Grower Summary

Developing Nutrient Management Recommendations for Selected Horticulture Crops

HNS 200 WP2

Final report

Project title: Developing Nutrient Management Recommendations for Selected Horticulture Crops.

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[The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with 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.]

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Headline

- Under low soil mineral N (SNS Index 0) or modest (SNS Index 2 / 3) and Magnesium (Mg) (Index 1 / Index 2) indices, growth of *Betula pendula, Carpinus betulus* and *Crataegus monogyna* transplants and seedlings was not increased by additional fertiliser nitrogen (N).
- No difference in mean plant height was obtained when *Betula pendula, Carpinus betulus* and *Crataegus monogyna* were fertilised with standard or slow-release N fertilisers.
- Carbon reductions through reducing N fertiliser usage will help growers to meet net zero. Calculations have shown that reducing or eliminating the use of fertiliser containing 27% N can save between 240 – 270 kg CO_2e / ha (1 – 3 applications respectively).

Background

Field HNS growers typically apply single nutrients known as straights (e.g., ammonium nitrate) or compound fertilisers (containing mixes of nitrogen (N), phosphorus (P) and potassium (K) fertilisers or N and sulphur (S)), with limited use of slow / controlled release fertilisers in some crops. Some nurseries carry out regular soil analysis to find out what levels of P, K, and magnesium (Mg) are present in the soil to help determine the correct rate of fertiliser to apply. Soil sampling for soil mineral nitrogen (SMN) is less common than sampling for P, K & Mg however there has been increased interest in this approach following the rapid increase in fertiliser N prices in 2022. In the past, some nurseries have not historically carried out regular soil analysis and have instead applied the same rates of fertiliser every year, regardless of soil nutrient indices / crop need. Some of those that do carry out regular soil analysis sometimes struggle to interpret the results The situation is complicated by the fact that there are no readily accessible standard fertiliser recommendations for field, soil-grown HNS species for UK growers. The most recent recommendations were published in 1988 in the 5th Edition of RB209 (**MAFF, 1988**) Soil testing for P, K, Mg, and pH is now a legal requirement in England under the Farming Rules for Water (FRfW).

Because of the high value of field grown HNS in relation to the price of fertiliser (despite recent high N prices), the cost of the fertiliser and its application is not always considered. Many growers use historic application rates of fertiliser rather than analysis-based application rates, which can result in excessive use of nutrients. However, there is the potential for savings to be made which can contribute to improved profitability (refer to financial benefits).

Growers must also comply with legislation such as limits on the amount of N (a total N limit of 250 kg/ha) contained in organic materials such as manure or green compost that can be applied in Nitrate Vulnerable Zones (NVZs) to prevent the pollution of water. There are no N-max limits for manufactured nitrogen fertiliser applied to HNS in the NVZ rules. In England 55% of land is in a designated NVZ. Fertiliser production and use directly contributes to greenhouse gas emissions and hence climate change so efficient use of N fertilisers is vitally important for the horticulture sector transition to net zero. High levels of P should be avoided (above Index 3) as surface run off (particularly where soil erosion is a problem) can transport phosphates into water courses.

Maintaining an unnecessarily high P Index is considered bad practice as it increases the risk of P loss to water and further legislation such as the implementation of phosphate vulnerable zones. There are not currently any phosphate vulnerable zones in the UK, but in Northern Ireland phosphate regulations have been part of their nutrient action programme since January 2020, with restrictions on the maximum phosphate fertiliser applications allowed in certain situations.

A better understanding of the nutritional needs of field grown HNS species, and the optimum type of fertiliser for HNS could help to optimise crop nutrition. For example, fertilisers containing muriate of potash (potassium chloride) can scorch the foliage and result in slow establishment of some chloride-sensitive genera; potassium sulphate is a more suitable K source for ornamental crops (**Lindberg and Cregg, 2022**). The potash in muriate of potash (MOP) is fully available to plants. High rates of application should be avoided at crop establishment, particularly when placed next to the seed, as this can inhibit germination or damage the seedling. MOP is suitable for all arable crops and grassland. The chloride content can be a disadvantage in certain specialist horticultural crops. Sulphate of potash (SOP) is generally regarded as a relatively high-cost source of potash for application to soil in agriculture but is a very important source of this nutrient in horticulture, as it is suitable in situations where both potash and sulphur are required or where chloride is a concern. (The fertiliser directory materials guide)

Aim of the trial: To determine the impact of novel fertiliser application methods on plant nutrient status and evaluate crop nutrient assessment methods (soil electrical conductivity (EC), tissue analysis or leaf chlorophyll measurement) to provide data that correlate most closely to crop nutritional needs.

