FACTSHEET 14/16
Field Vegetables (FV 409)

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Nitrogen and phosphorus recommendations for optimising yield and quality of sweetcorn

This factsheet provides results of nitrogen (N) and phosphorus (P) response experiments on sweetcorn (*Zea mays L. var. rugosa*) from work undertaken in AHDB Horticulture project FV 409, which was carried out during 2013 and 2014, to improve understanding of sweetcorn responses to N and P (Figure 1).

Figure 1. Nitrogen response experiment on the Isle of Wight (SNS index 0) showing a plot where 250kg N/ha was applied (100kg N/ha in the seedbed and the remainder top-dressed at growth stages V4–V6) (left) compared with a plot where no N was applied (right)

Action points

- Growers should consider the revised N recommendation rates given in this factsheet to reach maximum potential yields and maintain cob quality
- Apply no more than 100kg N/ha in the seedbed with the balance top-dressed between growth stages V4–V6*
- Assess Soil Nitrogen Supply (SNS) by measuring Soil Mineral Nitrogen (SMN) to 60cm rather than using the Field Assessment Method (FAM), especially for later drilled crops
- Crop available N supply from applications of organic materials should be taken into account when planning N fertiliser applications. Growers in Nitrate Vulnerable Zones (NVZs) must comply with the NVZ rules including the Nmax limit of 280kg N/ha for sweetcorn
- Use existing recommendations to guide P application rates.

*Refers to the number of visible leaf collars during the vegetative growth stages.

Introduction

The aim of the experiments was to provide improved N and P recommendations for sweetcorn grown and harvested as cobs for the fresh produce market. Yield responses to N were recorded in just over half of the crops in the trial across both years, and at SNS indices 0 to 1, rates of between 160 and 250kg N/ha were needed to provide optimum yields. These are in excess of recommendations in the Fertiliser Manual (RB209, 8th edition 2010); the revised N recommendations are given in this factsheet. These revised N recommendations are in good agreement with international N advice for maximum yield of sweetcorn (220kg N/ha; IFA, 1992).

SNS should be measured rather than estimated from tables in RB209. This is particularly important for late drilled crops where additional mineralisation prior to drilling may lead to a measured SNS higher than estimated by the FAM. The experiments indicated that sampling close to the time of drilling is the best time to assess SNS.

While sweetcorn is known to be sensitive to P deficiency, there is little evidence that current best practice guidelines should be changed and work in AHDB Horticulture project FV 409 supports existing recommendations in RB209. It is good practice to maintain soil phosphate indices by replacing the expected phosphate offtake. The target P index for field vegetables, including sweetcorn, is index 3. Current RB209 recommendations at P index 3 (25kg P_2O_5/ha) are sufficient to replace crop (phosphate) P_2O_5 offtake where only the cobs are harvested. However, if the whole crop is removed, growers should apply an additional 25kg P_2O_5/ha (at soil index 0–3) to account for the greater crop phosphate offtake.

Background

'Supersweet' sweetcorn, which is predominantly sold as fresh intact produce ranging from whole cobs to cobettes, now accounts for the majority of the UK area of sweetcorn. It differs from older varieties of the more traditional normal endosperm sweetcorn in its characteristic length of sweetness after picking, with the newer varieties remaining sweeter for longer. But, while breeders have improved yield potential and cob sweetness, fertiliser recommendations have not kept pace with the nutrient demands of these modern varieties. Nitrogen is the major plant nutrient and the previous recommended N rate for sweetcorn grown in the UK was 150kg N/ha at N index 0 (RB209 8th edition). Not only was this suggested to be out of date for modern high yielding varieties, but it was also lower than recommended internationally for maximum yield of sweetcorn (220kg N/ha; IFA,1992).

The project measured the yield responses of sweetcorn to N and P fertiliser in selected commercial genotypes, and evaluated N and P utilisation in relation to soil indices and SMN to 90cm depth. Measurements were also taken from the topsoil to 15cm for P_2O_5, potash (K_2O), and magnesium (as MgO) status prior to drilling.

