Factsheet 32/12 project FV 350

Field Vegetables

Nitrogen requirements for leeks

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Open pollinated leek varieties show large responses to nitrogen applications but until recently, no work had been carried out on the more vigorous F1 hybrids that are now grown commercially. This factsheet presents the results from HDC project FV 350, where the nitrogen (N) requirements of vigorous F1 hybrid leeks were assessed. The results support the revised fertiliser recommendations published in the 2010 edition of the Fertiliser Manual - RB209 (Defra 2010). Where leeks are to be harvested in the autumn, the application of supplementary nitrogen in August and September may be justified. For over-wintered crops, when summer N requirements are met, additional nitrogen may cause reductions in yield due to frost intolerance. The response to additional N in the spring is limited by the time to harvest.

Action points

- Assess fertiliser requirement by assessing soil nitrogen supply before drilling using the measurement method or by using the tables in the Fertiliser Manual.
- Aim to match fertiliser applications and N supply from soil to crop demand (with supporting irrigation if necessary).
- Avoid large amounts of broadcast N at time of drilling.
- Split the rest of the N, especially on light sandy soils.
- Consider evaluation of crop N status by crop sampling or leaving small areas of the field with less N.
- A crop N status of 1 indicates a balance between N supply from soil and fertiliser and crop demand.
- Avoid excessive amounts of autumn N, particularly if growing frost sensitive varieties.
- Applications of early spring N may be poorly utilised if the crop is harvested soon after application.
- While this factsheet indicates that N applications to leeks in closed periods can be beneficial, the reasons for any individual application need to be considered on a crop-by- crop basis, with written advice from a FACTS qualified advisor to comply with Nitrate Vulnerable Zone (NVZ) regulations.

Background

Previous UK experiments to test the response of older OP varieties of leeks to nitrogen (N) have shown that crop yield will increase with N applications, up to an excess of 500kg/ha N (Goodlass et al., 1997). More recent experiments, on a loamy sand soil, demonstrated a response to 375kg/ha N (Smith et al., 2000). In these experiments, most of the N was applied within a month of transplanting. It is therefore likely that it was not efficiently recovered by the crop. On the continent rates of N application to leeks are also much lower.

The recommendations for leeks in the new Fertiliser Manual RB209 (Defra 2010) (Table 1) provide similar recommendations for low soil nitrogen supply (SNS) soils, but larger recommendations for crops grown on high SNS soils than in earlier editions of RB209. These adjustments take into account the poor rooting of the crop. The new recommendations allow an additional 100kg/ha N depending on the appearance of the crop to support growth and colour (Figure 1).

Table 1. Nitrogen recommendations for leeks - Fertiliser Manual (Defra 2010).

SNS Index	0	1	2	3	4	5	6
N rate kg/ha N	200	190	170	160	130	80	40

Previously, scientific support for the additional 100kg/ha N was not available. Neither was there any evidence to support the application of fertiliser N during the NVZ closed period between the 1 September and the end of January, when the Fertiliser Manual was published. This is in contrast to grower experience, where between 80-100kg/ha N might be required by leeks on light Nottinghamshire sands.

The research was carried out with the more vigorous F1 hybrids that are grown today in mind and was designed to provide validation of the revised N recommendations in the new Fertiliser Manual, guidance for when the additional 100kg/ha N might be required and to demonstrate when N applications can be justified in the closed NVZ period.

1. Crop pictured on the left received 180kg/ha N and on the right 240kg/ha N in 2009.

The response of leeks to nitrogen

In 2009 and 2010, field trials were established to test the response of over-wintered leeks (cultivar Belton) on a sandy loam site at Wellesbourne (Warwick Crop Centre). An overview of treatments tested is shown in Table 2. In both years the response to high levels of N was tested. The effects of extra autumn and late winter N were tested in more detail in the second year.

In 2009/10, nitrogen fertiliser (ammonium nitrate), up to a rate of 360kg/ha N, was applied in late May and late June, with additional amounts of 60kg/ha in August, September and January, February 2010. One further treatment rate of 480kg/ha N was used, split between May and August 2009. Only the applications of extra N applied in September and January were applied in the NVZ closed period.