Year 3

Objective 1: To further evaluate / validate the soil and tissue analysis methods used in years one and two for correlation with crop nutritional needs on transplants of three commonly grown species from three vigour groups (high, medium, and low), using different straight or slow-release N). (**Transplant trial)**

Objective 2: Establish baseline nutritional information for two of the species of seedlings, from two vigour groups (as included in the transplant trial) using different straight or slow-release N). **(Seedling trial)**

Objective 3: To calculate potential reductions in carbon emissions associated with reduced N usage. **(Carbon emission from fertiliser use calculations)**

This work reported here is part of a wider project consisting of three work packages:

WP1. HNS (field and container) Literature review

WP2. Field tree production. To establish baseline information on nutrition for field-grown HNS trees by categorising the main plant families into vigour groups (e.g., Low; low – medium; medium - high), explore novel methods for applying fertilisers and determine the most suitable analyses (soil EC, tissue and/or leaf chlorophyll) to assess crop nutrient status (submitted as a separate report)

WP3. Container production. Optimisation of combined controlled release fertiliser (CRF) and liquid feed regimes for nursery stock liner production under protection

This is the final report for WP2. **The reports for WP1 and WP3 are submitted separately (see:** Developing nutrient management guidance for Hardy Nursery Stock | AHDB)**.**

Summary

During 2022 a field tree nutrition trial was carried out on field grown *Betula pendula* (high vigour)*, Carpinus betulus* (low vigour) and *Crataegus monogyna* (medium vigour) 1+1 transplants, post planting in their second year of growth using the host nursery's standard rate of fertiliser, see year 2 annual report for details of treatments.

The trial was repeated in 2023 to validate the results obtained in 2022 but the rates of Nitrogen were reduced to take account of slightly higher reserves in the soil.

Table 1. Field tree trial treatments, 2023.

Treatment and nutrient quantity	Product name / nutrient content	Nutrient component	Application rate (kg/ha)	
			Week 30	Week 34
1. Untreated	-	-	Untreated	Untreated
2. Straight 50 kg/ha N	Origin 27% N (27 - 0 - 0 + 10 SO_3)	NS Compound	186	-
3. Straight 100 kg/ha N	Origin 27% N (27:0:0 + 10 SO_3)	NS Compound	186	186
4. Straight (Floranid N31), 50 kg/ha N	Floranid N31 (31% N)	N	162	-

The field tree nutrition trial was set up in 2023 at Wyevale Nurseries, Transplant division, Ledbury, Herefordshire on three different species of transplants. Transplants were planted as one year old graded field grown seedlings of *Betula pendula, Carpinus betulus* and *Crataegus monogyna.* The one-year-old cold stored seedlings were planted on a standard system of four crop rows on a 1.2 m wide bed in loamy sand soil in late spring, plots were 3 m long. The aim of the work carried out was to determine if a straight and slow release of nitrogen impacted on plant nutrient status and growth and evaluate crop nutrient assessment methods (soil electrical conductivity (EC), tissue analysis or leaf chlorophyll measurement) to provide data that correlates most closely to crop nutritional needs. Floranid N31 was used as the slow-release N straight fertiliser, 3% of granules are coated with urea, the remaining 90% are coated in IBDU. The urea component requires microbial activity to release N as temperatures rise and the IBDU is broken down by the presence of water at 4°C and above, the product also contains a proportion of readily available N. This gives an activity Index of 98 – 99%; meaning that almost all the N can be taken up by the crop, preventing leeching – the product also has a low salt content. Standard straight fertilisers (e.g., Origin 27% N & 10 SO3) are much more prone to leaching following heavy rainfall.

Betula pendula were 60 – 80cm (high vigour), *Crataegus monogyna* were 40 – 60 cm (medium vigour) and *Carpinus betulus* (low vigour) were 20 – 40 cm transplants. These species were chosen as they are important species grown in large numbers, they also vary in vigour so were categorised into vigour groups.

Seedlings of *Carpinus betulus* and *Crataegus monogyna* which had been sown into seedbeds were also included within the trial to ascertain if trends in crop nutrition applied to both seedlings and transplants of the same species.

The fertilisers used are listed in **Table 1**. Leaf tissue analysis, measurements of the chlorophyll content of leaves (using an atLEAF hand-held device), soil EC, water content and temperature were carried out throughout the growing season. The height of selected transplants was also measured at the start of the trial and at the end of the growing season to determine differences in growth between treatments. Crop height is the main measure of crop performance for the grower.