As well as measuring yield response (marketable cobs/ha), total N and P uptake and total fresh and dry weights of the plants were measured in order to better estimate crop N requirement (needed to determine N recommendations). Total cob and marketable cob yields as t/ha, and measurements of cob sweetness (via Brix) were also recorded.

There was also a need to understand whether SMN measurements could usefully be taken into account when estimating crop N fertiliser requirement. Particularly for the late-sown sweetcorn crops, where SNS may be higher than estimated using the FAM due to increased mineralisation, and as a result crops may receive more fertiliser N than they need.

Nitrogen response studies

Eleven trials were completed over two cropping seasons, at three early and three late sown sites in 2013, and three early and two late sown sites in 2014 (Table 2) on commercial farms in West Sussex, Hampshire and the Isle of Wight. The effect of N application timing was also studied in the N response experiments, with N fertiliser applied using the following three approaches:

1. two-way: split 2/3 in seedbed at drilling, 1/3 at growth stage V4–V6 (= current practice)*
2. three-way: split 1/3 in seedbed at drilling, 1/3 at growth stage V4–V6, 1/3 at flowering
3. two-way: split none at drilling, 1/2 at growth stage V4–V6, 1/2 at flowering.

*The maximum applied in the seedbed was 100kg N/ha to follow current RB209 (8th edition) recommendations.

Yield response to nitrogen

Yield responses to N were recorded in just over half of the crops in the trial across both years, and at SNS indices 0 to 1 rates of between 160 and 250kg N/ha were needed to reach maximum marketable yields. An increase in marketable yield of cobs was seen at five of the experimental sites (Table 2). Where a curve (linear exponential) could be fitted to the yield data from individual sites, the optimum rates of N for maximum marketable yield from the six sites that responded to N were 196, 157, 227, 250, 232 and 227kg N/ha compared to previous recommendations (from RB209, 8th edition) of 150, 150, 100, 150, 150 and 150 respectively (Table 2 and Figure 2). There were two sites that showed no response to N, but both of them had high SNS indices at drilling. To enable growers to attain these potential yields in modern sweetcorn varieties, revised N recommendations are given in Table 1.

Table 1. Nitrogen recommendations (kg N/ha) to maximise gross yield of sweetcorn, based on SNS indices and SMN measured to 60cm and 90cm depth

SNS index (SMN [kg N/ha] to 90cm)	0 (<60)	1 (61–80)	2 (81–100)	3 (101–120)	4 (121–160)	5 (161–240)	6 (>240)
Equivalent SMN (kg N/ha) to 60cm	<40	41–53	54–66	67–80	81–107	108–160	Over 160
N recommended (kg N/ha)	220	175	125	75	0*	0*	0*

**A small amount of N may be needed if soil N levels are low in the top 0–30cm of soil. Growers should also apply no more than 100kg N/ha in the seedbed.*

Table 2. Marketable yield responses to applied N, and details of soil type, previous cropping and nutrient status of the trial sites

Site code, location and year	Sowing date	Harvest date	Previous crop	Soil index (P, K, Mg)	SMN to 90cm depth at drilling (kg N/ha) SNS index in brackets	Soil type	Optimum N rate (kg N/ha)	Yield at nil N applied (cobs/ha)	Yield at optimum N rate (cobs/ha)
Sites showing a positive response to N									
13/E1 Hampshire	April 22	Aug 13	Tenderstem broccoli	4, 2+, 2	54 (0)	Sandy clay loam	196	2,076	38,257
13/E2 West Sussex	April 23	Aug 20	Courgette	2, 2-, 3	54 (0)	Silty clay	157	28,823	33,752
14/E2 West Sussex	April 17	July 31	Sweetcorn	2, 1, 2	46 (0)	Silty clay loam	250**	2,802	32,332
14/E3 Isle of Wight	April 10	Aug 5	Sweetcorn	4, 2+, 2	43 (0)	Sandy loam	232	2,619	29,745
13/L2 Isle of Wight	May 15	Sept 11	Asparagus	4, 3, 2	75 (1)	Sandy silt loam	227	23,839	33,026
14/L3 West Sussex	June 1	Sept 19	Sweetcorn	3, 2-, 3	56 (0)	Silty clay loam	227	30,682	36,369
Sites showing no or little response to N									
14/E1 Hampshire	April 10	July 30	Wheat	5, 3, 4	138 (4)	Sandy clay loam (high gravel content)	0	28,316	28,316 (23,683*)
13/L3 West Sussex	May 23	Sept 19	Courgette	3, 2+, 4	100 (2–3)	Silty clay loam	0	23,905	23,905 (23,275*)

Details for trials from Isle of Wight, early 2013 (13/E3), and late 2014 (14/L2), and Hants, late 2013 (13/L1) and late 2014 (14/L1) have been omitted for site specific reasons, for further information see the final report for FV 409.