In 2010/11, the main dressings of nitrogen were applied in August and September, with 25kg/ha N applied at planting and additional amounts of 50kg/ha N applied in September, October and January, February 2011. Due to late planting half of the main dressing of nitrogen was applied in the NVZ closed period.

The main conclusions of these trials are reported in this factsheet, for details see the full reports for project FV 350 published in 2010 and 2011.

Table 2. Main treatments tested in the 2009 and 2010 experiments.

Start date	Treatments	Mineral N at start (kg/ha) to 90 cm (Index)	Fertiliser recommendation, kg/ha N	Main harvest date
1 April 2009	Response curve to 480kg/ha additional N at 240kg/ha summer N level.	54 (0)	200	2 Nov 2009
19 July 2010	Response curve to 500kg/ha additional N at 150 and 200kg/ha summer N levels.	79 (1)	190	11 Apr 2011

The responses in marketable yield are shown in Table 3. In the 2009/10 trial, where no nitrogen fertiliser was applied, crop growth was only 40% of that where 240kg/ha N had been applied and marketable yield from the unfertilised treatment was severely reduced. Where 180kg/ha N was applied, crop growth, up until November, was almost the same as with 240kg/ha N. An assessment of marketable yield was made in November. This was slightly higher where 180kg/ha N had been applied rather than 240kg/ha N but not as high as where 240kg/ha N had been applied with an additional 60kg/ha N in both August and September. The crop failed to overwinter due to severe frost damage early in 2010, none of the crop was of marketable quality in April 2010.

Table 3. Relative marketable yields in November 2009 and April 2011. Responses to additional N applied at Wellesbourne, where sufficient summer N had been applied. Percentage of yields: relative to 28t/ha where 240kg/ha N was applied in 2009, and relative to 22.1t/ha where 200kg/ha N was applied in 2011.

Growing season	Main N amount (kg/ha)	% Yield at 200 or 240 kg/ha N	Additional N applied (60kg/ha N applied at each timing in 2009 and 50kg/ha N in 2010)					
			Aug		Sep		Aug & Sep	
2009/10	nil	15						
	180	109	Not determined		Not determined		Not determined	
	240	**100**	116		Not determined		123	
	360	93						
	480	118						
			Sep	Oct	Sep & Oct	Jan	Feb	Jan & Feb
2010/11	nil	0						
	75	43						
	150	72	84	90	71	84	85	79
	200	**100**	59	74	56	82	81	83
	300	78						
	500	72						

The response of the 2009/10 crop to fertiliser observed in November was similar to what might have been expected from the Fertiliser Manual. The fertiliser recommendations for this crop based on an SNS index of 0 would have been for a main dressing of 200kg/ha N and up to 100kg/ha supplementary fertiliser.

The 2010/11 trial also suffered from severe winter weather in December but at an earlier stage of growth than in 2009/10, so was able to recover to produce yield of marketable quality in April. There was a clear response up to 200kg/ha summer applied N. Fresh weight marketable yield declined when higher amounts of N were applied. Where only 150kg/ha N had been applied in the summer there was benefit in applying an additional 50kg/ha N. October applied N was marginally more effective than N applied in September or the spring. More than 50kg/ha additional N was not beneficial. Where 200kg/ha N had already been applied, there was a depression in yield where further N was applied in the autumn. This was associated with the interaction between N in the crop and tolerance to the severe winter conditions. Where 200kg/ha N had been applied to the crop in the previous summer there was no benefit from additional N in the spring.

The Fertiliser Manual recommendations for 2010/11 crop based on an SNS index of 1 would have been for a main dressing of 190kg/ha N and up to 100kg/ha supplementary fertiliser.

