SHORT, NON-REFEREED PAPER

EFFECT OF FIBRE CONTENT AND SELF-TRASHING TRAITS ON *ELDANA SACCHARINA* WALKER STALK BORER DAMAGE IN SUGARCANE AND IMPLICATIONS FOR RESISTANCE BREEDING

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Abstract

Eldana saccharina (eldana) is the most destructive sugarcane stalk borer in South Africa causing losses estimated at R1 billion per annum. Breeding for resistance complements integrated eldana control strategies. Self-trashing is expected to reduce oviposition sites thus exposing eggs and larvae to predators while high fibre content (>14%) is expected to restrict larval feeding. The study aims to determine the effect of self-trashing and fibre on eldana damage and evaluate implications for resistance breeding. Data on number of bored stalks per genotype were collected from a Stage II trial (TSL16) planted at the SASRI Empangeni Research Station. Significant (F=1.86, P<0.0001) family effects were observed for eldana damage indicating genetic differences among families. Highly significant (F=4.05, P<0.0001) family effects were observed for fibre, while those of self-trashing were marginally significant (F=1.19, P=0.1046) indicating that selection for high fibre and high self-trashing families was possible. Simple linear regression showed a highly significant (P<0.0001) negative association representing 0.41% and 0.34% decrease in the number of bored stalks with every unit increase in self-trashing and fibre, respectively. Multiple linear regression showed highly significant (P<0.0001) 0.31% (self-trashing) and 0.33% (fibre) decreases in numbers of bored stalks, indicating a higher decrease in eldana damage when both high fibre and high self-trashing were present. Results suggest possible genetic independence between fibre and self-trashing, indicating that both traits can be selected simultaneously during breeding. Additive effects between fibre and self-trashing will accelerate breeding and selection for eldana resistance. Further studies will determine the genetic interactions with commercial traits.

Keywords: *Eldana saccharina*, resistance, sugarcane, self-trashing, breeding, fibre content

Introduction

Eldana saccharina Walker (Lepidoptera: Pyralidae) (eldana) is an indigenous insect pest of sugarcane in southern Africa, and is commonly known as the African sugarcane stalk/stem borer. Eldana is the most damaging pest of sugarcane in South Africa causing sugar losses estimated at more than R1 billion per annum (Horton *et al*., 2002; Assefa *et al*., 2008; Rutherford, 2015). The use of an Integrated Pest Management (IPM) approach combining chemical control, biological control and cultivation of resistant varieties has shown the potential to alleviate the damaging effects of this borer on sugarcane.

Sugarcane varietal resistance recognised in the early 1970's is an important approach to the control of the sugarcane stalk borer (Keeping and Rutherford, 2004). Several plant defence and/or tolerance mechanisms have been identified, viz. high fibre and hard stalk rindness from research conducted on a few commercial varieties (Mahlanza *et al*., 2014). More recently, a study by Nxumalo and Zhou (2017) showed reduced eldana damage with every unit increase in self-trashing. The application of these mechanisms, however, remains limited in breeding programmes.

The objectives of this study were to evaluate the combined effect of self-trashing and fibre content on eldana damage and implications on breeding for eldana resistance.

Materials and Methods

Data were collected from Stage II TSL16 single lines trial planted at Empangeni Research Station (103 masl; 28°45'S, 31°54'E) in 2016. A randomised completed block design with 164 families replicated three times was used. Each family was made up of several genotypes planted as 8 m single row plots. Genotypes within families were not replicated due to large numbers at the early stage of testing. Data were collected in 2017. At crop maturity, 12 stalks from each genotype (single line) were examined and scored for self-trashing and assessed for eldana damage. Self-trashing was scored from 0 to 3 with 0 representing clinging leaves, 1 representing slight self-trashing, 2 representing intermediate self-trashing and 3 representing highly self-trashing. After scoring for self-trashing, these stalks were trashed, examined for eldana entry and exit holes and the number of damaged stalks was recorded for each genotype. The 12 stalks were then bundled together and sent off to the South African Sugarcane Research Institute (SASRI) fertiliser advisory service (FAS) laboratory, where they were analysed for total fibre expressed as a percentage of sample fresh weight (fibre % cane) using standard methods (Shoones-Muir *et al.*, 2009).

