

## SHORT COMMUNICATION

**EFFECTS OF SILICON AND PLANT DEFENCE INDUCERS ON SUGARCANE YIELD PARAMETERS, *ELDANA SACCHARINA* WALKER (LEPIDOPTERA: PYRALIDAE) AND *FULMEKIOLA SERRATA* KOBUS (THYSANOPTERA: THIRIPIDAE)**

KEEPING M G<sup>1,2</sup>, MCFARLANE S A<sup>1</sup>, SEWPERSAD N<sup>1</sup> AND RUTHERFORD R S<sup>1</sup>

<sup>1</sup>South African Sugarcane Research Institute, P/Bag X02,  
Mt. Edgecombe 4300, South Africa

<sup>2</sup>School of Biological and Conservation Sciences, University of KwaZulu-Natal, P/Bag X01,  
Scottsville, 3209, South Africa

[malcolm.keeping@sugar.org.za](mailto:malcolm.keeping@sugar.org.za) [sharon.mcfarlane@sugar.org.za](mailto:sharon.mcfarlane@sugar.org.za)  
[nikki.sewpersad@sugar.org.za](mailto:nikki.sewpersad@sugar.org.za) [stuart.rutherford@sugar.org.za](mailto:stuart.rutherford@sugar.org.za)

### Abstract

Substantial evidence now exists for the beneficial effects of silicon (Si) fertilisation on sugarcane yield and in suppressing stalk borer infestation. Pot trials were used to examine the interactive effects of soil supplied Si and foliar sprays of the plant defence inducers, *cis*-jasmone (JA) and Bion® (a synthetic analogue of salicylic acid) on plant resistance to the borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae) and thrips, *Fulmekiola serrata* Kobus (Thysanoptera: Thripidae), as well as on yield and cane quality components. Silicon reduced borer survival and damage, but had no effect on thrips numbers. Jasmonic acid and Bion had no consistent effects on *E. saccharina* or thrips, either alone or in combination. Silicon treatment increased cane biomass, which translated into higher sucrose g/stalk. Factors contributing to increased biomass were greater internode length (and therefore stalk height), stalk width and tillering. In the plant and ratoon crop of trial ESI 2 the combined JA+Bion/Si- treatment produced lower cane and sucrose g/stalk than the JA+Bion/Si+ treatment. Notwithstanding the greater biomass of Si+ cane, infection of the plant crop of trial FSI 1 with sour rot resulted in significantly lower ERC% cane in Si+ cane compared with Si- cane, and consequently no gain in terms of sucrose g/stalk. There was evidence that Bion decreased yield. The interaction between Si+ and JA+Bion suggests that soluble, rather than amorphous Si, played a physiological role in increasing yield.

*Keywords:* induced resistance, silicon, sucrose yield, biomass, stalk borer, thrips

### Introduction

Studies using potted sugarcane fertilised with calcium silicate have demonstrated unequivocally the ability of root-applied silicon (Si) to significantly enhance plant resistance to stalk borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae), especially in borer-susceptible cultivars subjected to water stress (Keeping and Meyer, 2002; Kvedaras *et al.*, 2007a,b). From an applied viewpoint, this is important as water stress increases susceptibility of sugarcane to borer (Atkinson and Nuss, 1989), and therefore Si can provide improved

protection under conditions where susceptible varieties are most at risk (Kvedaras *et al.*, 2007a).

It has been argued that Si-mediated resistance to insect herbivores probably incorporates passive mechanical (constitutive) defence alongside an active, inducible biochemical response; in the latter, soluble Si may serve to prime plants for a more extensive and efficient systemic response to an attacking herbivore, in a manner reminiscent of well-know plant defence inducers such as jasmonic acid and salicylic acid (Keeping and Meyer, 2002; Reynolds *et al.*, 2009). The present study represents a first attempt to explore the possibility of Si-mediated induced defence against two major pests in South African sugarcane, with the hope that such responses may ultimately be harnessed for use in pest management. Also investigated were the effects that Si in combination with defence inducers may have on yield, whether positive or negative. Induced defence is commonly thought to involve some physiological cost to the plant (Walters and Heil, 2007).

The present study tested the hypotheses that: (a) Si, *cis*-jasmonone (JA) and Bion, the commercial formulation of benzothiadiazole (a synthetic analogue of salicylic acid) have direct and/or interactive effects on resistance to *E. saccharina* and *Fulmekiola serrata* (Kobus) (Thysanoptera: Thripidae); (b) Si, JA and Bion have direct and/or interactive effects on various yield components.

