SHORT, NON-REFEREED PAPER

LOCATION AND CROP-YEAR EFFECTS ON PARENT SELECTION FOR *ELDANA SACCHARINA* RESISTANCE

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Abstract

The stem borer, *Eldana saccharina* (eldana) is widespread in South Africa and causes approximately R1 billion loss to the industry per annum. Cultivation of resistant varieties forms part of an integrated pest management system. Parent evaluation information can be used to improve breeding and crossing efficiency because only resistant parents will be selected for crossing to generate resistant progenies. The objective of this study was to evaluate location and seasonal effects on eldana damage of progenies from selected parents. Data for percent bored stalks (PBS) were collected in the plant, first and second ratoon crops of 44 families planted to three replications at five locations. Highly significant female (F=12.45, P<0.0001) and male (F=8.79, P<0.0001) effects indicated high genetic differences for female and male parents. The location by female (F=2.65, P>0.0001) and location by male (F=1.76, P>0.0001) interaction effects were highly significant, indicating location specific parental selection. The results mean that it is possible to select parents specific to a breeding programme for resistance breeding. Highly significant interaction between crop by female (F=3.79, P>0.0001) and between crop by male effects (F=2.95, P>0.0001) indicated that progenies had different damage levels in different crop years. This may be attributed to seasonal effects because the trials were grown during drought seasons which can result in elevated eldana damage levels. The three- way interaction between location by crop by female (F=4.80, P>0.0001) and location by crop by male effects were highly significant (F=2.82, P>0.0001). The results highlighted that resistant parents can be selected for different breeding programmes and will be used to generate families with low eldana damage in breeding for resistance.

Keywords: eldana resistance, genotype by environment, female effects, crop effects, seasonal effects, PBS

Introduction

The sugarcane stem borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (eldana) is widespread in South Africa and causes approximately R1 billion annual loss in sugar production. Planting resistant varieties is part of an integrated eldana pest management programme. Breeding for eldana resistance started in the 1980s when E. saccharina was recognised as an economic pest of sugarcane (Nuss and Atkins, 1983; Nuss, 1991). Breeding involved crossing parents known to possess high levels of tolerance to produce selection populations.

The efficiency of a breeding programme depends on efficient parent evaluation and selection. In sugarcane breeding, parents are evaluated using progeny data collected from early stage breeding populations (Skinner *et al.,* 1987), therefore parents only reference progenies derived from crosses involving the parents. Families can be planted and evaluated across a range of locations, which is important if there is the potential of genotype by environment interaction.

Location references a breeding population and a breeding programme. Family by environment interactions data derived from progenies was used to evaluate parents for yield and quality in Australia (Bull *et al.,* 1992; Jackson*, et al.,* 1994). The objective of this study was to evaluate location and crop-year effects on eldana damage of progenies from selected parents.

Materials and Methods

Trial sites, experiment design and data collection

Data were collected from trials planted in 2014 at SASRI Pongola (irrigated), Gingindlovu (coastal long cycle), Empangeni (coastal short cycle) and Glenside (Midlands sandy soils) research stations.

The trials were laid out as randomised complete block designs with 44 families planted to three replications. Each family plot was made up of 32 sub-plot with each subplot planted to unreplicated genotype plots. Data were collected from the first 20 sub-plots within each family plot at harvest age. Where a family had sub-plots less than 20 then data were collected from all the sub-plots. The total number of millable stalks was counted and stripped of leaves for each family plot. The stripped stalks were inspected to count the stalks with eldana borer entry and exit holes which were converted to a percent of total stalks (PBS) (Leslie, 2013).

Data were analysed using the linear mixed model of the Statistical Analysis System (SAS Institute, 2009):

$$Y_{ijkl} = \mu + L_l + R(L)_{kl} + M_i + ML_{il} + MR(L)_{ikl} + C_j + LC_{jl} + CR(L)_{jkl} + MC_{ij} + MLC_{ijl} + E_{ijkl}$$