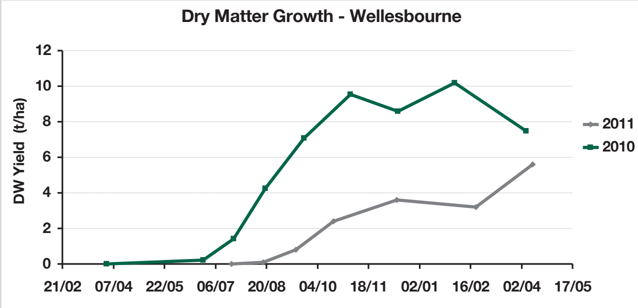
Growth and nitrogen offtake

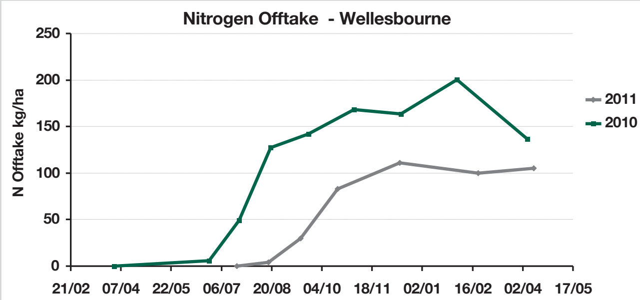
Figure 2 shows the patterns of growth and nitrogen offtake in the contrasting seasons of 2009 and 2010. Growth and nitrogen offtake are much smaller in the later planted crop.

In the 2009/10 trial, field assessments showed that most of the growth and N uptake occurred between August and November, with little occurring beyond December and only a small amount in spring 2010. The crop was severely affected by frost in January 2010 and failed to produce any marketable yield at a final harvest in April 2010.

In the 2010/11 trial, most of the growth and N uptake occurred between August and December, despite a later planting date. The crop was severely affected by frost in December, resulting in the loss of dry matter, although the crop had partially recovered by the main harvest in April.

From the measurements of N offtake in the crop, it is possible to estimate fertiliser recovery. Within a month of establishment, recovery was less than 3% of the N applied as fertiliser. Only by September 2009 and October 2010 did recovery reach around 30% of that applied. Any excess fertiliser N would be extremely susceptible to loss by leaching while the crop and its roots were still poorly developed. However, even by harvest, fertiliser recovery was less than 50% and was lower in the poorer crop in 2011 (Table 4).





2. Patterns of growth and N offtake in contrasting seasons – the crops received 240kg/ha N in 2009 and 200kg/ha N in 2010.

Table 4. Estimated fertiliser recovery in 2009 and 2010 experiments at Wellesbourne.

Date (2009/10 trial)	% Fertiliser recovery.	Date (2010/11 trial)	% Fertiliser recovery.
25 Jun 2009	2		
22 Jul 2009	12		
19 Aug 2009	22	17 Aug 2010	3
22 Sep 2009	34	15 Sep 2010	13
2 Nov 2009	47	18 Oct 2010	26
14 Dec 2009	46	13 Dec 2010	41
2 Feb 2010	46	22 Feb 2011	33
6 Apr 2010	42	14 Apr 2011	37

These results help to explain why earlier experiments (Goodlass et al., 1997) showed yield responses to high levels of fertiliser nitrogen, as it is likely that the fertiliser had been applied too early for efficient utilisation by the shallow rooted leek crop and hence, why split dressings through the season are now recommended.

Summary

The responses to supplementary N are summarised in Table 5. It may be that the higher dry weight yield in the 2009/10 trial (10.7t/ha compared with 5.6t/ha in 2010/11) explains the difference in response to the additional 100kg/ha N application between the two growing seasons (Figure 3). Furthermore, the results of the 2009/10 trial suggest that even on fertile sites, well supplied with available N (represented by the high early N plots in the experiment), there might still be a response to additional nitrogen in August and September for an autumn harvested crop. This was not supported by the results in the 2010/11 trial, where additional autumn applied N led to reduced yields because of frost damage.

Both crops were severely affected by frost, so severe in 2009/10 that no marketable crop overwintered. In 2010/11, the crop was less forward at the time of the frosts in December so the optimally fertilised crop avoided severe damage and still produced a marketable yield of 22.1t/ha compared with 28t/ha achieved by the 2009/10 crop in November 2009.

3. Contrasting growth in two seasons in 2009 (left) and 2010 (right).

Crop requirement in NVZ closed periods will need to be judged on a crop-by- crop basis taking into account yield potential, N already applied and time before harvest. In Nitrate Vulnerable Zones written advice from a FACTS qualified advisor will be required to comply with Nitrate Vulnerable Zone Regulations. Assessing crop N status may help determine requirements for supplementary nitrogen.

Table 5. A summary of crop responses to supplementary N in the spring and autumn.

