Grower Summary

FV 409

Sweetcorn: responses to Nitrogen and Phosphorus

Annual 2013

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Project Number:	FV 409
Project Title:	Sweetcorn: responses to Nitrogen and Phosphorus
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Headline

- Significant yield responses of marketable cobs to applied N were seen at three out of six sites, but there may be a significant risk of nitrate leaching over winter following harvest at the highest recommended N rate,

- There was no response of marketable cob yield to phosphate fertiliser at three sites with P indices of 3, and at most the increase in total crop uptake with applied P was only 10 kg P_2O_5/ha.

Background

Supersweet sweetcorn varieties, which are predominantly sold as fresh intact produce, i.e. whole cobs and cobettes, now account for the majority of the UK area of sweetcorn. These produce higher levels of sugar in the endosperm than traditional varieties, enabling a longer period of sweetness after picking and therefore better shelf life. The Assured Crop Produce protocol (2011) for sweetcorn advises that when choosing a variety the soil type, fertility, soil temperature characteristics, shelter and irrigation potential of the proposed site should be taken into consideration, as well as the requirements of the end customer.

Nitrogen (N) is the major plant nutrient and the maximum recommended rate for sweetcorn is 150 kg N/ha at N index 0 (DEFRA 2010). This advice appears to be inadequate for modern varieties since it is far lower than international guidelines such as IFA (1992), which recommend 220 kg N/ha. Fertiliser requirements for current UK cropping systems therefore need reviewing, addressing possible under-fertilising in early-sown crops and assessing the contribution that SMN measurements can make when determining crop N requirements, particularly for late-sown crops.

It is known that maize is sensitive to phosphorus deficiency (Archer, 1985) so it is appropriate to review P recommendations since demands of modern high yielding supersweet crops may well be higher than existing RB209 recommendations. Recent work has been undertaken in New Zealand on P nutrition of sweetcorn (Fletcher et al., 2006, 2008), but none in the UK. There have been problems with soil management practices (causing erosion) with forage maize, and since a large proportion of sweetcorn is grown on the south coast of England, agricultural practices in the south east and south west catchments are likely to come under scrutiny.

Summary

Six experiments were carried out at three early (E1-E3), and three late-sown (L1-L3) sites in 2013, on commercial premises in West Sussex, Hampshire and the Isle of Wight. Field experiments were carried out each examining the response to N or P fertiliser rates (six N response, and three separate P response experiments). The timing of fertiliser N treatment was also studied in the N response experiments, with fertiliser being applied as per the following treatments:

1, two-way: split 2/3 in seedbed at drilling, 1/3 at 45 days after drilling (current practice)*
2, three way split: 1/3 in seedbed at drilling, 1/3 at 45 days after drilling, 1/3 at flowering
3, two-way split: none at drilling, 1/2 at 45 days after drilling, 1/2 at flowering

*maximum applied in the seedbed was 100 kg N/ha (RB209 recommendations)

Phosphate was incorporated in the soil prior to drilling. N response experiments also evaluated the timing of N application. Measurements were made of soil mineral nitrogen (SMN) to 90 cm depth, and topsoil for phosphate (P), potassium (K), and magnesium (Mg) status prior to drilling. Fresh weight and dry weight yield, total cob and marketable cob yields and N and P offtakes were determined, as well as measurements of cob sweetness (via Brix).

Phosphate

There were no detected yield responses to applied phosphate, at any of the three sites, and no effects on other quality attributes such as sweetness. Prior to drilling, the experimental sites had soil P indices in the range 2 to 3 and a positive response may have been expected; maximum phosphate offtake was 60 kg P_2O_5/ha (range 20-60 kg P_2O_5/ha). The conclusion from this year of study is that there is no yield response of sweetcorn to phosphate fertiliser at soil index 3.

Nitrogen

At five out of six sites, there were significant increases in total N uptake ($P = 0.011$ to <0.001) by the sweetcorn crop, which were maximal at the highest rate applied, 320 kg N/ha. However out of 18 separate N rates x timing combinations studied, only six (at sites E1, E2 and L2) gave significant marketable cob yield responses to applied N (Figure 1). These results show that when harvesting an immature crop such as sweetcorn, getting more N into the plant does not necessarily deliver more marketable yield. Optimal N rates are shown in

Table 1 for treatment combinations which enabled curve fitting (using a crop value of 17p per marketable cob and 72 p/kg of N fertilizer).