where, $Y_{ijkl} =$ the observation for parent *i* (*i = 1 2 3 ….,g*) in C_j = crop year *j* (*j = 1,2,3…..c*), at L_l = location *l* (*l* = 1, 2, 3, …, l), in R_k = replication *k* (*k* = 1, 2, 3). L_l = the fixed effect of the *l*th location; $R(L)_{kl}$ = the random effect of *k*th replication nested within *l*th location; Mi = the fixed effect of the ith male; ML_{il} = the fixed effects interaction effect between the *i*th male in the *l*th location; $MR(L)_{ikl}$ = the random interaction effect between the *i*th male and the *k*th replication nested with the *l*th location C_j = the fixed effect of the *j*th crop-year; $LC_{\underline{jl}}$ = the fixed interaction effect between the *l*th location and jth crop; $CR(L)_{jkl}$ = random interaction effect between the *j*th crop year and the *k*th replication nested within the *l*th location; teraction effect between the *l*th location and the *i*th male and the *j*th crop year. A similar linear mixed model was used to analyse for female effects. Shapiro-Wilk statistic (P>0.05) showed no deviation from normal distribution.

Results and Discussion

Location, location by genotype, crop year, crop year by genotype, crop year by location, and location by crop year by genotype produced highly significant (P>0.001) F-values for both female and male genotypes (Table1). However, the male genotypes produced lower F-values for all effects than females. Female main effect F-values were 1.4 times larger than the male, indicating larger influence on progeny performance and suggesting potential maternal dominance for eldana damage. Female and male F-values indicated genetic control of progeny eldana damage by both parental genotypes, suggesting the importance of parent selection in eldana resistance breeding.

Location effects, F-values for female and male indicated significant differences in level of damage among locations. The locations reference breeding programmes at research stations. Gingindlovu (44.07%) had significantly (P<0.0001) more bored stalks than Pongola, Empangeni and Glenside. Pongola (20.07%) and Empangeni (19.63%) locations with similar damage levels had significantly more PBS than Glenside (7.14%) (Table 2).

Location by female and location by male interaction F-values indicated that levels of damage to genotypes fluctuated across locations. The high altitude and cooler Midlands regions were known to experience no damage from eldana. The irrigated and Empangeni areas where sugarcane was harvested at 12 months also experienced little or no damage. Genotype 95H0130 had consistently higher PBS than the mean across locations in contrast with genotype 01S1681, which displayed 65% more PBS than the trial mean at Glenside, but 25%, 31% and 22% less PBS than the mean at Pongola, Empangeni and Gingindlovu, respectively, suggesting influence of parent by location interaction.

The plant crop had significantly (P>0.0001) higher damage level (34 PBS) than the first (22 PBS) and second (9 PBS) ratoon crops, highlighting significant crop-year effect. The significant crop by female and crop by male effects F-values may be attributed to seasonal effects on crop-years where the 2014/2015 drought seasons resulted in elevated eldana damage. The location by crop by female and location by crop by male F-values indicated that eldana damage on progenies at locations was influenced by seasonal effects such as drought, which is known to be associated with high eldana prevalence. A drought stressed sugarcane crop is more susceptible to eldana damage. (SASRI, 2014). High eldana levels have always been found in the Gingindlovu areas due to longer cutting cycle and poorer soils. Whilst the midlands areas also have a longer cutting cycle, they experience low levels of eldana due to high altitude and long cooler conditions.

Table 1. The F-values, P-value, R2 and CV% for female and male effects for percent *Eldana saccharina* Walker (Lepidopter: Pyralidae) bored stalks.

Effect	Female		Effect	Male	
	F-Value	Pr > F		F-Value	Pr > F
Loc	118.42	0.0001	Loc	83	0.0001
Female	12.45	0.0001	Male	8.79	0.0001
Loc*Female	2.65	0.0001	Loc*Male	1.76	0.0052
Crop	297.19	0.0001	Crop	124.5	0.0001
Loc*Crop	166.6	0.0001	Loc*Crop	87.85	0.0001
Female*Crop	3.79	0.0001	Male*Crop	2.95	0.0001
Loc*Female*Crop	4.8	0.0001	Loc*Male*Crop	2.82	0.0001
R^2	0.55		R^2	0.51	
CV	77.51		CV	80.37	

Table 2. Least square means for percent bored stalks (PBS).

