Pakistan J. Zool., vol. 53(6), pp 2485-2488, 2021 DOI: https://dx.doi.org/10.17582/journal.pjz/20180712030748

Short Communication

Resistance to Borer Damage in Seedlings of New Varieties of Sugarcane

Zhi-Ming Luo*, Xiao-Yan Wang, Jiong Yin, Ying-Kun Huang, Wen-Feng Li, Rong-Yue Zhang, Hong-Li Shan, Xiao-Yan Cang and Jie Li

Sugarcane Research Institute, Yunnan Academy of Agricultural Sciences, Yunnan Key Laboratory of Sugarcane Genetic Improvement, Kaiyuan 661699, China.

Article Information
Received 12 July 2018
Revised 18 July 2019
Accepted 28 September 2020
Available online 15 October 2021

Authors' Contribution
Z-ML and Y-KH designed the experiment. Z-ML and X-YW wrote the paper. X-YW, R-YZ and H-LS participated in experimental investigation. JY executed the experiments. W-FL, X-YC and JL analysed the data.

Key words
Sugarcane, New varieties, Seedling stage, Borer damage

ABSTRACT

Quantification of resistance to borer pest damage in sugarcane varieties is key to sustainable crop protection and integrate pest management. Here, were assessed resistance to damage caused by two species of borer in seedlings of 12 new sugarcane varieties. The results showed that there were differences in resistance among the varieties, where varieties YT60, GT31, GT29, LC05-136, and YT55 were classified as showing moderate resistance, YZ06-407, YZ05-51, ROC22, YZ05-49, YZ03-194, and FN38 were found to be susceptible, and FN39 and DZ03-83 were shown to be highly susceptible. This study established a method to assess sugarcane seedling resistance to borer species that could be used in future resistance evaluations of novel sugarcane varieties during the crop breeding process.

Sugarcane is a key sugar crop in China, however, sugarcane boring insect pest species (Lepidoptera), which are widely distributed through areas of its cultivation, cause serious economic damage (Huang and Li, 2011). Borers feed on the host plant throughout crop development: They feed on the growing point in sugarcane seedlings, causing dead heart, while in the subsequent crop growth stages, they destroy stem tissue. Damage caused by borer feeding has been estimated to cause cane yield losses of 10-20%, with severe infestations resulting in up to 50% losses, and decreases in absolute sucrose content of 0.157-1.394% (Luo *et al*., 2009). Chemical control of insect borer species is currently the most widely practiced and effective management strategy in China (Shang and Huang, 2010), but this approach is economically costly, creates environmental contamination due to pesticide residues, leads to problems with insecticide resistance, and consequent pest resurgence (Liu *et al*., 2004; Yu *et al*., 2008). A more sustainable approach to sugarcane borer management is the development and use of borer-resistant sugarcane varieties (White *et al*., 2008).

Resistance to sugarcane borer species has been shown at the seedling stage and in mid-late growth (Gong *et al*., 2011), where some sugarcane varieties are resistant to borer damage at both growth stages, and others show resistance at one stage. Dead heart is an important characteristic of borer damage and degree of damage is usually assessed in the seedling stage as incidence of dead heart (Reay *et al*., 2003; Berry *et al*., 2010), and differences in incidence could be used to indicate resistance of sugarcane seedlings to borers (Reay *et al*., 2003; Gan *et al*., 2013). In this study, we tested resistance to borers in the seedling stage of new varieties of sugarcane to provide support for a potential alternative to chemical control of sugarcane borer species.

Materials and methods

We tested resistance in sugarcane 12 varieties: Yunzhe 03-194 (YZ 03-194), Yunzhe 05-51 (YZ 05-51), Yunzhe 06-407 (YZ 06-407), Yunzhe 05-49 (YZ 05-49), Yuetang 55 (YT 55), Yuetang 60 (YT 60), Funong 38 (FN 38), Funong 39 (FN 39), Guitang 29 (GT 29), Guitang 31 (GT 31), Dezhe 03-83 (DZ 03-83), and Liucheng 05-136 (LC 05-136). Variety ROC 22 was used as a control. Locally occurring populations of the borers *Sesamia inferens* Walker (Noctuidae) and *Tetramoera schistaceana* Snellen (Tortricidae) to naturally inoculate the crop plants, where *S. inferens* was dominant.