The soil was loamy sand. Soil analysis was taken prior to fertiliser application (**Table 5**). Topsoil samples (0-15 cm) were taken for pH and extractable P, K and Mg, and soil mineral nitrogen samples were taken to 90 cm. The site of the transplant trial was SMN Index 3, P Index 4, K Index 3 and Mg Index 2. The site of the seedling trial was SMN Index 2, P Index 4, K Index 2+ and Mg Index 2.

There were no statistically significant differences ($P>0.05$) in mean height measurements between any of the treatments (including the untreated controls); three transplanted species measured in weeks 30, 34 and 37; two seedling species measured in weeks 34, 37 and 41.

Results from tissue analysis, compared with published figures, indicated that levels of some major and micronutrients were either low or high in all species / treatments combination throughout the growing season (**Tables 10 and 14**).

In summary, levels of N in *Betula* transplants From week 30 in T1 (untreated) and T4 (Floranid N31) were lower than the published figures, all treatments resulted in lower N levels in *Betula* transplants than published figures in weeks 34 and 37.

In *Carpinus* transplants levels of N in leaf tissue from T1 (untreated) were at the top end of the target range, all other treatments in weeks 34 and 37 contained higher levels of N than the published figures. In week 37 all treatments contained higher levels of N in leaf tissue than the published figures. In *Carpinus* seedlings all treatments in weeks 34 and 37 were higher in N than the published figures and T3 was higher than the published figures in week 41.

Throughout the trial all treatments applied to *Crataegus* transplants and seedlings resulted in higher levels of N in leaf tissue than the published figures.

This suggests that both *Crataegus* and *Carpinus* are efficient at taking up available nitrogen.

Table 2: Assessment of crop P and K offtake for transplants*

Species	Quantity (kg / ha) of P uptake (as P_20_5)	Quantity (kg / ha) of K uptake (as K_20)
Betula	62	94
Carpinus	45	67
Crataegus	23	61

*Crop offtakes should be considered to determine if any additional P & K is required to maintain levels at the target index.

As it is necessary to ascertain how much N has leached when making N application decisions, crop N offtake assessments have not been done: The SNS index for each field can be determined either by the Field Assessment Method using records of soil type, previous cropping and excess winter rainfall, or by the measurement method using measurement of Soil Mineral Nitrogen (SMN).

Table 3: Carbon calculations. GHG emissions based on fertiliser choice and number of applications, given in kg CO_2e / ha.

Fertiliser	**Production**	**Supply**	**Applications**		**Use**	**Total**
Floranid N31	175.8704	2.9671	1	13.7770	7.6471	200.2617
			2	27.5541		214.0387
			3	41.3311		227.8158
Origin 27% N + 10 SO_3	166.6802	2.3291	1	13.7770	59.2470	242.0333
			2	27.5541		255.8104
			3	41.3311		269.5874

Carbon reductions through reduced fertiliser usage can help growers to meet net zero; Floranid N31 has lower carbon emissions associated with it use than Origin 27%N + 10 SO_3, however Floranid N31 is a more expensive source of N so is not widely used by commercial growers. Savings based on the number of applications of the products used have been calculated **(Table 3).** If no N fertiliser was applied, compared to a standard application of 150 kg N applied as Origin 27%N + 10 SO_3 this would result in a reduction of 269 kg CO_2e.

Discussion

The fertiliser treatments had no effect on crop growth (assessed by height measurements) in *Betula, Carpinus* or *Crataegus* transplants or seedlings within these trials during 2023. Although the reserves of nitrogen were slightly higher in 2023 than 2022, no crop response in either the transplants or the seedlings was observed when comparing the final heights of treatments with untreated controls at the end of the growing season. Chlorophyll content has been correlated to Nitrogen content determined by tissue analysis **(Figures 1 – 3).** The measurement of soil EC and Volumetric water content help to pick up changes in nutrition and water content and are useful tools to monitor trends.

During the 2022 growing season the crop performed equally well where fertiliser NPK and no fertiliser was applied, despite the low soil nitrogen supply (SMN Index 0, P Index 3, K Index 2+), which indicates a low requirement for additional nitrogen. However, the potential for a crop response to additional fertiliser NPK may have been limited by the very dry and hot summer of 2022. Less irrigation was applied to the trial plots during 2022 compared with a typical growing season because of limited water supplies due to the drought.

The host grower reported a significant impact on growth during 2022 due to a combination of high temperatures inducing periods of crop dormancy during the growing season. Drought is also thought to have impacted crop growth compared with an average season.

