Grower Summary

FV 370b

Wild rocket and baby leaf spinach: Impacts of nitrogen and phosphorus fertiliser applications on yield and quality

Final 2013

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.

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Headlines

- There was no crop response to phosphate fertiliser above P index 3, for wild rocket and spinach
- There is still a risk of exceeding the limits for nitrate in wild rocket if N is used in excess of crop requirement

Background

The aim of this project was to improve recommendations for nitrogen (N) and phosphate (P_2O_5) applications, as a route to optimising fertiliser use and production efficiency of field-grown wild rocket and baby leaf spinach.

In recent years our understanding of the N requirements of wild rocket have improved through HDC funded work. Project FV 370 examined the tissue nitrate concentrations (TNC) in commercial crops of wild rocket in 2010, and showed that while TNC levels were high in mid summer when there was a prolonged cold period of dull wet weather, there was scope to improve N recommendations by taking into account the relatively high levels of soil mineral N seen in some field situations. Subsequent work in 2011 in FV 370a has specifically investigated responses of wild rocket to N and has shown that there is scope to reduce N rates without compromising yield and quality. No previous work had been done which focused on phosphorus (P) nutrition in rocket and it is not clear when data on phosphate responses in spinach were last determined.

After its uptake and conversion to organic forms, phosphorus (P) is a highly mobile element within plants and it has a key role in respiration to drive crop growth (Archer, 1985). However, much P remains bound to soil particles, and high P indices are needed to get available P into the soil solution where it can be taken up by the plant. Phosphate application conveys agronomic benefits which include enhanced leaf quality and root branching and depth, but the precise concentration required both in the soil and for subsequent uptake by the plant remain to be elucidated. Lettuce is known to be responsive to applied phosphate, even when soil P indices are high (Fertiliser Manual, RB209; Defra 2010), and shallow rooted, fast growing crops like wild rocket and spinach could be the same.

Phosphorus pollution is of growing concern for the industry. Most soils now have adequate P indices, but one consequence is that the removal of P by erosion and/or run-off is of increasing concern. Under the Water Framework Directive (WFD; expected to be implemented by 2015), water quality will be assessed on a catchment basis. Since

phosphorus is more significant than nitrate in terms of eutrophication, the industry needs to demonstrate that it is applying phosphate at optimal levels for yield, but not in excess.

This work provides a basis for recommendations for phosphate (P_2O_5) fertilisers, as there are currently none in the Fertiliser Manual (RB209; Defra, 2010) for baby leaf crops such as rocket or spinach.

Summary

A series of six experiments was carried out (three spinach, and three wild rocket) in 2012, at commercial sites in Dorset, Kent, Norfolk, Shropshire and North Wales. Fully randomized factorial experiments were carried out, each examining 3 N fertiliser, and 6 phosphate fertiliser rates. Phosphate was incorporated in the soil prior to drilling, and N applied post drilling. Measurements were made of soil mineral nitrogen (SMN) to 30 cm depth, and topsoil P, potassium (K), magnesium (Mg) status prior to drilling. Fresh weight and dry weight yield, tissue nitrate concentration (TNC) and N and P offtakes were determined as well as visual observations of leaf quality and leaf breakdown (during shelf life over the 6 days post harvest).

Phosphate

There were no yield responses seen to applied phosphate, either in wild rocket or spinach, and no effects on TNC or other quality attributes. It should be noted that while commercial sites provide the perfect soil types for study, positioned as they are within real crop rotations, one limitation of this type of study, is the difficulty of maintaining the low nutrient indices prior to drilling, which are ideally required to detect crop nutrient responses. In this case it appeared that prior to drilling soil P indices were all in the range 3 to 6 (i.e. high). Therefore the conclusion from the parameters measured in this study is that there is no response to phosphate fertilisers at soil index 3 or above.

Nutrient offtakes

The maximum N offtake for wild rocket, averaged across the three sites of 2012 was 96 kg N/ha, and the maximum phosphate offtake was 21 kg P_2O_5/ha (Table 1). For spinach, the corresponding values were 69 kg N/ha and 28 kg P_2O_5/ha. The lower N offtake for spinach probably reflects the fact that its TNC is typically lower than that for rocket, as reflected in the EU limits (3,500 vs 6,000 mg NO_3^-/kg respectively).

Table 1. The maximum nitrogen and phosphate offtakes recorded for three spinach and three rocket crops where experiments were carried out in and 2012

Site-Species code	Max N offtake (kg/ha)	Max P_2O_5 offtake (kg/ha)
Spinach		
12/S1	41	30
12/S2	45	15
12/S3	122	39
Average spinach	*69*	*28*
Wild rocket		
12/R1	61	16
12/R2	145	27
12/R3	82	20
Average wild rocket	*96*	*21*

The phosphate offtakes quantified in Table 1 mean that growers now have a rational basis for calculating phosphate requirement for rotational purposes. Moreover, there may be opportunities for cost savings through reduced P inputs in situations where very high soil P indices,have been identified (and levels could be allowed to fall to P index 3).

When data are combined from 2011 (FV 370a) and 2012, the average N offtake for wild rocket was 113 kg N/ha.

Nitrate

The concentration of nitrate in spinach was well below the required EC limit at all three sites studied. With wild rocket, TNC at all sites were below the official limit of 6,000 mgNO_3^-/kg in all treatments. However at the highest N rate applied, TNC was above 5,000 mg NO_3^-/kg (5,200, 5,096 and 5,431 for sites R1, R2 and R3 respectively).