### Materials and Methods

Three trials (ESI 1, ESI 2, FSI 1) were established using seedlings of cultivar N38 planted into potted river sand in a shade house in a split-split plot design, with Si as whole plot and JA and Bion as sub-plots (nine replicates). Silicon was supplied as calcium silicate incorporated into the sand at 10 tons/ha (treatments) before planting; controls received no calcium silicate. Bion and JA were applied monthly by spraying green leaves with aqueous mixtures of the inducers until run-off in both single and combined treatments; controls were sprayed with an equal amount of de-ionised water. Final sprays were conducted 48 h before inoculation with *E. saccharina* or sampling for thrips. Concentrations of inducers were either 200  $\mu$ M for JA and 1.0 mM for Bion (ESI 1; FSI 1 plant crop), or 2000  $\mu$ M JA and 10 mM Bion (ESI 2 plant and ratoon crops, FSI 1 ratoon crop).

Trial ESI 1 was inoculated with 200 *E. saccharina* eggs per pot at 10 months, while the plant crop of ESI 2 was inoculated with one third instar larva per stalk (on three stalks per pot; see Kvedaras *et al.*, 2007b), also at 10 months. The ESI 2 ratoon crop was inoculated with 150 eggs per pot at 11.5 months. Inoculations followed a month of scheduled water stressing (Keeping and Meyer, 2002) in all trials, except the ratoon of FSI 1. FSI 1 was inoculated with *Fusarium* sp. (not considered in this paper), with the ratoon crop also sampled for thrips following inducer sprays. Duplicate, but uninoculated, pots with identical treatments were included in ESI 2 to provide information on yield. Egg-inoculated trials were harvested after 500 day-degrees of larval development; the ESI 2 plant crop (larva-inoculated) was harvested after 216 day-degrees of development. Data recorded included *E. saccharina* numbers and damage, various yield and stalk parameters, plus cane quality. Thrips numbers were determined from samples of one spindle per pot at about three months cane age during the population peak (December/January). Soil, leaf and stalk samples were taken at various times to determine Si and other nutrient status. Data were subjected to analysis of variance (all

reported P values derive from this), followed by Holm-Sidak multiple comparisons tests where appropriate.

## Results and Discussion

In all trials, Si treatment (Si+) increased stalk Si% ( $p < 0.001$ ), while in ESI 1 it reduced number of larvae recovered at harvest, number of internodes bored and stalk length bored ( $p < 0.001$ ). In ESI 2 plant crop, Si+ had no effect on individual third instar larval survival, mass gain, stalk penetration, number of internodes bored or stalk length bored. This is in direct contrast with the results of Kvedaras *et al.* (2007b) and Kvedaras and Keeping (2007), and is probably due to mid-instar larvae being protected in vials and allowed ample time for penetration and feeding, resulting in compensation over time for any initial differences that may have existed. However, in ESI 2 ratoon crop, which was egg-inoculated, Si+ reduced larval recovery ( $p = 0.016$ ) and number of internodes bored ( $p = 0.01$ ). In general, therefore, the previously reported effect of Si fertilisation in suppressing *E. saccharina* infestation through its adverse action on early instar stalk penetration and survival (Kvedaras and Keeping, 2007), is consistent with results presented here. By contrast, Si+ alone had no effect on *F. serrata* numbers in ESI 1 (two ratoon crops) or FSI 2 (one ratoon crop); possibly the very high within-treatment variability (C.V.% up to 172%) in thrips numbers masked any differences. Hence, there is no evidence to date that Si may assist in controlling sugarcane thrips populations. However, Subramanian and Gopaldaswamy (1988) reported that several silicon sources reduced field numbers of *Stenchaetothrips biformis* (Bagnall) (Thysanoptera: Thripidae) in rice.

Application of the defence inducers, JA and Bion, produced no direct (i.e. JA or Bion only treatments) or combined (i.e. JA+Bion treatments) effects on *E. saccharina* recovery, growth, stalk penetration or damage, and no effect on thrips abundance in spindle samples in any of the trials. There is, therefore, no evidence from this study that these well-known defence inducers have potential in managing either of the sugar industry's major pests.

In ESI 2 (plant crop), Si+ increased cane g/stalk ( $p = 0.002$ ) and therefore sucrose g/stalk ( $p = 0.004$ ), but had no effect on ERC%; however, Bion treatments had lower ERC% than all other treatments ( $p = 0.005$ ), indicating that this inducer could have a cost in terms of reduced sucrose production. In ESI 2 (ratoon), Si+ did not affect stalk biomass or ERC%, although there was an overall increase in sucrose g/stalk ( $p < 0.05$ ). In the plant and ratoon crop of ESI 2 the combined Si+/JA+Bion treatment produced higher stalk biomass ( $p < 0.05$ ) and higher sucrose g/stalk ( $p < 0.05$ ) than the Si-/JA+Bion treatment, indicating that Si had a significant positive effect on these yield components in the presence of JA+Bion. As amorphous Si is unlikely to be involved in such an interaction, this suggests that soluble Si played a physiological role in the observed yield increase.