This is the third year of nitrogen fertiliser response experiments on HNS. The first year (2019) tested the effect of broadcast application compared with band spread application of nitrogen fertiliser. Results from the first year showed no growth response to N, and it was suggested that this may have been because the species tested have a low requirement for N. This third fertiliser response experiment has also shown no response to N, despite low / modest soil nitrogen supply Index at both sites. This is an important result for growers and gives confidence in the consistent results within these trials indicating that *Betula, Carpinus* and *Crataegus* requirement for N may be lower than previously thought.

There was no correlation between chlorophyll content and growth in *Betula pendula, Carpinus betulus* or *Crataegus monogyna* at the soil N, P, K and Mg indices tested with and without fertilisers, in both the transplant and seedling trial

Conclusions

- No difference in growth (determined by height measurements) occurred within species between any of the three test subjects where no fertiliser was applied or where fertiliser was broadcast over plots in 2019, 2022 or 2023. This is an important result for growers and gives confidence in the consistent results within these trials over multiple growing seasons despite big differences in growing conditions having been experienced in the years that trials were undertaken.

- These trials indicate that the *Betula, Carpinus* and *Crataegus* requirement for N may be lower than previously thought. Growers should trial reducing N applications to these crops and compare resulting growth with their standard N application rate to determine where savings on N fertiliser (and associated carbon emissions) can be made.
- Good nutrient management is fundamental to economic and environmentally sustainable crop production by helping growers match inputs of nutrients (in fertiliser and organic materials) to crop demand; growers should scrutinise their N applications to field grown crops of *Betula, Carpinus* and *Crataegus*.
- Soil testing for pH, and extractable P, K and Mg to ensure that too low or excessively high soil indices do not occur. Growers should be aware that it is now a legal requirement for farmers in England under the Farming Rules for Water. Growers must test their soil at least every 5 years.
- Field grown HNS growers should aim to maintain soil at P Index 2, K Index 2 and Mg Index 2, which is consistent with target Index values for arable and fruit crops published in RB209.
- There is not a target SMN index for N as this nutrient is mobile and is prone to leaching; the SMN index is a means of quantifying how much N is available for crop uptake. This figure should be considered when planning N applications.
- It has been possible to correlate chlorophyll content to the nitrogen content as determined by tissue analysis, this demonstrates trends relating to chlorophyll content and the percentage of nitrogen in leaf tissue of three species.

Financial Benefits

The host nursery application of 180 kg/ha 27-0-0+10S, (27% N), fertiliser cost £323/ha. The slow-release form of N (Floranid N31) is roughly three times, more expensive per kilogram of N than the grower standard fertiliser costing £3.02 kg compared to straight N at £1.03 per kg. Floranid N31 is described by the manufacturer as providing a controlled release of N over a period of 3-4 months. Controlled/slow-release fertilisers can help reduce N losses to the environment and therefore ensure more of the N is available to the crop. The use of controlled release N fertiliser is likely to be most beneficial in wet years when there is risk of fertiliser N leaching below rooting depth following heavy rainfall. Despite 2023 being a wet summer there was no apparent benefit in terms of crop growth from using a slow-release form of nitrogen compared to a cheaper straight form of nitrogen.

There was no difference in growth between any of the treatments within any species including the untreated plots that received no fertiliser (where N and Mg was the only likely limiting factor) in 2022 (N was the only likely limiting factor in 2023). This implies these species have a low N requirement. *Betula* may not have a high N requirement for growth as it readily naturally colonises heathland and other habitats that are naturally low in N. These results indicate that there may be potential for growers to reduce N applications on these species (growers typically apply 150 kg N/ha) whilst maintaining crop growth.

A modest reduction of 50 kg N/ha to typical fertiliser N application rates would save growers £51.66/ha, whereas a 100 kg N/ha would save £103.33/ha, and a 150 kg N/ha would save £154.99/ha at current fertiliser prices of £350/tonne of Ammonium Nitrate (AHDB, 2024). Growers are advised to trial gradual reductions of 50 kg N/ha on a proportion of their crop (monitoring growth closely) for species not tested in this programme of work. A similar approach could be taken with *Betula, Carpinus* and *Crataegus* where desired in order to build confidence in this approach.

Action Points

- Test soil for pH, P, K and Mg at least every 5 years and ideally every 3 years. Aim to keep soil at P Index 2 and K Index 2-. There may be no need to apply additional fertiliser P and K above these target soil indices.
- Assess soil nitrogen supply (SNS) using guidance in AHDB Nutrient Management Guide. Consider sampling for soil mineral nitrogen (0-90 cm) to further improve N management.
- Review current N application rates to field grown HNS and consider whether reductions can be made.