SHORT COMMUNICATION

THE IMPACT OF NITROGEN AND SILICON NUTRITION ON THE RESISTANCE OF SUGARCANE VARIETIES TO *ELDANA SACCHARINA* (LEPIDOPTERA: PYRALIDAE)

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Abstract

Crop and sucrose loss from damage by *Eldana saccharina* Walker (Lepidoptera: Pyralidae) still ranks as being the most important factor limiting productivity in the South African sugar industry. There is ample evidence from the literature that nutrients such as nitrogen and silicon play important roles in the susceptibility and resistance of a range of crops to stalk borer damage. In our own industry, studies conducted in 1989 showed that high N usage under conditions of moisture stress greatly increased survival of larvae and infestation of sugarcane by *E. saccharina*. Recent studies have emphasized the important role of applied silicon in improving the resistance of sugarcane to *E. saccharina* infestation even in the more resistant varieties such as N21 and N33. Because the effects of nitrogen and silicon on *E. saccharina* behavior have previously been studied independently, a preliminary glasshouse trial was conducted to study the combined influence of these nutrients on *E. saccharina* infestation in five cane varieties (NCo376, N31, N35, N36 and N37) to determine whether applied silicon can offset the negative effects of applied N on *E. saccharina* build-up.

The results showed that the equivalent of 200 kg/ha applied silicon reduced the percent stalk length damaged by an average of 47% across all five varieties that were included in the trial. Maximum reductions in percent damaged stalk length using silicon treatment ranged from a 70% average at the lowest N level (60 kg/ha N), to 39% at the intermediate N level (120 kg/ha N) and 35% at the highest N treatment (180 kg/ha N). The use of silicon will enable many growers who have severely cut back on their nitrogen applications to reduce the risk of *E. saccharina* damage, and to resume applying the normal recommended rates of nitrogen, thereby ensuring that nitrogen will not limit crop yield.

Keywords: sugarcane, nitrogen, silicon, calcium silicate, soil nutrients, variety, host-plant resistance, *E. saccharina*, stalk borer, insect pest

Introduction

There is increasing evidence in the literature that the development of phytophagous insects often depends on the physiological condition of the plant and particularly its nutrient and stress status (White 1984). The use of nitrogen fertilisers to enhance plant nutrition frequently influences the longevity, fecundity and damage caused by insects and mites (Scriber 1984). Atkinson and Nuss (1989) have shown that with sugarcane, excessive N usage under conditions of moisture stress greatly increased survival and growth of *Eldana saccharina* Walker (Lepidoptera: Pyralidae) larvae. Savant *et al*. (1999) drew attention to the observation that increased incidence of stalk borers (*E. saccharina* and *Chilo auricilius*) in sugarcane with high N application alone, could probably have been prevented by application of silica together with N fertilisers. Recent studies by SASRI researchers have emphasized the important role of applied silicon in improving the resistance of sugarcane to *E. saccharina* infestation, but the trials were conducted at a single level of nitrogen fertilisation (Keeping and Meyer 2002, 2003; Meyer and Keeping 2005). Because many cane growers have cut back on their nitrogen applications in order to reduce the risk of *E. saccharina* damage, it was considered important to know more about the interaction between nitrogen and silicon nutrition and their impact on *E. saccharina* infestation and yield of sugarcane.

Methodology

Five currently used South African sugarcane varieties that are susceptible or of intermediate susceptibility to *E. saccharina* (NCo376, N31 N35, N36 and N37) were initially established in an outdoor hydroponic sand culture trial, using three concentrations of N nutrient solution applied as ammonium sulphate [N_1=low (30 mg/kg N); N_2=moderate (60 mg/kg); N_3=high (90 mg/kg)] and two concentrations of silicon (Si0=zero, Si1=600 mg/kg) applied before planting in the form of a local calcium silicate (Calmasil) incorporated thoroughly into the sand. Plants were established from disease-free single bud setts planted directly into 25 L drained black plastic pots filled with washed and sieved Umgeni river sand. Nutrients and tap water were supplied from a continuous bath of nutrient solution in 50 L galvanised steel trays, into which the pots were placed. The height of this nutrient solution 'water table' was kept at between 5 and 10 cm and each tray contained five pots, each with a different variety. Solutions were replaced weekly with fresh tap water and basal nutrients supplied using Hygrotech® Seedling Mix.

