Grower Summary

FV 359

Nutrient Requirements for Field Grown Herbs.

Final Report 2011

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Headline

- Yields and shelf-life of coriander and mint are influenced by the availability of nitrogen (N). Data to support growers in the application of suitable rates of N has been generated.

Background and expected deliverables

At an estimated total value of £77 Million in the UK, herbs form a significant sector of the market and yet there is little specific information to support the industry in producing herb crops. In particular, this project focussed on the nutrient requirements of field grown herbs and, given the wide range of both species and mineral elements relevant to this question, addressed specific issues.

Firstly, since UK herb production is largely focussed towards fresh weight yield, nitrogen was chosen as the key element to investigate. Applying correct levels of nitrogen was expected to produce the biggest gains in terms of fresh weight yield, yet it is also a mobile element that causes diffuse pollution when used in excess. Establishing suitable rates of N is expected to improve productivity whilst minimising waste and pollution. Secondly, two species were chosen for the investigation based on their prominence in the UK market and their cropping patterns. Coriander was chosen as an annual type with a single harvest and mint was chosen as a perennial with a more complex repeat harvest requirement as well as a longer term production period (typically up to 5 years, although this project examined the first two years of production).

Whilst the commercial aim of maximising yield is important, growers of fresh herbs are also concerned that they do not compromise product quality and hence evaluation of N availability on product shelf life formed an integral part of the assessments carried out. As coriander is particularly susceptible to problems with shelf life, additional treatments were included in the project to assess the potential for extending post harvest longevity. The treatments followed from observations made in a previous HDC funded project (PC 259) where adding salt to a hydroponic feed solution improved shelf life. Given the potential for salt to impair soil quality in the longer term the use of extra K on plots was assessed as an element that may equally increase osmotic pressure on the plant prior to harvesting

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The project was therefore designed to:-

- Produce data regarding the N requirements of coriander and mint grown in UK conditions which will be of direct use for UK commercial production.

- Determine how N fertiliser rate may impact on shelf life of fresh bunches of coriander and mint.

- Evaluate the potential for enhancing coriander shelf life through the use of K top dressing.

Since shoot tissue analysis formed a significant component of the work, summaries of nutrient status of a wider range of elements beyond nitrogen were also generated and summarized as a supplementary reference source.

Values for nitrogen (N) in this report refer to elemental N rather than nitrates. Yields quoted are for individual crops (coriander) or for sequential cuts from a single crop (mint).

Summary of the project and main conclusions

- Data was generated to support growers in the application of suitable rates of N to field grown coriander and mint. Yields of coriander and mint were clearly influenced by availability of N, and data from the trials was used to generate provisional recommendations for N fertiliser applications. These now need to be tested on a wider range of sites and in different years.

- Leaf greenness of coriander and mint were improved by N applications, but there were no further increases in greenness at levels of available N above 131-172 kg/ha.

- Wilting was the main factor determining the shelf life of coriander; samples grown without N application wilted most slowly but these had poor leaf colour quality. Where N was applied at 60 kg/ha or more, differences in wilting between N rates were small or not statistically significant.

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- Browning/ necrosis was the main factor determining the shelf life of mint. At the first cut of the second season, samples grown on plots with 51-78 kg/ha available N had a longer shelf life than samples grown on plots with lower or higher levels of available N; in the second and third cuts, shelf life decreased with increasing availability of N.

Coriander – yield

Response of coriander to six levels of N (from 0 to 300 kg/ha N applied) was assessed in randomised plots at Warwick University, Wellesbourne on crops drilled in May, July and August 2009. Application was split as one third as a base dressing and two thirds as a top dressing. In separate trials at Valley Produce, all of the N was applied as a top dressing. Estimates of yield were made by sampling each crop on three occasions (i.e. two interim samples and a final harvest sample). The level of applied N associated with the highest yield varied with drilling date and also, to some extent, time of sampling. Table A indicates the N treatment producing maximum fresh and dry weight yield for each sample from the Wellesbourne trials, together with the final fresh weight yield for the most productive N treatment for each trial. Since the N available to the crop is a combination of that available from the fertiliser applied and that already available in the soil, the table includes a figure for available N to 30cm depth. This is calculated from the mineral N analyses carried out on soil samples prior to drilling each trial plus the amount of N applied as the treatment.

