiency or excess and the planned N strategy should be adjusted if necessary.
- Recommendations assume good growing conditions.

NB In Scotland Refer to Technical Note TN621 Fertiliser recommendations for vegetables, minority arable crops and bulbs (SAC 2009).

HDC factsheet 09/12 provides a summary of this project. It can be accessed through the HDC website www.hdc.org.uk.