The pots were arranged in a randomised split-plot design with N and Si as whole plot treatments and variety as a split plot treatment. The treatments were replicated four times. Leaf and stalk samples were taken twice over the course of the trial to track plant Si uptake in controls and treatments for all varieties. After nine months, the supply of nutrients was halted and watering was reduced to induce stress. Since stalk number varied extensively between pots, all stalks/tillers in excess of five were removed at the base. In August 2003, the trial was transferred to a shade house (in the same design) for inoculation with *E. saccharina* eggs. Pots with three or less stalks were inoculated with 100 eggs while those with more than three stalks were inoculated with two batches of about 100 eggs each (i.e. 200 eggs). Pots were irrigated at 2 mins/day, which maintained the stressed condition. The infestation was allowed to progress to 500 day-degrees (=52 days after inoculation), whereupon the entire trial was harvested to determine borer performance (number and mass of *E. saccharina* larvae and pupae) and stalk damage (length of stalk bored and number of internodes bored). Data were subjected to analysis of variance (ANOVA), with N and Si treatment as main effects.

Results

Overall, applied N significantly increased the relative percentage yield response in sucrose (Table 1). In the absence of Si, the response tended to be curvilinear while in the presence of Si the response tended to be linear up to the highest N level. On average, the applied Si treatment increased relative yield response by 16% across all three N treatments and varieties. Highly significant differences ($p<0.0005$; ANOVA) in susceptibility to *E. saccharina* were obtained in response to the nitrogen and silicon treatments. Nitrogen treatment in the absence of Si increased overall susceptibility (calculated as a weighted mean of borer performance and damage and expressed as a percent of the trial mean, *sensu* Keeping and Meyer 2002), from an average of 68% at the low level of N to 208% at the high level of N across all varieties. NCo376 and N35 showed the greatest change in susceptibility with increasing N levels, ranging from resistant (<50% of trial mean) at the low level of N to highly susceptible (>175% of trial mean) at the high level of N (see Figure 1). Variety N31 was the least affected by N, but was already high (144% of trial mean) at the low level of N. Of interest was that the least susceptible variety in this trial, N37, while relatively unaffected at the low and intermediate levels of N (37% and 34% of trial mean, respectively), became susceptible at the high level of N (166%).

Table 1. Impact of nitrogen and silicon treatment on relative sucrose yield and *E. saccharina* damage (average across five varieties).

N level	Si level*	Relative sucrose yield (%)	% stalks damaged	% internodes damaged	Weighted % of trial mean**
N1	Si0	44	79	14	68
N2	Si0	68	74	11	90
N3	Si0	79	87	17	208
N1	Si1	49	42	5	19
N2	Si1	74	55	7	61
N3	Si1	100	76	11	155
LSD (p=0.05)		19	14	3	25

*Si0=no Si; Si1=with Si; **See text for explanation.

Overall, treatment with Si had a significant impact in reducing the promotional effects of N treatment on *E. saccharina* survival and damage. Percentage stalks damaged was reduced by an average of 47% across all five susceptible varieties that were included in the trial. Maximum reductions in percent stalks damaged from silicon treatment, ranged from a 70% average at the lowest N level, to 39% at the intermediate N level down to 35% at the highest N treatment. The beneficial effect of Si in reducing borer damage at the high N level was also evident in the reduced stalk length bored, lower number of internodes damaged, lower borer numbers and borer mass. Hence, 'susceptibility' (as a percentage of the trial mean; see above) declined from an average of 208% in the absence of Si to 155% where Si had been applied. The greatest reduction from Si treatment, from 226% to 152%, was recorded for N35. Si treatment also produced benefits at the low level of N with susceptibility declining on average from 68% to 19%. The susceptible variety N31 showed the greatest benefit to Si treatment at the lowest level of N, declining from 144% to 26%.