Variety	PONGOLA		EMPANGENI		GINGINDLOVU		GLENSIDE	
	Estimate	%T. Mean	Estimate	%T. Mean	Estimate	%T. Mean	Estimate	%T. Mean
Female								
00K0769	14.78	74	16.81	86	22.5	51	1.55	22
01G1662	8.29	41	11.8	60	22.83	52	3.6	50
01S1681	14.98	75	13.5	69	34.23	78	11.82	165
03S0282	14.25	71	20.9	106	40.77	93	9.85	138
05U0114	13.32	66	5.99	31	18.12	41	1.52	21
79F0779	23.38	116	27.6	141	52.01	118	6.6	92
82Z3441	27.56	137	25.96	132	52.3	119	7.42	104
85W0426	20.37	101	24.95	127	44.25	100	4.23	59
89F1649	25.66	128	24.82	126	54.96	125	4.88	68
92W0077	14.26	71	15.66	80	34.8	79	6.26	88
95H0130	36.92	184	29.57	151	62.94	143	11.5	161
96H0289	11.14	56	14.56	74	42.95	97	12.72	178
98B0460	18.75	93	19.23	98	48.92	111	9.6	134
98S0082	21.1	105	22.03	112	53.72	122	2.52	35
99B1659	18.45	92	21.16	108	46.16	105	4.74	66
99F1718	24.48	122	20.09	102	61.37	139	9.75	136
99S1362	16.11	80	17.88	91	33.81	77	6.16	86
N25	20.82	104	18.1	92	41.53	94	7.24	101
Male								
00F0602	35.53	177	32.08	163	58.66	133	2.4	34
01K0433	10.09	50	16.86	86	20.92	47	2.64	37
05U0696	7.56	38	11.22	57	23.69	54	5.53	77
76E0537	11.62	58	14.57	74	27.95	63	3.68	51
87L0573	12.6	63	17.6	90	41.7	95	13.47	188
91W1482	13.3	66	6.06	31	18.12	41	1.47	21
92L0429	13.86	69	20.96	107	30.37	69	3.13	44
92W0763	14.56	73	22.65	115	48.62	110	7.18	100
94H0323	28.7	143	23.8	121	58.11	132	10.71	150
94M0382	10.78	54	6.06	31	17.51	40	4	56
95H0517	17.78	89	21.74	111	46.98	107	8.85	124
99B1889	16.27	81	9.81	50	40.57	92	10.15	142
99B1979	11.15	56	14.65	75	42.95	97	12.63	177
99F2004	23.12	115	19.53	99	39.3	89	10.48	147
99S0106	14.35	71	17.28	88	30.47	69	4.98	70
99S1504	16.61	83	13.74	70	37.38	85	6.31	88
Location mean	20.07	100	19.63	100	44.07	100	7.15	100

Conclusion

Female genotypes F-value was higher than the male genotypes F-value suggesting more genetic contribution to progenies from female than male parents for eldana resistance. The importance of screening genotypes for damage across different crop years was highlighted by the significant crop by genotype result. This would provide valuable information on the performance of a variety in different seasonal conditions like a drought year or optimal water conditions season. The results suggest that the locations do influence how progenies react to eldana damage where damage levels fluctuate across locations. The study showed that resistant parents can be selected for different breeding programmes and will be used to generate families with low eldana damage in breeding for resistance.

REFERENCES

Bull JK, Hogarth DM and Basford KE (1992). Impact of genotype by environment interaction on response to selection in sugarcane. *Aus J Exp Agric* 32: 731-737.

Jackson PA, McRae TA and Hogarth DM (1994). Selecting superior sugarcane crosses for the Herbet River district. *Proc Aust Soc Sug Cane Technol* 16: 47-54.

Leslie GW (2013). Aspects of sampling *Eldana saccharina* Walker (Lepidoptera: Pyralidae) populations and damage in sugarcane. *Proc S Afr Sug Technol Ass*. 86: 311-320.

Nuss KJ and Atkinson PR (1983). Methods used to measure the susceptibility of sugarcane varieties to attack by *Eldana saccharina* (Walker). *Proc S Afr Sug Technol Ass* 57: 92.

Nuss KJ (1991). Screening sugarcane varieties for resistance to Eldana borer. *Proc S Afr Sug Technol Ass* 65: 92-95.

SAS Version 9.2 (2009). SAS/STAT user's guide, version 9.2 SAS Institute, Cary, North Carolina, USA.

SASRI (2014). An Integrated Pest Management (IPM) approach for the control of the stalk borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae). Manual published by the South African Sugarcane Research Institute, Mount Edgecombe, South Africa.

Skinner JC, Hogarth DM and Wu KK (1987). Selection methods, criteria and indices. pp 409-453 In: DJ Heinz (Ed) *Sugarcane Improvement Through Breeding*. Elsevier, Amsterdam.