Season	Supplementary N		N in Closed Period	Comments
	Autumn	Spring		
2009/10	Yes	No	Yes (rapidly growing crop)	No response to spring N because of frost damage.
2010/11	No	No	Yes* (rapidly growing late crop)	Period between spring N and harvest too short to show a response.

***Half of the main dressing was applied in closed period.**

Assessing crop N status

In order to sustain optimum amounts of growth, nitrogen supply from soil and fertiliser should match crop requirement. Shortages of N can lead to poor growth but excess N can increase crop susceptibility to frost damage.

There are many tools that can be used to asses crop N status and some of their benefits and drawbacks are discussed below.

Crop Sampling

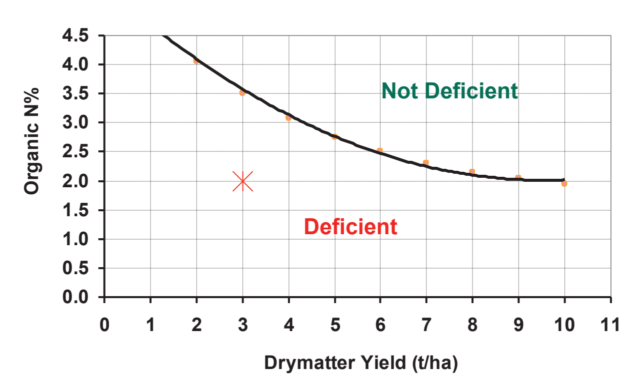
The N status of leek crops is estimated by reference to a critical N curve derived from experiments at Wellesbourne in 2009, and 2010. The final project report for FV 350 shows how the critical N curve was determined.

N status is the ratio of the actual % organic N content of the whole crop relative to the critical organic N content at a particular dry matter yield.

N status = Actual organic N% / critical organic N%

Organic N content – *is the nitrogen content of the whole crop excluding any mineral nitrate and is determined by Kjeldahl digestion of crop material. Alternatively, it can be determined by measuring Total N and subtracting the Nitrate-N content.*

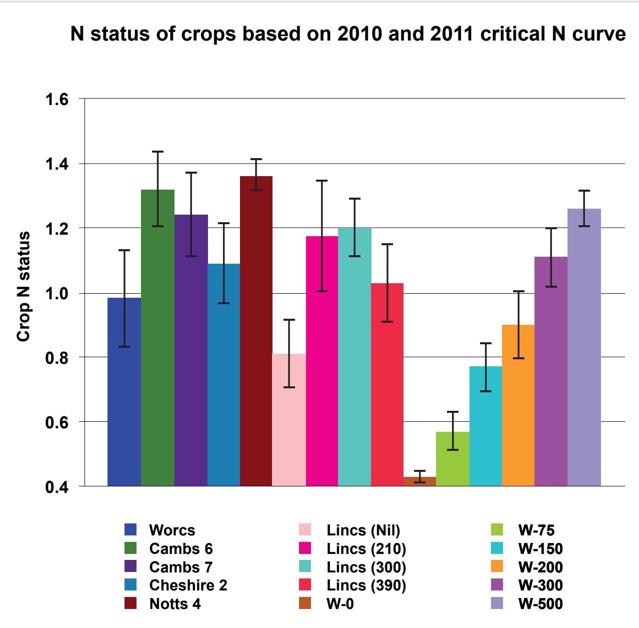
Figure 4 shows an example critical N curve – any point above the line suggests an N status of above 1 and below the curve one less than 1. An example point is shown where the whole crop drymatter is 3t/ha and the organic N content is 2%. With a whole crop drymatter of 3t/ha the N content is well below the critical value of 3.5% so the crop N status is 0.6.



4. Critical N curve for leeks, derived from Wellesbourne experiments.

N status can be determined at any stage of growth except where the growth is very small (less than 2t/ha drymatter yield). Representative crop samples must be taken, the drymatter yield and organic N content of the whole above ground crop recorded. A draft protocol is available from HDC. The results should be compared with the critical N curve shown above.

Further work needs to be carried out to perfect the method for commercial use but preliminary results are reported here. Figure 5 compares the N status at Wellesbourne and a range of commercial crops. A value of 1 indicates that N supply was matched with nitrogen demand, providing the maximum potential for growth. Values greater than 1 indicate an excessive supply of N. Values less than 1, such as those where no fertiliser had been applied, suggest that N was in short supply and that growth was likely to have been limited.



