Grower Summary

Brassica Strategic Centres

(England and Scotland) – Broccoli N Response

FV 462

Final report 2022

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Project leader:	Angela Huckle, ADAS Boxworth
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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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1. Grower Summary

1.1 Headline

- Broccoli crops show a strong response to additional nitrogen (N) application, and this can have a significant impact on marketable yields per hectare.
- Existing N recommendations are robust, although care must be taken to ensure accurate determination of soil mineral nitrogen (SMN) is carried out when planning fertiliser applications.
- Care must be taken to avoid excess N applications to reduce the risk of spear rot or hollow stem incidence in susceptible varieties.

1.2 Background

Broccoli is a major UK crop, with significant customer demand for both traditional broccoli and purple sprouting varieties or newer Tenderstem. Although UK growers have access to specific recommendations for N provision to guide fertiliser management (Nutrient management guide, RB 209), growers are concerned about the influence of nitrogen on susceptible varieties of broccoli to spear/head rot. A wide range of recommendations are given in the literature, covering 112 – 450 kg N/ha depending on cultivation system and time of application (Bakker *et al*., 2008). Earlier editions of RB209 (8th Edition – 2008) did not differentiate between broccoli and cauliflower, giving the same recommendations for each crop, recommending 290 kg N/ha at soil nitrogen supply (SNS) Index 0 for summer/autumn plantings, and only recommending a 100 kg N/ha base dressing under conditions where poor establishment was likely. The 2010 update of the 8th edition of RB209 split broccoli from cauliflower, recommending a lower application of 235 kg N/ha at SNS Index 0 compared with 290 kg N/ha for cauliflower following an industry request due to the risk of head rot and assumptions that critical N content was lower for broccoli compared with cauliflower, although this remains to be tested. For Scotland, recommendations from SRUC for broccoli are higher than RB209, primarily as a result of a concern that lower rates would restrict some growers. A summary of current recommendations are given in below (Table 1).

Table 1. Summary of current recommendations for broccoli cultivation in the UK based on RB209 (England/Wales) and the SRUC Technical Note (TN – Scotland).

SNS Index (RB209)	0	1	2	3	4	5
N residue group (TN)	1	2	3	4	5	6
kg N/ha	<60	61-80	81-100	101-120	121-160	>160
RB209	235	200	165	135	80	0
SRUC TN	270	260	250	230	180	140

In addition to ensuring maximum yields which can be achieved, crop nutrient status can be linked with a number of postharvest quality indicators, including both physical (abiotic) and pathological (biotic) disorders. Hollow stem is the occurrence of an air-filled cavity within the stem below the head which is visible when the stem is cut at harvest. In addition to visible spoilage, the presence of the inner cavity can increase postharvest disease incidence to reduce yields further. The incidence of hollow stem is linked with rapid plant growth caused by wide plant spacing, high N levels, warm/moist weather or boron deficiency (Vigier & Cutcliffe, 1984). For instance, Moniruzzaman *et al.* (2007) demonstrated a three-fold increase in hollow stem area in broccoli when 200 kg N/ha was applied compared to 100 kg N/ha, although this effect showed a significant interaction with boron (B) application, where hollow stem incidence was reduced with increased B availability. Similarly, head rot, or spear rot, caused by infection in the broccoli head by a range of pathogens including *Pseudomonas* and *Erwinia* species can show increased incidence with greater nitrogen availability. Due to difficulties controlling head rot with pesticides this can lead to significant crop losses, especially under conditions of prolonged damp weather. For example, Everaarts (1994) reported an increase in head rot incidence from 39% at 0 kg N/ha to 88-90% at rates of 98 – 196 kg N/ha. As a result, it was considered relevant to include scoring of the incidence of spear rot and hollow stem in response to N application to test whether marketable yields can be adversely affected due to increased incidence of these conditions with greater N application.