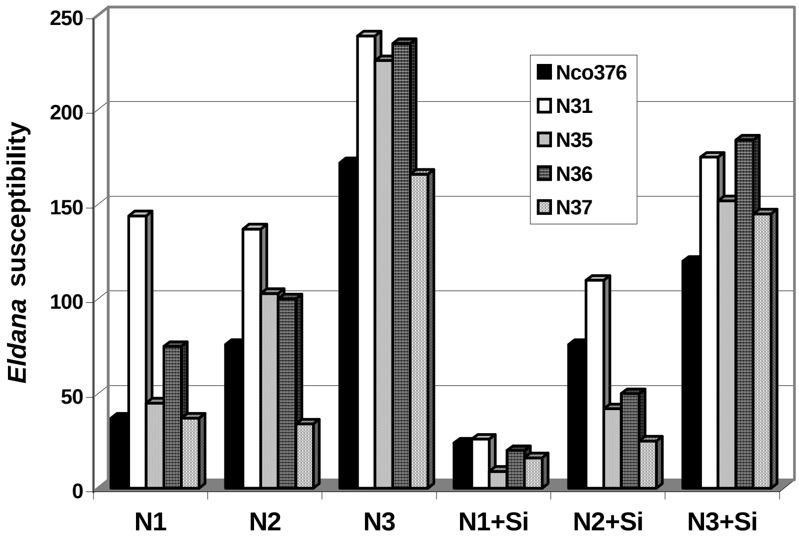

Figure 1. Effect of nitrogen treatment in the absence and presence of silicon on susceptibility to *E. saccharina* in five sugarcane varieties, where N1=60 kg N/ha, N2=120 kg N/ha and N3=180 kg N/ha. *E. saccharina* susceptibility is calculated as a weighted % of the trial mean of borer performance and damage (see text).

It was evident from leaf and stalk tissue analysis that increased nitrogen application increased nitrogen and reduced silicon uptake, and this condition in turn favoured increased borer survival and damage. Overall, the relatively poor performance of varieties N31 and N35 compared with N37 may be ascribed to the greater susceptibility of these two varieties to *E. saccharina*, resulting in a severe loss in cane yield as well as sucrose content. However, the addition of Si at the high rate of N tended to mitigate against borer damage, resulting in an improvement in sucrose yield (non-significant).

A further important outcome from the trial was the finding that the leaf and stalk N/Si ratio was better correlated with resistance to stalk borer than either N% or Si% expressed separately. Leaf N/Si ratios above 2:1 were associated with cane showing increasing risk from *E. saccharina* damage. High resistance to *E. saccharina* (per cent of trial mean below 50%) was associated with N/Si leaf ratios below 2 whereas moderate resistance (50% to 100% of trial mean) was associated with N/Si ratios varying from 2 to 4. Average to low resistance (>100% of trial mean) tended to be associated with leaf N/Si ratios in excess of 4.

Conclusions

- The results of this investigation confirm that the effect of nitrogen and silicon treatment on varietal resistance to *E. saccharina* are significant but that the effects are opposite, with nitrogen increasing susceptibility to the borer and applied Si reducing susceptibility to the borer. In general, nitrogen has a greater impact on *E. saccharina* susceptibility than silicon.
- The results support the suggestion by Savant *et al* (1999) that the increased incidence of *E. saccharina* stalk borer in sugarcane with high N application alone (Coulibaly 1990, cited in Savant *et al* 1999), could probably have been prevented by application of silicon together with N fertilisers.
- Although further work is needed, the results imply that where growers have severely cut back on their N application in order to reduce the risk from *E. saccharina* damage, the application of silicon will enable the normal FAS recommended levels of N to be resumed, without increasing the risk from borer damage.
- The present studies indicate that the N/Si ratio is better correlated with potential *E. saccharina* damage than Si alone and that sugarcane with values in excess of 2:1 are associated with increasing risk from borer damage. The silicon status of the stalk is also closely related to borer damage and silicon levels below 0.2% are associated with increasing risk of borer damage.
- There is good reason to believe that in future, the SASRI Fertiliser Advisory Service will be able to provide growers with an *E. saccharina* susceptibility risk assessment based on the leaf N/Si ratio, once further validations have been carried out.

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