Table A. *N treatments producing the maximum fresh and dry weight coriander yields from the Wellesbourne trials.*

Rate of applied (and available) N producing maximum yield (kg/ha)	Drilling Date		
	21/05/09	23/07/09	11/08/09
Interim sample 1	300 (325)	160 (204)	60 (81)
Interim sample 2	300 (325)	110 (154)	60 (81)
Final sample	230 (255)	110 (154)	60 (81)
Yield (t/ha Fwt) from the best N treatment*	47.8	15.6	26.0

**The lowest N application treatment above which no further significant increases in yield were obtained.*

Trials at the commercial site (Valley Produce) considered 5 rates of N (from 0 to 276 kg/ha) on plots drilled in June and August 2009. These trials were less responsive to the rate of N applied but background N levels also differed. These data provide a benchmark for the Wellesbourne trials, and while response to applied N varied between the two sites,

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reasonable agreement is found if calculated available N levels (to 30cm depth) generating maximum yield are compared; as can be seen from the Table B.

Table B. *Treatments producing the maximum fresh and dry weight coriander yields from the Valley Produce trials.*

Rate of applied (and available) N producing maximum yield (kg/ha)	Drilling Date	
	17/06/09	11/08/09
Interim sample	60 (293)	60 (131)
Final sample	60 (293)	0 (79)
Yield (t/ha Fwt) from the best N treatment *	40.4	11.9

**The lowest N application treatment above which no further significant increases in yield were obtained.*

The shoot N content for plants from the most productive N treatments have been summarised in Table C. These data are broken down into N in the organic form (i.e. integrated into the shoot tissue) and in the nitrate (or NO3-N) form (i.e. N which has been taken up but was not necessarily required for growth i.e. luxury feeding); as well as the more conventional total N form which would be available in routine analyses. As these data represent samples taken from different stages of crop development they provide a reference source against which growers can compare their own analyses to check on crop progress.

It is clear from these data that most of the total N in the coriander shoot tissue was in the organic form. Organic N declined as the crop matured whilst the accumulation of the excess NO3-N increased. Guidelines for mineral N content for coriander have not been found in the literature but data for lettuce and spinach suggest that levels should be below 3,500 to 4,000 mg/kg (EU Regulation 563/2002) which equates to 0.4% and therefore within the range measured here.

Table C. *Coriander shoot N content for plots producing maximum growth.*

sample / drilling	% Organic N	% NO_3-N	% Total N
WHRI			
interim 1 sample (at 4-5 true leaves)	4.0-5.1	0.2-0.8	4.3-5.7
interim 2 sample (at 7-9 true leaves)	3.3-5.0	0.3-0.9	4.2-5.4
Final harvest sample	2.7-4.5	0.1-1.1	3.2-5.3
Valley Produce			
interim sample (at 7-9 true leaves)	4.0-5.0	0.3-1.1	4.8-5.8
Final harvest sample	4.0-4.6	0.6-1.1	4.9-5.6

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N offtake was also calculated using the yield data for each available N treatment producing maximum growth at final harvest stage and the relevant tissue analysis data which suggest that the level of organic N removed in coriander shoots at final harvest was 132 kg/ha N for the crop drilled in May, 52 kg/ha N for the crop drilled in July and 64 kg/ha for the crop drilled in August. The N offtake varied between crops due to the difference in dry matter yield and organic N content. The N offtake figures are based on the cropped area and would need to be adjusted if working on a gross field area basis (i.e. reduce to around 75% to account for unproductive space in wheelings and field headlands).

Provisional recommendations for fertiliser N for field grown coriander have been produced using the data generated in these trials. The assumptions supporting these recommendations are detailed in the main report.

Table D. *Preliminary N fertiliser recommendations (kg/ha) for coriander*.