Due to increasing incidence of head rot in Lincolnshire and Scotland in recent years, it was decided to review evidence to support N application recommendations for current UK varieties. This was addressed through a series of targeted trials at representative commercial sites in the east (Lincolnshire) and south (Cornwall) and in Scotland (Fife and Perthshire) to further examine the response of broccoli to nitrogen applications. The trials were established to test the following core objectives:

1. Determine economic optimum N rate for broccoli marketable yield.
2. Assess the impact of two different N application timings on broccoli marketable yields (Scotland only).
3. Assess the effect of N rate and timing on spear/head rot incidence.

1.3 Summary of 2021 Trials

Nitrogen application rates were chosen to test both existing recommendations and the rate ranges discussed above. Six application rates over two timings between 0 – 200 kg N/ha were used in Cornwall and Lincolnshire allowing full coverage of RB209 recommendations for those sites of 0 – 80 kg N/ha whilst allowing for testing of “luxury” application rates up to 200 kg

N/ha. Applications were split between two timings – once shortly after planting, followed by a second application one month later. For Scotland, seven application rates of 0 – 270 kg N/ha were tested covering recommendations of up to 250 kg N/ha in the SRUC technical notes. A base application one month pre-planting was only included at the 220 kg N/ha treatment, with the other treatments split between applications at planting, one month after planting and at heading. A summary of treatments is given in Table 2 and 3 below.

All other major nutrient requirements (P, K, Mg) were assessed and applied as necessary to RB209 recommendations to ensure no other nutrients were limiting. It was also ensured that the sites were at the correct soil pH. All other aspects of crop cultivation, including planting, and control of weeds, pests and diseases were carried out as per usual commercial practice by the host growers.

Nitrogen treatments were applied in triplicate to a randomised block design, with each block covering a 7m stretch of 3 beds, although harvest assessments were only taken from a 5m stretch of the central bed to prevent the influence of edge effects between treatments. A 20m buffer zone around the trial area was marked out to prevent N application from spreading into the trial plots when the commercial crop applications were made. Applications were made by hand with nitrogen applied as calcium ammonium nitrate (27%).

Table 2. Summary of treatments for Cornwall and Lincolnshire.

Treatment No	Timing 1 Just after planting	Timing 2 1 month later	Total N applied
	kg N/ha		
1 (Nil N)	0	0	0
2	60	0	60
3	60	30	90
4	80	40	120
5	100	60	160
6	120	80	200

Table 3. Summary of treatments for Fife and Perthshire, Scotland.

Trt No	Timing 1 Base	Timing 2 Just after planting	Timing 3 1 month later	Timing 4 At heading	Total N applied
	kg N/ha				
1 (Nil N)	0	0	0	0	0
2	0	60	0	0	60
3	0	60	60	0	120
4	0	80	80	20	180
5	0	100	80	40	220
6	0	120	100	50	270
7	100	0	80	40	220

Site Details

Trial sites were identified to achieve broad geographical spread across the UK, covering Truro, Cornwall, in the southwest, Lincolnshire in the east, and Fife and Perthshire in Scotland. Summary information for each site is given in Table 4 below. Soil analysis was carried out prior to planting to gain soil nitrogen status at 0, 60 and 90cm (although SMN sampling was performed only to 60cm at Cornwall due to shallower soils). This demonstrated a broad range of pre-trial soil N content across the trial sites with RB209 recommendations ranging from 0 – 165 kg N/ha, and these were used to decide N application treatments.

Table 4. Summary site details for trial sites. * A small amount of nitrogen may be needed if SMN levels are low in the top 30cm of soil. Numbers in Italics – Scottish Technical Note recommendations

Site	Soil Mineral Nitrogen (SMN) (kg N/ha)	Soil Nitrogen Supply (SNS Index)	Recommended N (RB209) (kg N/ha)	Planting Date	Harvest Date	Variety
Cornwall	184	6	0* (*140*)	27/4	23/7	Steel
Fife	127	4	80 (*180*)	2/6	19/8	Parthenon
Perthshire	89	2	165 (*250*)	10/6	20/8	Parthenon
Lincolnshire	156	4	80 (*180*)	9/8	15/11	Covina

1.4 Summary of Results

A response to increasing N applications was observed at all sites, but the level of response varied depending on the initial starting SMN (Figure 1). The response was weakest in Lincolnshire and Cornwall, where the high initial SMN reduced the crop response to supplementary N applications. The greatest response was seen in both Perthshire and Fife where marketable yields were increased by 10x/5x respectively with N applications up to 270 kg N/ha. However, increased N application showed a strong correlation with increasing postharvest quality reductions as a result of both hollow stem and spear rot. The increase in these conditions, coupled with the reduced N response at higher N applications saw a levelling off of yield between 120 – 220 kg N/ha.

