Grower Summary

HNS 193

Nutrient management in Hardy Nursery Stock
(NutrHONS project)

Annual 2016

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GROWER SUMMARY

Headline

The trial aims to establish a protocol for collecting and monitoring the nutritional inputs and outputs of container hardy nursery stock growing systems. Several on-nursery hand-held pieces of equipment have been tested across a range of ornamental species and the readings compared to traditional laboratory techniques. So far the biggest problem has been obtaining on-nursery tissue or sap extracts to use with the hand-held meters.

Background

Equipment

Monitoring plant nutrient status has traditionally been done through soil nutrient and/or tissue analysis. Tissue analysis methods have been widely applied to plants due to their reliability in organic nitrogen determination, but they are time-consuming and destructive. Therefore, the focus of these studies is to test easy to use and non-destructive new tools designed for plant nitrogen (N) status estimation.

This project is initially testing five different pieces of equipment that were affordable and easy to use. The methods for sensing plant N used in this first year trial are as follows:

Nitrogen in plant sap

The extraction of plant sap is a destructive method that includes the detachment of the main petiole of the leaves, cutting it into small pieces and press it using a garlic press. As petioles in ornamental plants are mostly very small, in this trial leaf samples, including the petiole, were used and leaf sap was analysed.

Two pieces of equipment were used to measure the concentration of nitrate in leaf sap.

Merck Nitrate test strip

Nitrate test strips change colour when exposed to nitrate contained in the sample of plant sap. The colour can then be compared to a colour chart (subjective method) or be measured by a hand-held reflectometer. The Merck test strips used during this project were those for the detection of nitrate the Merckoquant NO_3. This test strip measures from 0 ppm to a maximum of 500 ppm NO_3. Merck test strips are quick, easy to use and very cheap (£30.00 per 100

pieces). Quant strip tests measure in nitrates instead of nitrate-N, therefore readings must be divided by 4.43 to find the nitrate-N value.

Horiba Laquatwin Nitrate kit

For this piece of equipment, nitrate levels in plant sap are measured using a nitrate sensitive electrode. This compact nitrate sensor has an operational range from 23 to 2,300 mg/L and only needs a few drops of plant sap to generate a reading (enough to cover both electrodes).

However, this technology does have some disadvantages:

(1) It does not measure total N in plant tissue but only NO_3-N,

(2) The presence of other ions such as chloride, bicarbonate or nitrite can affect measurements (b).[1]

(3) Frequent calibration is also needed to maintain the accuracy of the sensor (every 5 samples)

(4) Readings should be make in the shade since direct sunlight can affect the meter.

Optical sensing methods

The greenness of the leaves represents the amount of chlorophyll found in the chloroplasts. Leaf chlorophyll content can be used as an N status indicator, because this is an essential element in photosynthetic protein synthesis. Leaf chlorophyll content increases with N supply and decreases when N is limiting.

atLEAF$^+$

The atLEAF$^+$ is a sensor that measures leaf Chlorophyll content in a similar way as a SPAD meter, but has the advantage of being cheaper. It is a non-destructive, hand-held, lightweight and easy-to-use sensor.

The device works by inserting the leaf into the aperture in the front of the sensor and clicking on the measure button. There are two LED emitters in the upper part of the aperture at two wavelengths, red at 660 nm and near infra-red (NIR) at 940 nm. Light filtered through the leaf is captured by a sensor below it which measures the absorbance of the leaf. The difference in transmission of the filtered wavelengths gives a measure of chlorophyll content in atLEAF$^+$ units. The sensor continues to sample the scanned area as long as the measure button is being pressed. An average value of the measurements will appear when the measure button is released. The device can measure leaves that are up to 0.1 in (2.5 mm) in thickness. Measurements can be stored and easily uploaded to a computer.

[1] This has always been a problem with ion specific electrodes

According to literature this sensor is not very effective at collecting readings on leaves with small widths like conifers. Unlike SPAD that makes the measurements in a closed chamber which clamps over the leaf, and has a filter to clear other wavelengths in the light spectrum, the atLEAF^{+} sensor takes measurements in an open aperture and has no filters. This is likely to affect the readings because: (1) the position of the leaf can vary (closer to the top part of the aperture or to the lower part) and (2) this aperture allows for light to reach the sensor diode and interfere with the reading.

Fieldscout Green Index App

This App was developed to capture differences in 'greenness' between maize leaves. The app captures images using the iPhone digital camera and determines the DGCI (Dark Green Colour Index) of plant leaves (between 0 and 1). When purchasing this App, growers should also purchase a reference board which is used as a background when taking pictures of the leaves. The green and yellow discs present on this board are known colours (standards) used by the software to calibrate differences in light conditions; the pink background increases contrast and reduces noise, and the grey colour calibrates the white balance.

