Fertiliser P effects on biomass partitioning and quality of sweet corn in a cool temperate environment.

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Abstract

The objective of this study was to examine the effects of fertiliser P on sweet corn biomass, biomass partitioning and ear quality (ear dimensions) in a cool temperate climate. 'Challenger' sweet corn was sown at 71,000 plants/ha in 2001/02 and 2002/03 at a low P site (Olsen P= 6 µg/ml) at Lincoln, Canterbury, New Zealand. In 2001/02 crops received 0, 50, 100, 150, or 200 kg P/ha. In 2002/03 these same plots were used but an additional 0, 10, 20, and 40 kg P/ha were added respectively. Thus total P fertiliser rates over two years were 0, 50,110,170, and 240 kg P/ha.

Crop biomass ranged from 9.7 t ha^{-1} with no P fertiliser in 2001/02 to 16.7 t ha^{-1} with 170 kg P/ha in 2002/03. Despite this range biomass partitioning was conservative across treatments being 46% vegetative, 33% ears and 21% kernels. P fertiliser affected the quality of ears, with the unfilled tip length decreasing by 2.2 mm for every 1 t ha^{-1} increase in total crop DM. Thus saleable yield and quality of sweet corn was maximised by fertiliser treatments that maximised total crop yield.

Media summary

Sweet corn kernel yield was a constant 21% of the total crop biomass for crops that yielded 9.7 to 16.7 t ha^{-1} of crop biomass.

Key Words

Ear diameter, ear length, phosphorus response, *Zea mays* L., sweet corn

Introduction

Sanchez *et. al.* (1989) demonstrated a 60% increase in marketable yield of sweet corn when 60 kg P/ha was applied. Traditionally such nutrient responses have been examined using simple asymptotic relationships that are extremely site specific. The degree of response depends on pre-existing soil nutrient levels and crop yield potential (Reid, 2002; Reid *et al.,* 2002) as set by environmental factors such as temperature, moisture, and solar radiation.

A greater understanding of yield responses can be gained by examining the response of individual crop components that are of interest to producers. Such analyses indicate the extent of yield response and the mechanisms by which they occur. For example, kernel yield in sweet corn may increase due to increased total biomass with conservative partitioning as shown for N in grain maize (Papanov *et. al*,2001). Alternatively increased partitioning to kernels with conservative biomass may occur, or a combination of the two responses.

Kernel yield is the component of the sweet corn crop in which processors are most interested. However, when sweet corn is sold as a fresh market product the yield of kernels and ears, and the quality of ears is of paramount importance and value. In particular the ear length, diameter and tip fill are valued quality traits for most end uses and particularly for the fresh market (Rogers *et. al.,* 2000). This paper reports the results of two experiments that measured the response of biomass yield, partitioning and quality (ear dimensions) to fertiliser P in 'Challenger' sweet corn grown in a cool temperate environment.

Methods

Experimental details

Two experiments were conducted in successive seasons at Lincoln (43? 62' S and 172? 44' E), Canterbury, New Zealand on a low P site (Olsen P = 6 µg/ml). Experiment 1 (2001/02) consisted of five rates of fertiliser P (0, 50, 100, 150, and 200 kg P/ha) applied in split applications on 6 and 14 October as triple super phosphate N, P, K, S: 0, 21, 0, 0) arranged in a randomised complete block design with three replicates. Basal applications of sulphur (35 kg S/ha) and nitrogen (300 kg N/ha) were applied during the growing season. 'Challenger' sweet corn was hand sown into these plots on 25 October 2001 to give a final population of 71,000 plants/ha.

In Experiment 2 (2002/03) these same plots were used but an additional 0, 10, 20, and 40 kg P/ha were added respectively. Thus total P fertiliser rates over two years were 0, 50,110,170, and 240 kg P/ha. This experiment was also hand sown at 71, 000 plants/ha, on 7 November 2002.

Measurements

Crops were harvested at canning maturity (72% kernel moisture content) and dissected into component parts (vegetative parts, ears without kernels, and kernels) before being dried in a forced air oven. Before drying the length, diameter and unfilled tip length of the primary (uppermost) ears were also measured. All biomass values are presented on a dry matter basis.

Results and Discussion

Biomass responses

Fertiliser P increased ($p<0.05$) total crop biomass (Table 1) with a range from 9.7 to 16.7 t ha^{-1} across the two seasons. These results were expected because the soil P level (6 µg/ml), was markedly less than the 30-35 µg/ml recommended for sweet corn (Clarke *et. al.* 1986).

Table 1 Total crop biomass responses of 'Challenger' sweet corn grown at Lincoln, Canterbury, New Zealand in 2001/02 and 2002/03 to five rates of fertiliser P. LSD is least significant difference (p<0.05).