Since there is a significant possibility that the limits will be reviewed within two years of their introduction (in 2012) for rocket, the limits may be tightened (reduced) to 5,000 mg NO_3^-/kg. This would pose a threat to the UK growers of rocket, particularly in situations where excess N is available to the crop.

Visual quality parameters

Effects of N and P on visual quality parameters were generally small and insignificant. No nutrient deficiencies were observed, and at four of the six sites, leaves were green and healthy and no variation in overall colour score was observed. In some cases, an increase in the incidence of blemishes or bruising, was seen with applied N compared to nil N treatments. However applied P treatments overall had no major effect on leaf quality.

Only one site showed appreciable leaf breakdown and this was spinach site 12/S3 which also demonstrated a reduction in yield in response to applied N. This was because the SMN at drilling was very high (137 kg/ha), clearly demonstrating an additional risk factor resulting from over-application of N.

There were some indications that with a combination of high N and high P applications, quality traits such as leaf breakdown were worse. This observation simply underlines the fact that it is generally inefficient to over-supply nutrients, which is reflected in the risk of exceeding limits for TNC (in the case of N) and other quality parameters.

Yield responses to N

Given that there were no interactions and no overall P effects on yield, the effects of applied N can be considered separately. As found in the previous studies in 2011 (FV 370a), there were strong effects of N on yield. The responses in 2012 can be summarized as shown in Table 2.

The data from the present study, combined with that from 2011 for wild rocket, allowed quantification of both apparent recovery of the SMN to 30 cm depth measured prior to drilling, and the apparent recovery of applied fertiliser N and this is discussed in further detail in the Science section. Recommendations are also related to the soil nitrogen supply (SNS) index system used in the Fertiliser Manual (RB209).

Table 2. The recommended applied fertiliser N rates recorded for three spinach and three rocket crops, where response experiments were carried out in 2012

Scenario	Site-Species code	SMN to 30 cm depth prior to drilling (kg N/ha)	Highest applied N rate at which response seen (kg N/ha)
1. Response to high amounts of N (>100 kg N/ha)	12/S1	22	110
	12/R1	36	120
	12/R3	39	110
2. Response to moderate amounts of N (40-60 kg N/ha)	12/S2	67	60
3. No response to applied N	12/S3	137	0
	12/R2	143	0

The recovery of SMN was *ca*. 60% for spinach and 90% for rocket. Spinach tends to emerge more slowly than rocket, but develops more rapidly once emerged. Therefore one reason for the lower recovery of SMN in the spinach crops might be due to greater losses of N by leaching, and/or immobilization in soil organic matter, in the longer period between drilling and emergence.

The recovery of fertiliser N was ca. 60% for wild rocket and 40% for spinach. For the wide range of vegetable crops in the Fertiliser Manual (RB209; Defra, Appendix 10), the recovery of fertiliser N has a common value of 60%. Similarly, N fertiliser efficiency of wheat is ~60% (Sylvester-Bradley *et al*., 2008 and 2009) but historically there are few original data for vegetable crops. The results suggest that a 60% recovery is correct for wild rocket, but spinach appeared to have a lower recovery value. However this value for spinach represents data from only two sites, and so should be treated with caution.

Fertiliser recovery should ideally be measured using labelled N fertiliser, or estimated from the slope of N offtake plotted against N applied (where full N response data are available). However in the two years of studying N responses, limited data sets were available, with only two sites (in 2011) showing significant responses to N with more than two N treatments applied. Until more data are available, it may be wise for simplicity to treat spinach as for rocket and other crops, and also assume a value of 60% recovery. It is important to remember however that this is based on measurements only to 30cm depth. There will also be losses of N below rooting depth when considered over the full growing season across multiple crops.

Financial Benefits

In 2011, 1,222 ha of baby leaf spinach and 460 ha of wild rocket was grown, worth £54M at retail level. There is a requirement for continued vigilance on nitrate levels, and the industry as a whole needs to demonstrate to the Food Standards Agency and the European Commission that it is endeavouring to reduce nitrate in these crops. Failure to address the problem may result in increased losses due to rejection of crop, and potentially loss of the wild rocket crop in the UK if growers cannot comply with Commission (and/or retailers) limits.

There may be an opportunity to save the cost of phosphate fertiliser, where high P indices are seen in field vegetable rotations.

Action Points

- Growers should estimate crop N requirement before cropping with rocket and spinach, specifically;

  - Sites with low, medium or high N requirements respectively can be defined broadly as those with soil mineral N (to 30 cm depth) pre-drilling, of: (1) >65 kg N/ha, (2) 30 to 65 kg N/ha, or (3) up to 30 kg N/ha,

  - An alternative method is presented for estimating N requirement, assuming that: average crop demands are 69 kg N/ha in spinach and 110 kg N/ha in wild rocket; apparent recoveries of SMN (to 30 cm) depth are in the range 60-90% and apparent fertiliser N recoveries are 60% (further details in Science section),

- It should be noted that tissue nitrate concentration in wild rocket, in every experiment in 2012, exceeded 5,000 mg NO_3^-/kg at the highest N level (or when N was applied in excess) and were therefore close to the current EC limits of 6,000 mg NO_3^-/kg; there is a danger that these limits could be reduced (tightened) in the future,

- This work suggests that further attention should be paid to N management in wild rocket crops including taking into account mineralisation of N from crop residues, particularly for later sown crops where conditions are warm and moist and SMN may be building up in the soil pre-drilling,

- As P indices appear to be high in these salad production systems, care must be taken to avoid over application of phosphate.