Because N status is not the only factor that affects the greenness of the leaves (water stress, temperature, and cultivar also do), the DGCI readings taken in a field must be compared with readings taken in a high-N reference area. Recent studies show that DGCI is closely related to the N content in leaves as well as with SPAD readings.

Electrical conductivity (EC) in substrate

Monitoring the N present in the growing media through substrate analysis, is a method widely applied in the hardy nursery stock industry. However, sampling growing media is labour-intensive, expensive, and growers have to wait for the results in order to be able to adjust fertilisation regimes.

"Procheck" and "GS3" sensor probe

The sensor GS3 from Decagon measures soil moisture, temperature, and electrical conductivity (EC) of the substrate. The probe has three steel needles that improve sensor contact in porous substrates such as peat or perlite. By measuring EC in the substrate solution, the sensor measures the total amount of salts dissolved in pore water. It does not give information on the amount of a specific nutrient. However since the majority of salts in the substrate are macronutrients, EC can be used as an indicator of the presence of macronutrients in the growing medium.

Summary

This report covers the first 12 months of the three-year project. The aim of the project is to try to relate crop performance measured using various hand-held instruments, to traditional sampling and laboratory analysis results. Additionally, by monitoring rainfall and irrigation inputs, we look at the nutrient balance between the inputs, uptake by plants, and outputs through leaching.

In this first year two main trial sites were established, Greenmount College in Northern Ireland and PCS Research Station at Destelbergen, Ghent, Belgium. It was anticipated that their geographic positions would give some different inputs, such as hours of sunshine, temperature and rainfall. The trials were established using the same base substrate, plant species and increasing rates of CRF fertiliser. Four commonly grown hardy nursery stock subjects were selected based on criteria such as, colour reaction to fertilisers, vigour of growth in relation to fertiliser rates, and growth habit. These subjects were *Viburnum tinus*, *Chamaecyparis pisifera*, *Skimmia japonica* and *Buddleja davidii*.

At each of the sites the rainfall, irrigation and other climate data was collected. At pre-determined growth stages, samples of plant tissue, substrate mix and runoff from specific trial plants were collected and sent for full analysis. In addition to the traditional sampling, the site operators measured parameters such as sap 'N' content, leaf chlorophyll reflectance, moisture and EC levels in the substrate using a range of hand-held instruments, and a novel mobile phone app for measuring the health of leaf tissue, all with varying levels of success.