An understanding of site yield potential is important to determine fertiliser requirements, and this is dependent on factors such as aspect, soil type and previous cropping history. For example, yield responses at the two late sites were quite different: L2 had a good response with max yield of 33,026 cobs/ha at 220 kg N/ha, with 75 kg N/ha available as SMN at drilling, while L3 showed no yield response with a lower yield between 25,000 and 28,000 cobs/ha, with 100 kg N/ha as SMN at drilling (Figure 1).

Soil mineral N to 90 cm depth prior to drilling was 54-60 kg N/ha at the early drilled sites and 70-100kg N/ha at the late drilled sites, i.e. 1-2 Soil Nitrogen Supply (SNS) indices higher at the late sites, suggesting that N recommendations should be lower for late sown crops (e.g. 20 kg N/ha lower moving from SNS index 0 to 1, or 1 to 2). As estimated from total crop N uptake measured in the zero N plots, and assuming the crop can recover all the N available in the soil immediately prior to drilling, it was seen that around 28 kg N/ha was mineralised (i.e. became available) between drilling and harvest in early sown crops and 8 kg N/ha in late sown crop. Although these figures are for a single season and a narrow range of soil types, these rates of mineralisation should be considered when estimating SNS and fertiliser strategies.

The maximum N offtake for sweetcorn across the six sites in 2013 was around 170 kg N/ha (range 70-170 kg N/ha), even at the highest N rate where 320 kg N/ha was applied. Combined with the fact that total N offtake in cobs is relatively low (80-100 kg N/ha if all cobs are removed from the field) this implies that even though the economically optimum N rates are higher than those recommended in RB209, it would be difficult to justify such higher N rates from an environmental point of view because of the risk of nitrate leaching over winter following harvest, particularly in those situations when unmarketable cobs are returned to the field. For example at site E2 where the harvest index and N offtake in cobs was calculated, the maximum offtake (all cobs) was 83 kg N/ha. However, considering that on average 75% of these cobs were marketable, then only 62 kg N/ha would have been removed from the field. This means that although the maximum N uptake for the whole sweetcorn crop was 160 kg N/ha, only 60 kg N/ha was removed from the field as marketable cobs. The 100 kg N/ha remaining in crop residues would be at risk of leaching over winter. Where unmarketable cobs are processed further e.g. through anaerobic digestion, and N returned as digestate to crops in the following growing season, a case can be made that higher N rates could be sustained responsibly, but this will be very much site and business dependent.