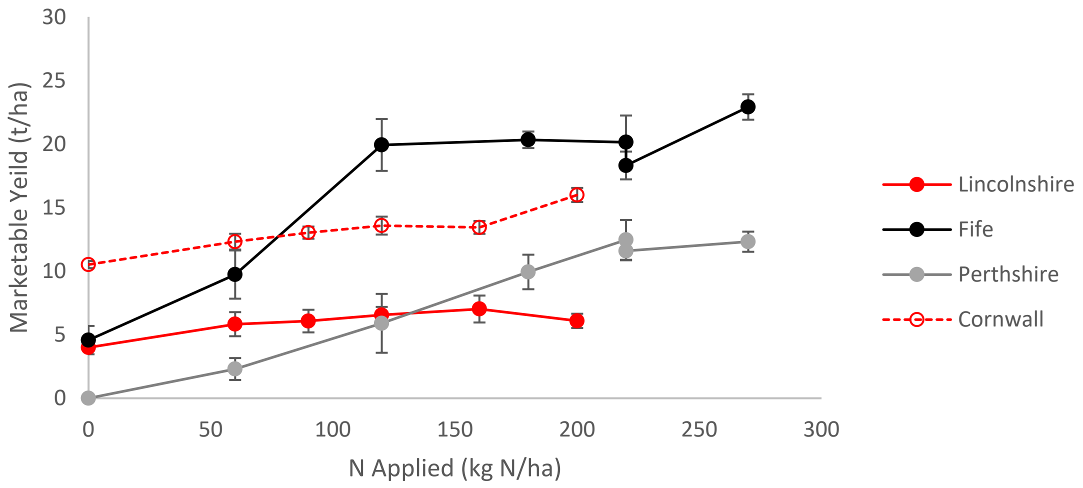

Figure 1. Marketable yield response to N application, 2021 trials.

Whilst increased N application did lead to greater yields, once the cost of current fertiliser costs and postharvest losses were taken into account diminishing returns were seen with increased N applications above 200 kg N/ha at the majority of sites examined (Figure 2). This was also mirrored by a general decline in nitrogen use efficiency with greater N application, demonstrating that greater proportions of available N were not being utilised by the crop.