Fertiliser P 2001/02	*Crop biomass (t ha^{-1})*	*Fertiliser P 2002/03*	*Crop biomass (t ha^{-1})*
0	9.7 a	0	11.8 a
50	12.8 ab	50	15.0 b
100	14.3 b	110	15.6 b
150	14.5 b	170	16.7 b
200	15.9 b	240	15.2 b
significance	$p<0.05$	significance	$p<0.05$

LSD	3.4	LSD	2.5

Values followed by the same letter are not significantly different ($p<0.05$)

Partitioning

Crop biomass was conservatively partitioned amongst individual crop components across the full range of total crop biomass [21% kernel (Figure 1 a), 33% ear (excluding kernels) (Figure 1 b) and 46% vegetative parts (Figure 1 c)]. There were no substantial deviations from these relationships at any rate of P fertiliser. These results agree with Papanov *et. al.* (2001), which showed that increases in maize grain yield with N fertiliser were due to increases in total biomass and not changes in partitioning to grains. In both cases the implication is that factors that affect the total biomass production will directly affect the harvestable yield. For sweet corn producers the penalty of lost total crop yield is directly reflected in kernel yield with no compensatory increase in kernel growth. In this experiment fertiliser P was the cause of yield limitations but the conservative response suggests any management or environmental factors that limit total crop yield causes a proportionate reduction in kernel yield.

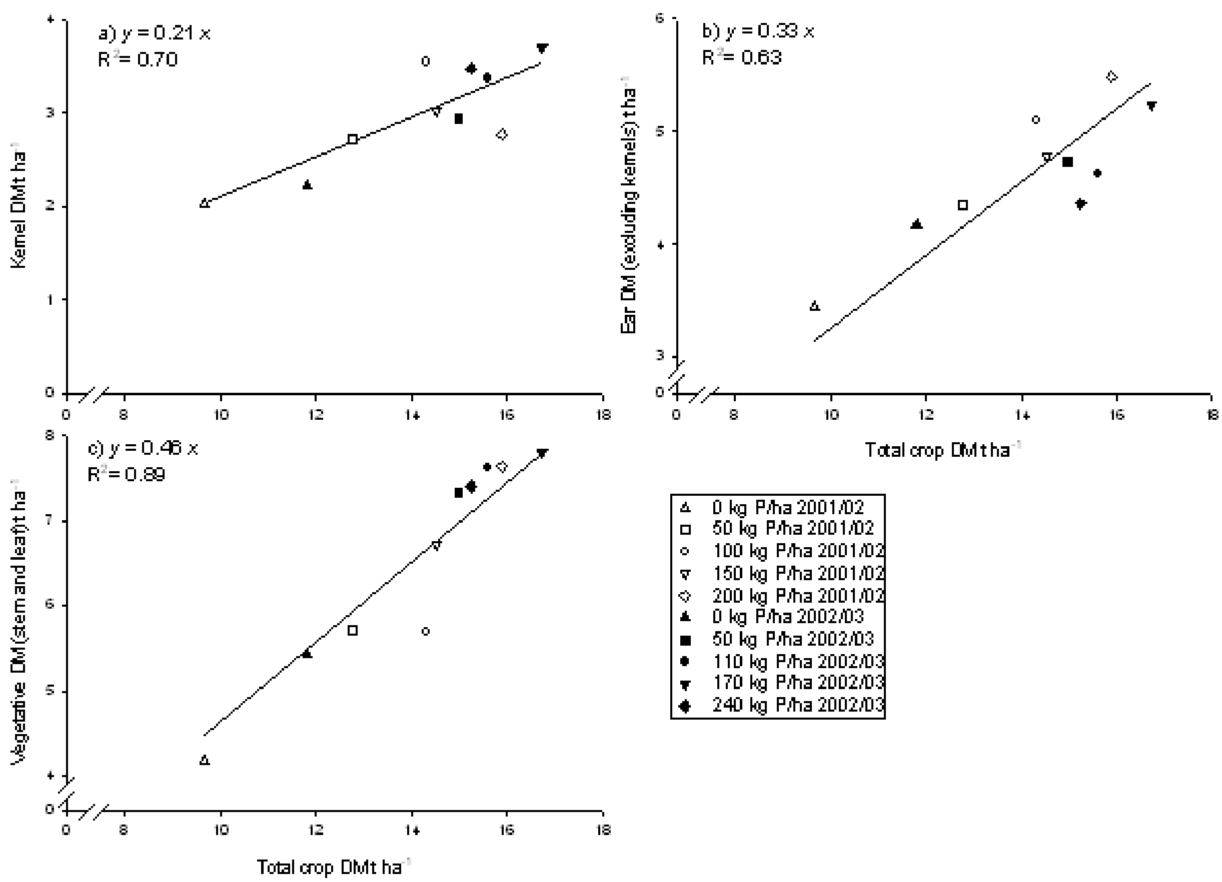

Figure 1. Linear relationships between 'Challenger' sweet corn crop biomass and kernel biomass (a), ear biomass (b), and vegetative biomass (c), grown at Lincoln, Canterbury New Zealand in 2001/02 and 2002/03. Data are from two successive P fertiliser experiments, with fertiliser rates and symbols outlined in the legend. These regressions are forced through the origin.