'SNS' Index * (Mineral N (kg/ha) to 90cm)	0 (50)	1 (70)	2 (90)	3 (110)	4 (140)	5 (200)	6 (250)
Proposed rate of N	140	125	115	105	90	55	30

*(*Note: SNS index should be based on a measurement of mineral N to 30cm depth. It should be multiplied by 3 (i.e. to correct to 90cm depth) to provide the relevant SNS index)*

Coriander – quality and shelf life

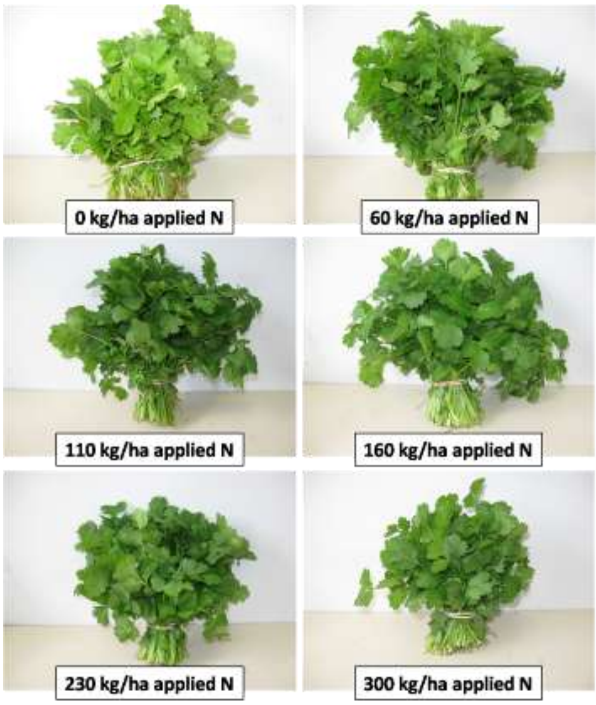

Fig. A. *Comparison of bunches of coriander at the start of shelf life trials from the range of applied N treatments.*

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N rate also impacted on bunch quality in that foliage had a deeper green colour at higher rates of N. This can be seen in the photograph of bunches harvested from the crop drilled 23/07/09 and was also quantified through leaf greenness measurements via a hand held SPAD meter. These data suggested that bunches without N fertiliser application were less green than from the higher rates of N and the 60 kg/ha applied N rate also had lower SPAD values than higher rates from the first trial drilled. It seems likely that the 0 N treatments at least are at risk of rejection on quality grounds. However for applied N rates above 110 kg/ha (i.e. available N of 131-154 kg/ha) there were no further significant improvements in depth of leaf colour. For each of the trials drilled at Wellesbourne, product deterioration was largely as a result of wilting with bunches on average deteriorating to an unusable state by 6 to 11 days from harvest. The 0 rate of applied N (21-44kg/ha available N) overall produced the longest shelf life but also produced inferior and probably unmarketable bunch quality, as noted previously. Differences in shelf life between rates of applied N (60-300 kg/ha) were small and inconsistent. Applying extra potassium (K) as a top dressing resulted in a slight increase in shoot K content in final harvest samples but had no impact on yield or on product shelf life.

Mint - yield

Mint plots were planted on 05/05/09 at Wellesbourne and on 9-11/05/09 at Valley Produce (VP) from rooted transplants of Spanish mint with the aim of establishing the crop for more detailed work in the second year of the project. Rates of applied N between 0 and 300 kg/ha were tested with fertiliser applied as a base dressing prior to transplanting and then again as a top dressing each time the crop was topped. Plots were topped on two occasions in the first year (June and August) to assist establishment and then cut back at the end of the season (early October), with shoot material that was removed on each occasion quantified for 'yield' as well as shoot mineral content. At each harvest, the topped shoot material (tops) and remaining shoot material cut to ground level (bases) were recorded and analysed separately. At WHRI, maximum yield of mint cut at the end of the first season was associated with the highest rate of N (i.e. 200 kg/ha applied N or 229 kg/ha available N (to 30cm depth of soil) based on initial soil mineral N analysis) on each occasion.