**Average yield across all N rates applied (60–320kg N/ha).*

***For this site based on the modelled curve, the optimum yield was not reached. However, the maximum yield in the trials was recorded at 250kg N/ha and this has been taken as the figure for optimum N.*

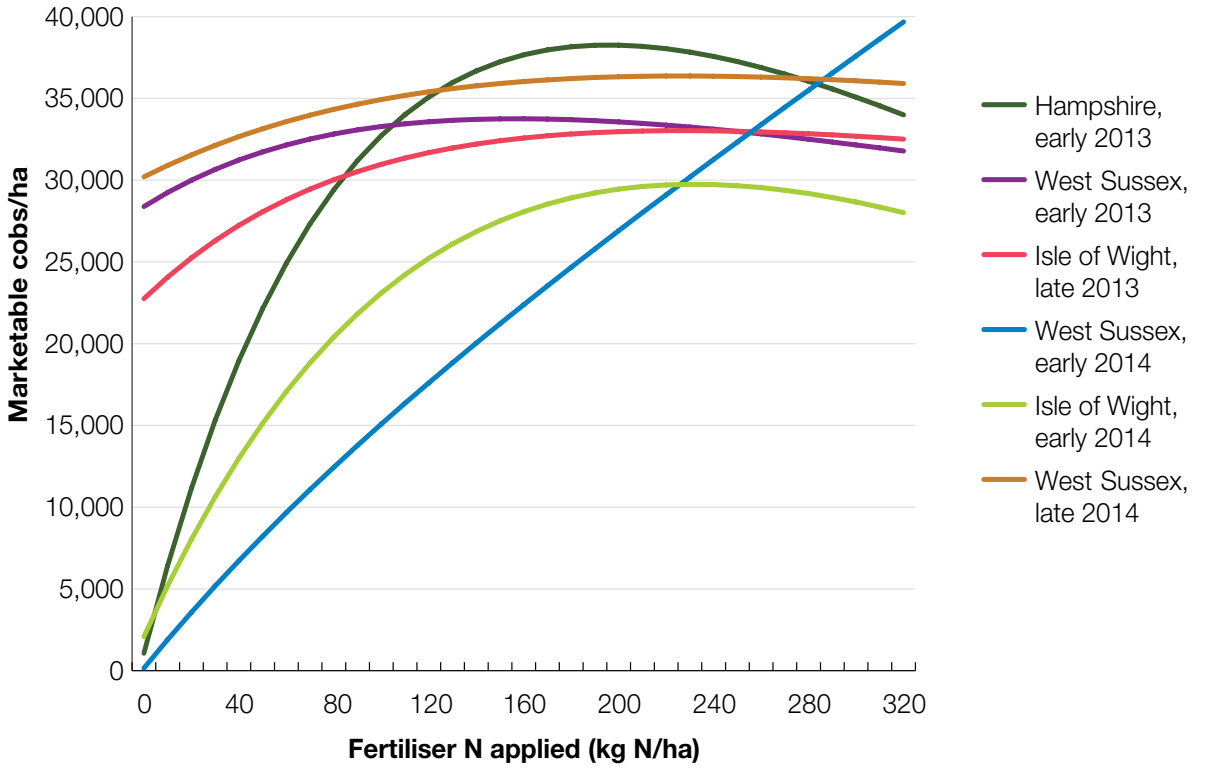

Figure 2. Yield response curves showing influence on yields of the revised recommendations compared to the previous rates (red line = SNS index 1 site, other lines = SNS index 0 sites)

Table 3 compares the difference in yield (%) between the previous recommendations for N (from RB209 8th edition), the optimum N rate (measured at each site) and the revised N recommendations, which allow an additional 70kg N/ha for SNS index 0 sites, and an additional 75kg N/ha for the index 1 site for the N responsive crops. The revised recommendations also bring the N recommendations at SNS index 0 in line with international recommendations of 220kg/ha N for sweetcorn (IFA, 1992).