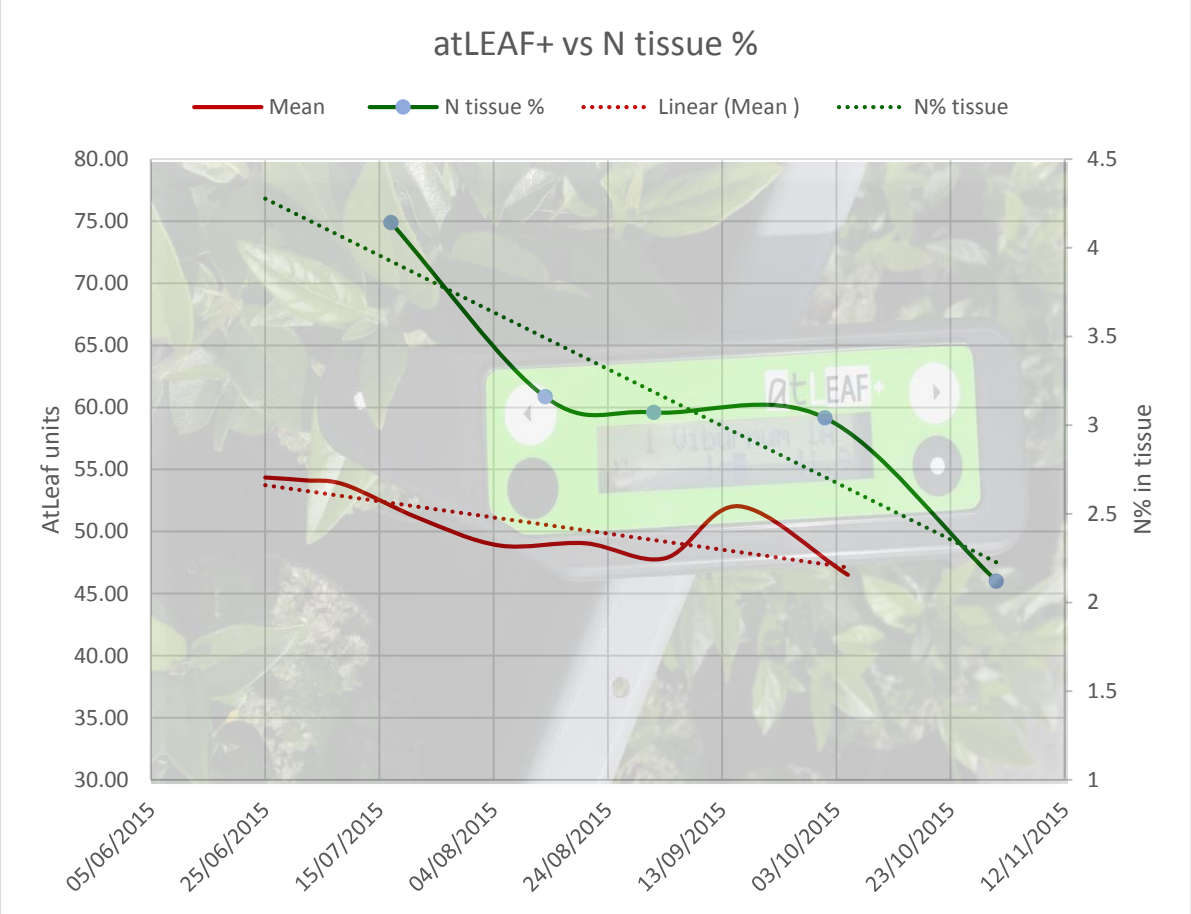

Figure 1. atLEAF⁺ N values compared to leaf tissue N % by analysis

A wealth of data has been collected and already shows a strong correlation between plant health and nitrogen status, using leaf light reflectance. These findings are comparable to tissue analysis (see Figure 1 and page 18 for more detail). Additionally, substrate probing techniques used on the nursery also appear to give accurate measurements of plant health and growth. One of the main problems when using hand-held instruments, is that where 'sap' is required for readings, it is very difficult to get enough sap from some of the hardy nursery stock plants tested, and the end results may be so coloured that they interfere with the reading being made. Work by the States of Guernsey advisory service indicate that this is a common problem with sap analysis, but can be overcome (Smith, 1987; Marchant-Smith, 1995). This will be looked at in more detail in the second year of the project.

Data on the leaching of nutrients from the system is closely related to the vigour of growth of the selected species, although caution is needed as some of the plants in the trial were not of good quality and hence their performance may have skewed the results.

In the second year of the project, the same two monitoring sites will be used again, and additionally J Coles and Sons Ltd. of Leicester will also host a trial. This is to hopefully give a geographical mid-site in terms of climate and growth conditions. Each of the sites will major on one plant species and take samples every two weeks, in addition to measuring the wider

range of plants. Two other growers, Osberton Grange and Frank. P. Matthews have agreed to trial specific hand-held pieces of equipment to establish whether they are easy to use.

There are also planned open days and visits to the trial sites through the autumn of 2016, and a series of hands-on workshops will be held across the winter period 2016-17.

Financial Benefits

Annual UK sales of CRF fertilisers are currently £4m (across all manufacturers) with a farm gate market value of £1b for all hardy ornamental plants. The cost of fertiliser is quite a small percentage of sales but the effect on a grower's sales when they have a nutrition problem can be a very high. We asked a group of seven nursery stock growers what the crop losses were from nutritional problems. No one was able to quantify these losses. The below is from Table 1 from the science section showing the price of the equipment assessed during the project:

Equipment	**Measurement**	**Price**
'Merck' Nitrate test strip	Nitrate – NO_3	£30.00 per 100 tests
Horiba 'LAQUAtwin' Nitrate kit	Nitrate – NO_3	£380.00
'Procheck' and GS3 sensor probe	volumetric water content, temperature and electrical conductivity	£730.00
atLEAF$^+$ meter	chlorophyll concentration	£210.00
'Fieldscout' Green Index App	DGCI (Dark Green Colour Index) & SPAD (chlorophyll concentration)	£100.00 (excluding smart phone)
'Pour-thru' devices	Pour-thru water collection	£24.00 each
Davis 'Vantage PRO2'	Weather data	£980.00

Action Points

Growers must decide whether they are introducing an on-nursery monitoring system and they must then engage and train a suitable member of staff to make the measurements and develop the trends for a range of subjects.

For growers the current messages are:

1) Various instruments are sold for on-nursery testing but currently there is little guidance on how to achieve a data set which can be interpreted easily for hardy nursery stock,
2) Both substrate conductivity and leaf colour offer promising data to determine leaf N content,
3) The extraction of sap and leaf samples from nursery stock subjects is at best difficult and may require additional treatment before testing,

4) If the monitoring is to be meaningful, the time of day of sampling, the frequency of sampling and the consistency of the operator need to be taken into account.