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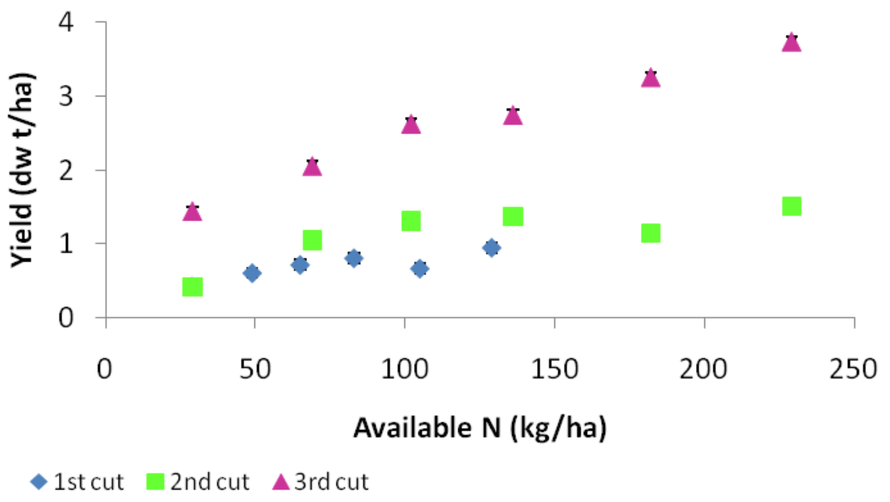

Fig. B. *Response of mint at Wellesbourne to available N during year 1 from two topping samples and one end of season sample.*

In year 2, the optimum available N was in the range 178-283 kg/ha for the yield of tops of all three cuts, although the difference in yield with that achieved at available N of 78-122 kg/ha was very small and only statistically significant for the second and third cuts.

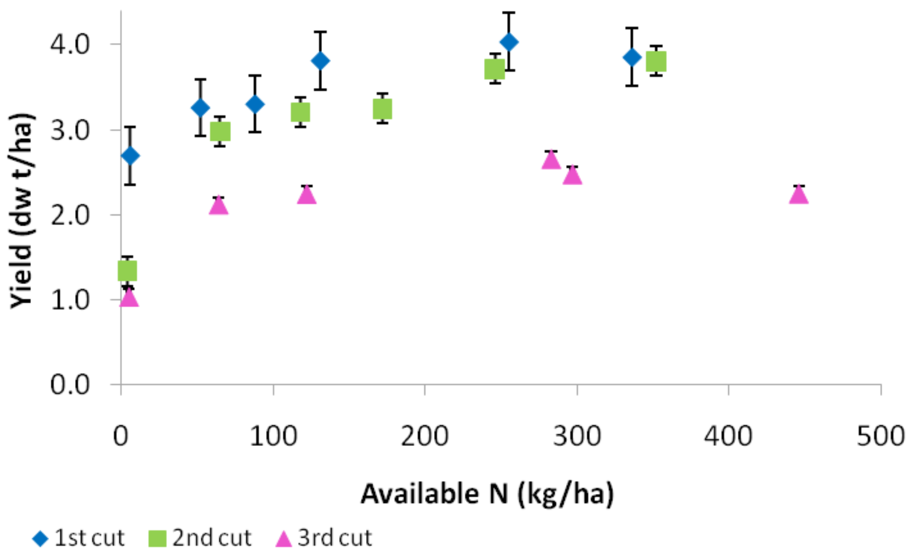

Fig. C. *Yield response of mint shoot tops at Wellesbourne to available N in year 2*.

Table E lists the N treatment producing maximum fresh and dry weight yield for each sample from the Wellesbourne trial together with the final fresh weight yield at harvest for the most productive N treatment for each cutting. As with coriander, since N available to the crop is a combination of that available from the fertiliser applied and that already available in the soil, the table includes a figure for available N to 30cm depth which is calculated from the mineral N analyses carried out on soil samples prior to drilling each trial plus the amount of N applied as the treatment.

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Table E. Rate of applied (and available) N to each mint cut in Years 1 and 2 producing maximum yield, and the yields from the best treatments (Wellesbourne)

Cutting date	07/07/09 10/05/10	06/08/09 05/07/10	05/10/09 06/09/10
Year 1	-	-	200 (229)
Year 2	154 (178)	230 (246)	160 (283)
Yield (t/ha Fwt) from the best N treatment *	32.4	23.3	Year 1 11.3 Year 2 28.4

**The lowest N application treatment above which no further significant increases in yield were obtained.*

In the first season, mint yield in Valley Produce trials was not responsive to available N. However, due to the lack of true replication and randomisation of N treatments in the Valley Produce trials, this result should be treated with caution. In the first cut, yield of bases was slightly higher from the 48-179 kg/ha available N rates than from higher available N rates. There were no other significant differences in yield of tops or bases from the first three cuts of the first season at Valley Produce. Due to problems of scheduling N applications and harvesting, no reliable data on response of mint yield to available N was obtained from the second season mint trial at Valley Produce, although yields and mineral analyses of plant tissue provided useful comparisons with data collected from Wellesbourne. Most of the nitrogen in mint shoots was in the organic form. Nitrogen levels were highest in the second cut of the first year.