5. N status of crops in Spring 2011. Data from commercial sites, with Wellesbourne (W) for comparison.

At Wellesbourne the application rate of 200kg/ha N produced the highest marketable yields and had an N status of 0.9. Lower nitrogen application rates resulted in lower N status and reduced yield, Table 6.

Table 6. Wellesbourne February 2011 N status and Drymatter (DM) yields.

N rate kg/ha N	DM Yield t/ha	N Status
0	1.2	0.4
75	2.2	0.6
150	2.8	0.8
200	3.2	0.9
300	3.0	1.1
500	3.0	1.3

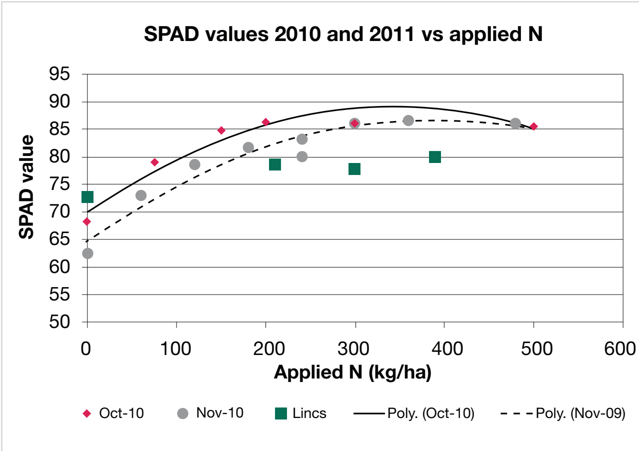
For the commercial sites, the N status ranged from 0.81 to 1.4. The Worcester and Cheshire sites showed the closest match between N supply and crop N demand, as judged by their N status. At the Lincolnshire site, the yield in the unfertilised area was little different to the areas receiving fertiliser. The N status varied from 0.81 without fertiliser to 1.22 where 300kg/ha N fertiliser had been applied; with little difference in total dry weight or fresh marketable yield.

The site with the most positive N status was in Nottinghamshire, which had a large amount of fertiliser applied but was associated with a lower yield at the time of sampling.

Chlorophyll Measurements

Relative chlorophyll measurements based on leaf colour were made in October 2010 at the Wellesbourne site using a Minolta SPAD-502 meter. Measurements increased as applied N increased (Figure 6). The highest measurements broadly corresponded with the highest drymatter yields. The readings for the Lincolnshire site in January are also shown. The range of SPAD readings again differed to those made at Wellesbourne.

This suggests that a full response curve on each field would be necessary to decide whether additional fertiliser is required. Without such a response curve, interpretation of the SPAD readings would be difficult, as the target reading varies with time of year and probably also with variety and site, in part because the SPAD meter actually measures chlorophyll and does not measure N directly. Therefore, isolated use of such techniques would not be particularly helpful in deciding whether and how much supplementary N is required.



6. SPAD chlorophyll readings from 2010 and 2011 Wellesbourne experiments (readings taken in October 2010 and early November 2009, respectively). Data also shown from measurements made at the commercial site in Lincolnshire in 2011. Fitted lines shown for each sampling date.

Interpretation of crop N status

Crop N status determined by crop sampling is a prototype system and its interpretation has yet to be fully tested on commercial crops.

- While the guideline might be to aim for a crop N status of 1 it might only be practical with regular feeding when ferti-irrigation techniques are used.
- Where fertiliser application is based on base dressings and a series of topdressings there may be stages where an N status well above 1 may be appropriate. These might be where fertiliser is applied in advance of crop growth, where N from later applied fertiliser would not be available because of dry soil conditions.
- Research in the FV 350 project does suggest that N status before overwintering should not be excessively above 1 because of the risk of frost damage in sensitive cultivars.
- There may be occasions where crops might be deficient in N because the uptake of available N has been restricted by poor soil structure/root growth.

References

Defra (2010). Fertiliser Manual (RB209) 8th Edition June 2010.

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Figure references

Photographs supplied by Warwick Crop Centre.

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Notes

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

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