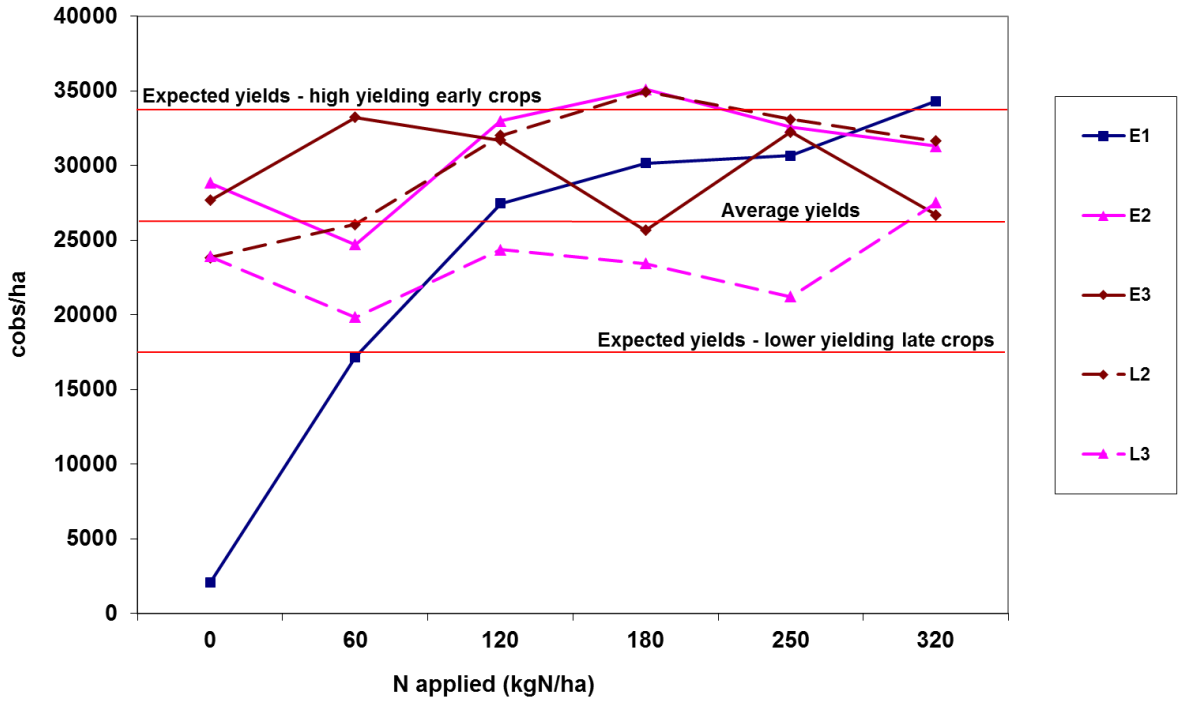

Figure 1. Effect of nitrogen application rates on numbers of marketable cobs from early and late drilled sweetcorn crops in Hants, Sussex and Isle of Wight, 2013 (means of the three N timings treatments in each experiment are shown).

Table 1. Economic optimum nitrogen application rates and timings (in bold) for the three sites with a significant response to marketable yield and where curve fitting could be carried out, Hants, Sussex and Isle of Wight, 2013

Site	N Timing treatment	SMN (Feb)	Available N at drilling	RB209 Rec. rate*	Economic Optimum (kg N/ha)	Cobs/ha at optimum
E1	All timing data combined	24	69	150	320	33,510
E1	**Seedbed + 45 days**	**24**	**69**	**150**	**196**	**38,257**
E1	3-way split	24	69	150	170	33,153
E1	No seedbed	24	69	150	320	36,142
E2	**Seedbed timings combined**	**37**	**82**	**150**	**157**	**33,752**
L2	**All timing data combined**	**29**	**103**	**100**	**227**	**33,026**

*Calculated from SNS Index prior to drilling

Nitrogen timing

In the two early crops which were picked at the correct crop ripeness (E1 and E2), there was a significant increase in cob weight (P = 0.05 and 0.09) when the nitrogen was applied in the seedbed with the remainder applied as a 2nd application 45 days later just before stem extension (N timing treatment 1). There was no significant effect of the timing of the application of the nitrogen on the later crops, which is probably due to the greater amount of available nitrogen at the time of drilling from mineralized soil residues, as indicated by the higher SMN at drilling.

Cob sweetness

There were no significant effects of any treatments on cob sweetness. All cobs measured had Brix values greater than 14ºBx. (Minimum sweetness required for the market is 10ºBx.)

Financial Benefits

The UK sweetcorn market is worth ca. £25.7M at retail level based on the annual volume of 18,000 tonnes/ha crop grown in 2013. This study suggests that for some late crops drilled without polythene covers in May and intended for harvest in September to October, it may be possible to apply less N fertiliser, when mineralisation from previous crop residues in a high SNS situation is expected. A soil mineral nitrogen (SMN) sample taken just prior to drilling could show that as much as 100 kg N/ha will already be available, allowing fertiliser inputs to be reduced according to the yield potential. If 85 kg N/ha as ammonium nitrate (current price of £250/t) could be saved, then the grower would benefit by £65/ha (ca. £60/ha taking into account the cost of SMN testing). If ca. 35% of crops in the UK are established as late crops, this is equivalent to around 780 ha of sweetcorn, and a potential saving overall of £45,000/annum from lower N inputs.

Action Points

- This single year of study indicate that RB209 recommendations are appropriate for sweetcorn production, both maximising cob yield and minimising the environmental impacts from excess fertiliser use.
- Providing most of the nitrogen early in growth appears to be the best strategy for early sown crops, but timing is less critical for late sown crops for yield optimization.
- Growers should take into account SMN to 90 cm depth prior to drilling, particularly for late sown crops, before deciding on the SNS index of a particular site,

- For late sown crops, consideration should be given to retesting for SMN prior to drilling, even if a soil sample was previously taken in winter/early spring.
- The results suggest that growers should not have any concerns about under- or over-fertilising ‘supersweet’ sweetcorn with respect to the effects of N on cob sweetness.
- While sweetcorn is known to be sensitive to P deficiency, there is little evidence that current best practice guidelines should be changed at present.