Table F. *Mint shoot N content for plots producing maximum growth.*

	% Organic N	% NO_3-N	% Total N
Year 1			
1st Cut	2.41	0.01	2.42
2nd Cut	4.03	0.26	4.29
3rd Cut	2.31	0.03	2.35
Year 2			
1st Cut	3.48	0.08	3.56
2nd Cut	2.88	0.02	2.90
3rd Cut	2.82	0.07	2.89

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N offtake was also calculated using the yield data for each available N treatment producing maximum crop growth at harvest and the relevant tissue analysis data which suggest that the level of organic N removed in mint shoots at harvest ranged from 15 kg N/ha in the first cut of Year 1 to 179 kg N/ha in the first cut of the second year (equivalent to 11.3 and 134.3 kg N /ha allowing for 25% unproductive area).

Provisional recommendations for fertiliser N for field grown mint have been produced using the data generated in these trials. The assumptions supporting these recommendations are detailed in the main report. These recommendations are for each cutting in an established crop in the second year of production.

The figures in Table G assume that the base material from the shoots (and the associated nitrogen content) is removed from the field after cutting. If the bases remain in the field after cutting, the figures should be reduced by 30 kg/ha N to allow for the nitrogen content of the shoot bases which becomes available to the next cutting.

Table G. *Preliminary N fertiliser recommendations for each cutting of established mint crops.*

'SNS' Index *	0	1	2	3	4	5	6
(Mineral N (kg/ha) to 90cm)	*(50)*	*(70)*	*(90)*	*(110)*	*(140)*	*(200)*	*(250)*
Proposed rate of N (base mowing removed)	**180**	**170**	**160**	**150**	**130**	**100**	**70**

*(*Note: SNS index should be based on a measurement of mineral N to 30cm depth. It should be multiplied by 3 (i.e. to correct to 90cm depth) to provide the relevant SNS index)*

Mint – quality and shelf life

In year 1, leaf greenness (as measured by a SPAD meter) at the start of shelf life was not influenced by level of available N. However, in Year 2 of the crop, leaf greenness of mint was improved by N applications, but there were no further increases in greenness at levels of available N above 122-172 kg/ha. The samples from the second cutting were greener than those from the first and third cuttings.

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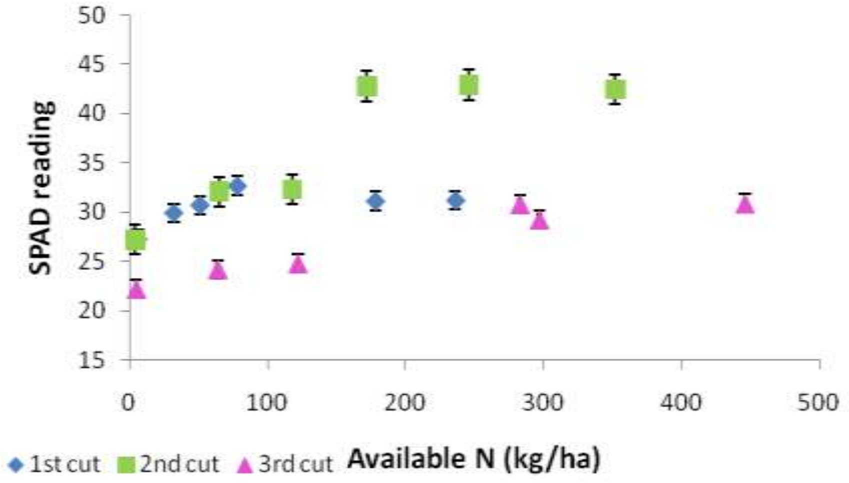

Fig. D. *Effect of available N on leaf greenness of bunches of mint at the start of shelf life.*