Ear dimensions

In fresh market sweet corn the value of the crop depends both on the saleable yield and the quality of the individual ears as indicated by their dimensions and degree of tip fill. The length of the unfilled tip on primary ears decreased by 2.2 (?0.65) mm for every 1 t ha^{-1} increase in total crop DM (Figure 2), probably because the crops receiving P fertiliser were able to supply more carbohydrate to the developing ears. These results show that the maximum crop quality (i.e. minimum unfilled tip length) occurred when crop DM was maximised. In the current study the difference in total crop yield, and hence unfilled tip length (Figure 2), was obtained using P fertiliser treatments. The linear response (R2=0.54) between total crop yield and unfilled tip length was obtained using P fertiliser treatments. The results, however, are in complete accord with previous results from New Zealand which indicate that environmental and management factors such as moisture (Stone *et. al.,* 2001), N fertiliser (Stone *et. al.,* 1998), and sowing date (Rogers *et. al.,* 2000) that limit total sweet corn crop biomass also limit the degree of tip filling on developing ears. It seems likely, therefore, that the key to maximising ear quality (via tip fill) is to grow sweet corn crops with high biomass and yield by ensuring that the supply of water, nutrients, and radiation is adequate.

In contrast the mean ear length (201 mm) was unaffected by P fertiliser and total crop biomass (data not shown). However, applying P fertiliser did increase the mean ear diameter by 0.6 mm for every 1 t ha^{-1} increase in total crop DM (data not shown). These increases were of such a narrow range (47-56 mm) that they would not have notably affected consumer quality. The lack of major effect of crop biomass on either ear length or diameter suggests that these traits are under strong genetic control and not altered in the 'normal' range of assimilate supply.

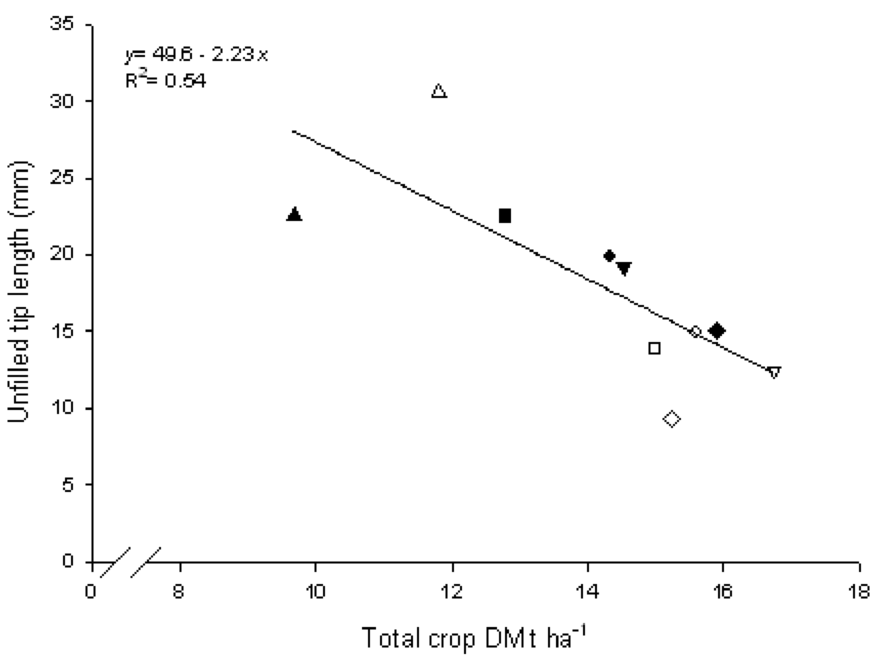

Figure 2. Linear relationship between 'Challenger' sweet corn crop biomass and unfilled tip length of primary (uppermost) ears, grown at Lincoln, Canterbury New Zealand in 2001/02 and 2002/03. Symbols are the same as Figure 1.

Conclusion

Total crop biomass was increased by the application of P fertiliser in both seasons. Biomass was partitioned conservatively into vegetative biomass (46%), ears (excluding kernels 33%), and kernels (21%). Increases in sweet corn yield due to P fertiliser were caused by changes in total crop biomass and not biomass partitioning. Furthermore the unfilled ear tip length was linearly related to the total crop biomass, with higher yielding crops having less unfilled tip length. It appears that the key to maximum sweet corn yield, quality and hence value is simply the growth of crops with high biomass.

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