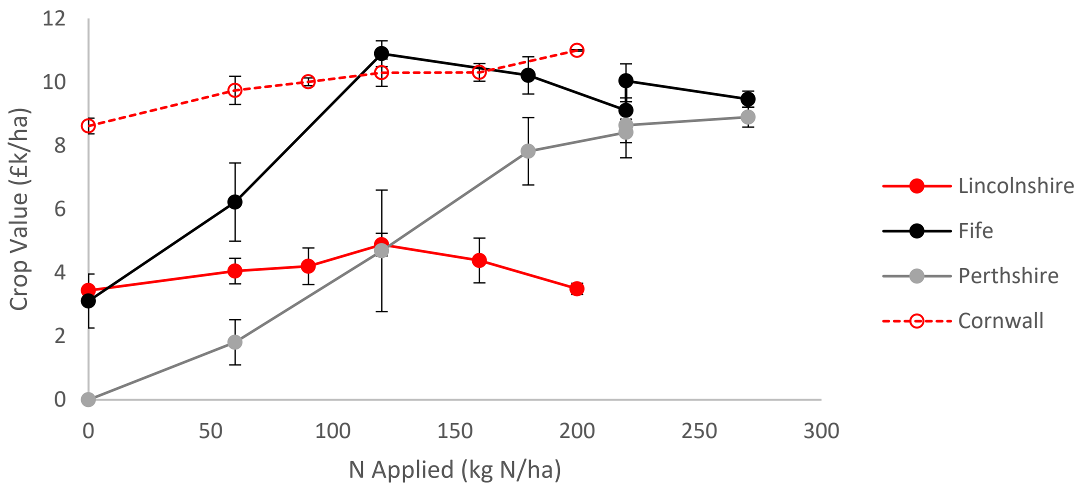

Figure 2. Summary figures for crop economic returns per ha.

Taking into account the increasing costs of N, levelling off of the yield responses and increased proportion of postharvest quality reductions, cost:benefit relationships for increased N application demonstrate a proportionate reduction in returns for higher N application (Figure 3). These relationships generally concur with current recommendations for broccoli taken from both RB209 and the Scottish Technical Notes.

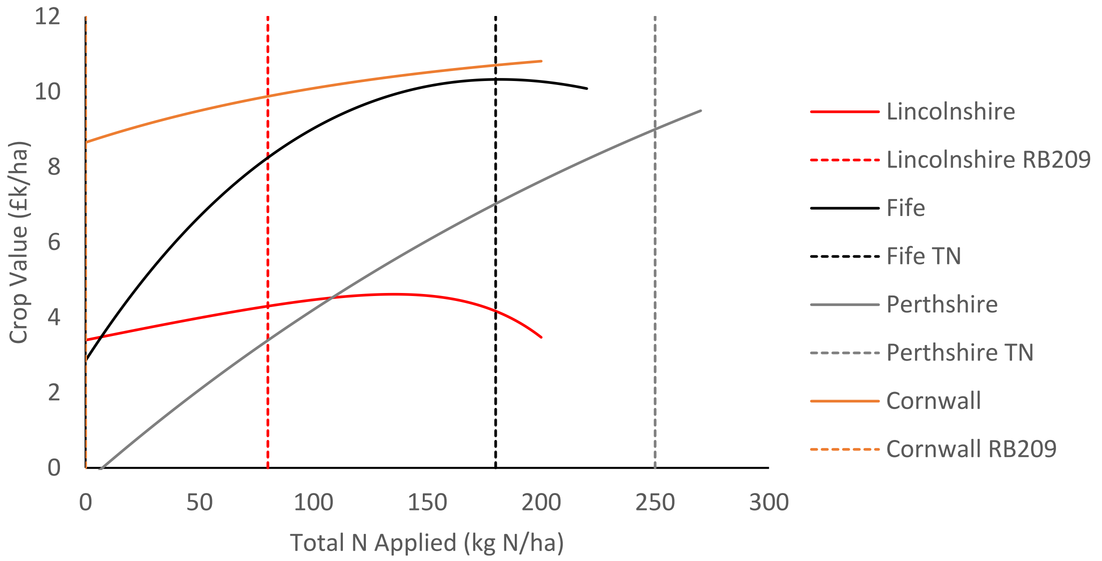

Figure 3. Fitted curves to economic optima for nitrogen application. RB209/Scottish Technical Note recommendations are by dashed lines.

In addition to testing the relationship between total N application and yield, a limited dimension of these trials assessed the relationship between base dressing and top dressing for the first N application. Results from Scotland indicated that base dressing prior to planting gave a significantly stronger yield response and brought harvest date forward due to faster early growth, especially where pre-planting SMN values were low. But, this also increased the risk of incidence of head rot.

In addition to supporting current recommendations for N application, these results support the careful use of soil analysis and SMN calculation to determine N applications – especially on soils that are likely to have high pre-planting N. This will ensure that N is not applied to excess and minimises both environmental and economic costs, whilst reducing the risk of postharvest losses.

1.5 Grower Action Points

- Ensure accurate soil analysis is taken, especially in situations where SMN may be uncertain or high, to enable accurate determination of crop N requirements.
- Promote existing soil N reserves to further reduce the need for supplementary N provision.