Nitrogen recommendations

Based on the sweetcorn N response experiments over two seasons, N recommendations have been revised and are based on achieving maximum marketable yields.

Application timing

The experiments indicated that providing most of the N early in growth, to ensure it is available prior to the sweetcorn's maximum period of demand for vegetative growth (V6–R1), appears to be the best strategy with respect to matching crop uptake to optimise cob yields.

Cobs from two of the early crops showed a weekly significant increase in weight when the N was applied in the seedbed (N timing treatment 1), compared to timings where no or little N was applied in the seedbed. Application timing made no significant difference to the cob weights of the late sown crops, probably due to the higher SMN at drilling. In these cases, less N could be applied in the seedbed.

Growers should apply N as two or three applications, with up to 100kg N/ha applied in the seedbed and the balance top-dressed at V4–V6 (Figure 3).

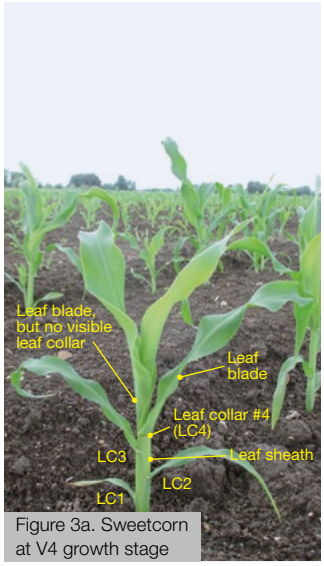

Figure 3a. Sweetcorn at V4 growth stage


Figure 3b. Sweetcorn at V6 growth stage

Assessment of SNS

SNS for early crops is usually assessed using the FAM tables in RB209. For late drilled sweetcorn crops the FAM may underestimate SNS indices by as much as one index. It is therefore recommended that SMN is measured close to drilling date. SMN samples should be taken to a depth of at least 60cm in 30cm sections (ie 0–30cm and 30–60cm). If taking SMN samples to less than 90cm, the results should be adjusted to take into account that the RB209 SNS indices are based on 0–90cm. This factsheet provides N recommendations based on both SMN in 0–60cm and 0–90cm. Further advice on SMN sampling is given in AHDB Horticulture Factsheet 09/12 'Soil nitrogen supply for field vegetables'.

Table 3. Impact on yield of revised recommendations or trial optimum, relative to yields that would have been achieved based on the Fertiliser Manual (RB209, 8th edition 2010) recommendations

Site	SNS index (and measured kg N/ha) to 90cm at drilling	RB209, 8th edition recommended N application rate (kg N/ha)	Revised (table 1) recommended N application rate (kg N/ha)	Optimum N application rate from trial (kg N/ha)	Marketable cob yield and % of the optimum yield when N applied at:			
					RB209, 8th edition		Revised rate from table 1 in the factsheet	
					Cobs per ha	%	Cobs per ha	%
13/E1 Hampshire	0 (54)	150	220	200	37,242	97	38,039	99
13/E2 West Sussex	0 (54)	150	220	157	33,748	100	33,364	99
14/E2 West Sussex	0 (46)	150	220	250**	21,215	66	29,102	90
14/E3 Isle of Wight	0 (43)	150	220	230	27,511	92	29,707	100
13/L2 Isle of Wight	1 (75)	100	175	230	30,967	94	32,714	99
14/L3 West Sussex	0 (56)	150	220	230	35,909	98	36,367	100
14/E1 Hampshire	4 (138)	0	0	0	28,316	100	28,316	100
13/L3 West Sussex	2–3 (100)	0–50	75–125	0	23,905	100	23,905	100
Average over all crops						93		98

Where possible, for each site a curve was fitted to the N response data – based on this fitted curve, yields at RB209 (8th edition) N rate, and the revised recommended N rate were calculated and compared to the optimum N rate measured for each trial.