In ESI 1 and ESI 2 (plant), factors contributing to increased biomass of Si+ cane were greater internodes per stalk ( $p < 0.05$ ) and greater stalk length ( $p < 0.015$ ); in ESI 2 (ratoon) Si+ had no effect on internodes per stalk. In FSI 1 (ratoon), Si+ increased cane g/stalk ( $p = 0.004$ ), purity ( $p = 0.029$ ) and therefore sucrose g/stalk ( $p = 0.003$ ), but not ERC%. In FSI 1, factors contributing to increased cane biomass included greater internode length ( $p = 0.002$ ; ratoon), stalk width ( $p < 0.001$ ; plant and ratoon) and tillering ( $p = 0.009$ ; plant). Since number of internodes in FSI 1 (plant) was less in Si+ cane ( $p = 0.006$ ), increased internode length accounted for the increased overall stalk length ( $p = 0.003$ ). The Bion inducer treatment in

FSI 1 (ratoon) reduced both stalk width ( $p=0.008$ ) and internode length ( $p<0.001$ ) below that of the JA treatment and control, again suggesting a yield cost for this treatment.

Notwithstanding the greater biomass of Si+ cane, infection of much of the plant crop of trial FSI 1 with sour rot (*Phaeocystroma sacchari* (J.B. Ellis & Everhart) B. Sutton) resulted in significantly lower ( $p=0.005$ ) ERC% cane in Si+ cane compared with Si- cane and consequently no gain in sucrose g/stalk. Water stress is known to promote *P. sacchari* infection and development (Liu *et al.*, 1977; Goodall *et al.*, 1999); hence the scheduled water stressing of this crop may explain the pathogen's presence. The tendency for Si+ treatments to be infected may be related to their increased biomass: in the field, higher yielding crops are often more prone to sour rot infection when they become stressed.

### Conclusions

Our results support the well-documented observation that Si increases resistance to sugarcane stalk borers (Reynolds *et al.*, 2009), but provide no evidence that Si offers protection against sugarcane thrips. We also found no evidence that the inducers alone or in combination with Si suppressed stalk borer or thrips infestation. Our results show clearly that the effect of Si+ on yield is expressed predominantly as increased internode length (and therefore stalk length) and stalk diameter, leading to greater individual stalk mass and sucrose g/stalk. The significant interaction between JA+Bion and Si+ in promoting yield suggests that soluble Si played a physiological role in increasing yield, in addition to any role played by amorphous Si. Bion application, on the other hand, appears to impose a physiological cost to the plant in reduced yield.

### Acknowledgements

The authors are grateful to the following individuals for assistance in the experimental work: Andrew Govender, Kas Chinnasamy, members of the SASRI technical teams, Sumita Ramgareeb, Pavithra Govender, Khanyisile Buthelezi, Innocent Mkhize, Parushka Maharaj and Slindile Sithole. The SASRI Insect Unit supplied the *E. saccharina* eggs and larvae. Funding was provided by the South African Sugar Association.

### REFERENCES

- Atkinson, PR and Nuss, KJ (1989). Associations between host-plant nitrogen and infestations of the sugarcane borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *Bull Ent Res* 79: 489-506.
- Goodall, JL, McFarlane, SA and Roux, C (1999). An unusual stalk rot caused by *Phaeocystroma sacchari* in the KwaZulu-Natal Midlands. *Proc S Afr Sug Technol Ass* 73: 114-117.
- Keeping, MG and Meyer, JH (2002). Calcium silicate enhances resistance of sugarcane to the African stalk borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *Agr Forest Entomol* 4: 265-274.
- Kvedaras, OL and Keeping, MG (2007). Silicon impedes stalk penetration by the borer *Eldana saccharina* in sugarcane. *Entomol exp appl* 125: 103-110.
- Kvedaras, OL, Keeping, MG, Goebel, FR and Byrne, MJ (2007a). Water stress augments silicon-mediated resistance of susceptible sugarcane cultivars to the stalk borer *Eldana saccharina* (Lepidoptera: Pyralidae). *Bull Ent Res* 97: 175-183.

- Kvedaras, OL, Keeping, MG, Goebel, FR and Byrne, MJ (2007b). Larval performance of the pyralid borer *Eldana saccharina* Walker and stalk damage in sugarcane: influence of plant silicon, cultivar and feeding site. *Int J Pest Manag* 53: 183-194.
- Liu, HP, Wang, SL and Wismer, CA (1977). Study on rind disease of sugarcane in Pernambuco, Brazil. *Proc Int Soc Sug Cane Technol* 16: 365-381.
- Reynolds, OL, Keeping, MG and Meyer, JH (2009). Silicon-augmented resistance of plants to herbivorous insects: a review. *Ann Appl Biol* 155: 171-186.
- Subramanian, S and Gopalaswamy, A (1988). Effect of silicate materials in rice crop pests. *Int Rice Res Newsletter* 13: 32.
- Walters, D and Heil, M (2007). Costs and trade-offs associated with induced resistance. *Physiol Mol Plant P* 71: 3-17.