Bunches of mint harvested at the end of the first season when the crop was cut back were assessed for shelf life but leaf disease rendered them unfit for use two weeks after harvest. Within this period, the rate of N applied during production did not influence shelf life in storage. The main cause of shelf life failure in Year 2 was also browning/necrosis. Samples from the first cut had a longer shelf life than those from the second and third cuts. The effect of available N on shelf life also differed between the first cut and the second and third cuts. In the first cut, samples from plots with available N of 51-78 kg/ha had a significantly longer shelf life than samples from plots with lower or higher levels of available N. However, in the two later cuts in Year 2, increasing levels of available N reduced shelf life, with a difference of five days between the lowest and highest available N levels.

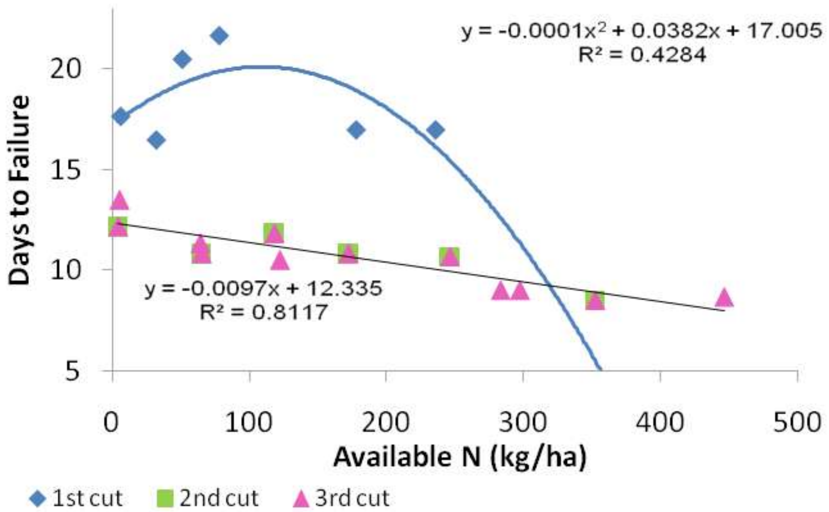

Fig. E. *Effect of available nitrogen on days to failure in shelf life (mainly due to leaf necrosis and some yellowing).*

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Financial benefits

By identifying optimum rates of available N for crop yield, there is an immediate cost saving in avoiding the use of excess N fertiliser. As a case study, the coriander crops at Valley Produce are likely to have been treated with N at the 160 kg/ha rate. At an SNS index of 5 (using the value of SMN to 90 cm of 203 kg/ha from the values in Table 5, VP drilling 17/06/09 and Table B of the current version of RB209 for a medium soil in rotation) the recommended application rate would be reduced to 55 kg/ha. This would equate to a saving of 105 kg/ha N, and at an estimated fertiliser N cost of £175 per tonne for a 34% N product, would be worth £54 per ha per crop which with the potential for three crops per year would be £163 per ha per annum.

The results for mint have shown that increases in available N above 78-122 kg/ha resulted in only very small increases in yield (if any), were unnecessary in terms of product greenness, and can have a detrimental effect on shelf life in terms of leaf browning/necrosis.

The benefits of being able to justify fertiliser inputs for produce assurance schemes are essential for some businesses in order comply with customer demands as well as meeting obligations to minimise impact on the environment.

Action points for growers

- Growers should review their current fertiliser programmes in line with the data generated for coriander in the first year and for mint in the first and second years of this project. Typical shoot N concentrations and N offtake for well grown crops are included in this grower summary as well as an RB209 format recommendation table. Guidance for establishing SNS levels is given in HDC News No. 162 (April 2010, p14).

- Applying the correct rate of N will ensure optimum yield, quality (in terms of greenness) and shelf life (delayed browning/necrosis of mint) as well as efficient returns on fertiliser inputs and minimised leaching of N.

- Growers requiring information about the wider range of mineral elements required to produce a healthy crop should refer to tables in the main report where concentrations of a wider range of nutrients are summarised from the analytical data compiled from these trials. Whilst the trials here did not attempt to optimise this wider range of

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nutrients, the data should provide at least an indication of nutrient status for well grown crops.

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