***For this site based on the modelled curve, the optimum yield was not reached. However, the maximum yield in the trials was recorded at 250 kg N/ha and this has been taken as the figure for optimum N.*

Table 4. Possible adjustments to N recommendations (kg N/ha) as affected by economic fluctuations

Cost fertiliser N (£/kgN)	£0.40	£0.60	£0.80	£1.00	£1.20	£1.40
Cob farmgate price (pence/cob)	Reduction in N (kg N/ha)					
20	0	0	0	0	0	0
15	0	0	0	0	-5	-10
10	0	0	-10	-15	-20	-20
5	-10	-20	-30	-40	-50	-55

Environmental considerations

Sweetcorn has a relatively low fertiliser N recovery of around 28% as it is a comparatively shallow rooted crop and is usually drilled in wide rows. Growth is also slow in the early stages of plant development. The placement of N at drilling may increase the efficiency of recovery of N from fertiliser, but this was not tested in these experiments.

Applying N fertiliser at the revised recommended rates and removing only cobs will leave about 76kg N/ha in 20 t/ha of crop residues (Figure 4) but as its carbon:nitrogen ratio is relatively high (more than 20 parts carbon to one nitrogen), breakdown is likely to be slow. Therefore, there is a lower risk of N leaching than from residues that degrade more quickly, such as Brassica leaves or salad crops.

The risk of overwinter N leaching can also be minimised by establishing non-legume cover crops following harvest of the sweetcorn crop. Winter cover crops such as grasses, cereals, radish and non-legume mixes can typically take up around 50kg N/ha and, once ploughed in, some of this N will be released in spring for use by the following crop.

Figure 4. Mechanised sweetcorn harvesting showing typical post-harvest crop residues

Economic considerations

The N recommendations given in this factsheet are based on achieving economic optimum yield based on a price per cob of 17p and a fertiliser cost of 96p/kg N (2014 prices).

At these prices the N rates to achieve the maximum crop yield and economic optimum yield are similar. However, if the price of fertiliser was to rise, or the price of produce was to drop, then growers should consider reducing rates according to the adjustments given in Table 4 to maintain profit margins. However, it should be noted that if the N rate is reduced then the maximum potential yield will not be reached.

Phosphorus response studies

Farmers growing sweetcorn or forage maize can face problems with managing soil erosion – and as a large proportion of the sweetcorn crop is grown on the south coast of England, agricultural practices for crops including sweetcorn in water catchments in the south-east and south-west are likely to come under increasing scrutiny to reduce risk of phosphate loss from soils.

The trial sites used in FV 409 had soil phosphate indices in the range of 2 to 3 before drilling. There was an indication of a yield response up to 180kg P_2O_5/ha applied at one site with a soil phosphate index 2 in 2014. However, this yield response was not significant and there was no response to applied P measured at any of the other sites in either year. There was no effect of applied P on sweetness or any other aspect of quality.

The results support existing recommendations in RB209 (table 5). It is good practice to maintain soil phosphate indices by replacing the expected phosphate offtake. The target P index for field vegetables, including sweetcorn, is index 3. Current RB209 recommendations at P index 3 (25kg P_2O_5/ha) are sufficient to replace crop P_2O_5 offtake where only the cobs are removed (Table 5). However, if the whole crop is removed (eg for silage), growers should apply an additional 25kg P_2O_5/ha (at soil index 0–3) to account for the greater crop phosphate offtake.

Table 5. Phosphate recommendations (Fertiliser Manual, RB209 8th edition, 2010)

P index	0	1	2	3	4	5	6
P recommended (kg P_2O_5/ha)	175	125	75	25	0	0	0

The placement of phosphate at drilling may increase the efficiency of P use and result in other agronomic benefits such as a higher growth rate, particularly early in the season when the crop can struggle to compete against weeds.

Acknowledgements

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Further information

AHDB Horticulture Project Final Report FV 409: 'Nitrogen and phosphorus responses in sweetcorn'.

AHDB Horticulture Factsheet 9/12: 'Soil nitrogen supply for field vegetables'.

AHDB Horticulture Project Final Report FV 345a: 'Soil nitrogen supply for field vegetables'.

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Growth stage references

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