Data were analysed for family effects for eldana damage, self-trashing and fibre using the linear mixed model:

$$Yijk = \mu + Rj + Fk + RFjk + Ejkl \qquad \text{Equation 1}$$

where Yijk is the ith self-trashing/fibre score in the jth replication of the kth family measured on the lth genotype, μ is other overall mean, Rj is the random effect of the jth replication, Fk is the fixed effect of the kth family, RFjk is the random interaction effect of the jth replication by the kth family and is the experimental error for family effects, Eijkl is the residual error. Families' effects were fixed to estimate means as is practised at this stage in sugarcane breeding.

A simple linear regressing was used to determine the relation between eldana damage and fibre as well as eldana damage and self-trashing using the equation,

$$Y_i = a + bx_i + e_i \qquad \text{Equation 2}$$

where Yi was the eldana damage in the ith genotype, a was the intercept, b was the coefficient or slope, xi was the fibre or self-trashing score of the ith genotype and also the independent variable and e_i was the error.

Multiple linear regression was used to determine the combined effect of self-trashing and fibre on eldana damage using the equation,

$$Yi = a + b_1x_{1i} + b_2x_{2i} + e_i \qquad \text{Equation 3}$$

where a was the intercept, b_1 was the slope of the effects of self-trashing, b_2 was the slope of the effect of fibre, x_{1i} was the self-trashing score of the *i*th genotype, x_{2i} was fibre content of the *i*th genotype, and e_i was the error.

Results and Discussion

Significant differences (F=1.86, P<0.0001) were observed among families for eldana damage suggesting that families with low eldana damage could be identified and selected from these breeding populations (Table 1). There were highly significant (F=4.05, P<0.0001) family effects for fibre while those of self-trashing were marginally significant (F=1.19, P=0.1046), suggesting genetic variability for these traits (Table 1).

Table 1. The fixed effects for fibre content and self-trashing. F-value = F distribution statistic, P>F = probability of obtaining a larger value of the F statistic.

Fixed effects			
Effect	**Eldana damage**	**Fibre content**	**Self-trashing**
Family	F-value = 1.86 p-value <0.0001	F-value = 4.05 p-value <0.0001	F-value = 1.19 p-value = 0.1046

Simple linear regression showed a significant negative association representing a 0.41% (P<0.0001) and 0.34% (P<0.0001) decrease in the number of bored stalks with every unit increase in self-trashing and fibre, respectively (Table 2). This suggests the influence of self-trashing and fibre in reducing eldana damage. The number of bored stalks decreased significantly from 31% (clinging leaves) to 28% (intermediate self-trashing) (F=12.80, P<0.0001) for self-trashing while those of fibre decreased significantly from 37% (low fibre) to 22% (high fibre) (F=1.85, P<0.0001).

Table 2. The regression coefficients (estimate), their standard error (SE), t distribution statistic (t-value) and probability of obtaining a larger value of the t-statistic (Pr>t).

Linear regression					
Parameter	**DF**	**Estimate**	**SE**	**t-value**	**Pr>t**
Intercept	1	3.620	0.054	66.52	<0.0001
Self-trashing	1	-0.408	0.081	-5.02	<0.0001
Intercept	1	8.133	0.352	23.10	<0.0001
Fibre	1	-0.340	0.025	-13.39	<0.0001
Multiple regression					
Intercept	1	8.129	0.351	23.13	<0.0001
Self-trashing	1	-0.309	0.080	-3.87	0.0001
Fibre	1	-0.331	0.025	-12.98	<0.0001

Multiple linear regression showed highly significant (P<0.0001) 0.31% (self-trashing) and 0.33% (fibre) decrease in number of bored stalks, indicating a higher decrease in eldana damage when both high fibre and high self-trashing were present (Table 2). This suggests possible genetic independence between fibre and self-trashing which indicates that both traits can be selected simultaneously during breeding. The number of bored stalks decreased significantly from 31% (clinging leaves) to 29% (intermediate self-trashing) (F=10.79, P<0.0001) for self-trashing, while for fibre decreased significantly from 36% (low fibre) to 22% (high fibre) (F=15.30, P<0.0001).

In conclusion, results indicated that self-trashing and fibre content traits are associated with the reduction in eldana damage and the interaction of both traits may alleviate damage caused by eldana. These traits may offer an additional resistance mechanism to combat eldana in sugarcane; however, further studies are required to validate the relationship between self-trashing and fibre content with eldana damage. Also, studies are required to determine the interaction of these traits, particularly fibre content, with traits of economic significance.

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