The experiment was carried out in a field at the Sugarcane Research Institute, Yunnan Academy of Agricultural Sciences in China (23.7°N, 103.23°E). Three replicates of seedlings of the 12 varieties were planted on March 4, 2015 in a randomized block design. The 27.5-m^2 plots comprised five rows, 1 m apart and 5.5 m long, in which 165 double buds were planted. The sugarcane was harvested on March 2, 2016, and damage to the ratoons of

* Corresponding author: kylzm@163.com
0030-9923/2021/0006-2485 $ 9.00/0

these plants was monitored during 2017. Non-insecticide management of the plots followed standard practice.

The newly planted and ratoon sugarcane were inoculated at the seedling stage with locally occurring borers known to naturally feed on sugar cane. In mid-June, when occurrence of borer-damaged dead heart had stabilized, incidence of dead heart was recorded as:

Incidence of dead heart (%) = number of plants with dead heart / total number of seedlings assessed × 100

We calculated a borer damage index based on the incidence of dead heart following Heinrichs (1985), who described a similar method for another species of borer, *Chilo supressalis* Walker (Crambidae), where:

Borer damage index = Incidence of dead heart in test variety / Incidence of dead heart in control

The borer damage index was then used to classify degree of damage resistance (Table I).

The data were sorted by Excel. We tested for differences in resistance to borer damage in the seedling stage damage to seedlings and ratoons among varieties using analysis of variance, and Duncan's new multiple range test was used to test for differences between varieties in SPSS software. Similarity in resistance was analyzed using cluster analysis in SPSS software.

Table I. Classification of sugarcane borer resistance in sugarcane seedlings.

Borer damage index	Resistance
0-0.25	High Resistant (HR)
0.26-0.50	Resistant (R)
0.51-0.75	Moderate Resistance (MR)
0.76-1.25	Susceptible (S)
>1.25	Highly Susceptible (HS)

Results

All varieties, including the control, suffered sugarcane borer damage at the seedling stage in planted cane, but the degree of borer damage differed among the varieties (Table II). Incidence of dead heart between the least (YT60) and most damaged (FN39) varieties differed by a factor of 4.7. Varieties YT55, YT60, GT29, GT31, and LC05-136 had less damage than the control, while DZ03-83 and FN39 had greater damage. Accordingly, borer damage index of the varieties varied (Table II), where they were classified to four resistance grades: YT60 was shown to be resistant; YT55, GT29, GT31, and LC05-136 were shown to have moderate resistance; YZ03-194, YZ05-51, YZ06-407, YZ05-49, and FN38 were susceptible; and, FN39 and DZ03-83 were highly susceptible.

Table II. Resistance to borer damage at the seedling stage in the sugarcane varieties.

Sugarcane variety	Dead heart rate	Differences at P < 0.05	Differences at P <0.01	Borer damage index	Resistance
YZ03-194	10.26±1.57	bc	BCD	0.96	S
YZ05-51	11.39±3.41	b	BC	1.06	S
YZ06-407	10.61±1.05	b	BC	0.99	S
YZ05-49	10.65±1.98	b	BC	1.00	S
YT55	6.92±1.42	cde	CDE	0.65	MR
YT60	3.56±0.81	e	E	0.33	R
FN38	8.10±1.43	bcd	CDE	0.76	S
FN39	16.70±1.78	a	A	1.56	HS
GT29	5.70±0.06	de	DE	0.53	MR
GT31	5.68±1.02	de	DE	0.53	MR
DZ03-83	14.99±2.57	a	AB	1.40	HS
LC05-136	6.63±1.57	de	CDE	0.62	MR
ROC22	10.71±3.10	b	BC	1.00	S

Different letters within a column indicate differences in resistance between varieties.

Table III. Resistance to borer damage in seedling stage ratoons of the sugarcane varieties.

Sugarcane variety	Dead heart rate	Differences at P < 0.05	Differences at P <0.01	Borer damage index	Resistance
YZ03-194	9.26±1.91	ab	AB	1.00	S
YZ05-51	8.11±1.27	bc	AB	0.87	S
YZ06-407	8.44±0.75	ab	AB	0.91	S
YZ05-49	9.49±1.38	ab	AB	1.02	S
YT55	4.22±1.27	c	B	0.45	R
YT60	4.30±0.70	c	B	0.46	MR
FN38	8.17±2.48	bc	AB	0.88	S
FN39	12.41±0.92	a	A	1.33	HS
GT29	4.08±0.41	c	B	0.44	R
GT31	5.45±1.47	bc	B	0.59	MR
DZ03-83	12.33±0.36	a	A	1.33	HS
LC05-136	4.33±0.99	c	B	0.47	MR
ROC22	9.30±0.85	ab	AB	1.00	S

Different letters within a column indicate differences in resistance between varieties.

We found that all varieties, including the control, suffered dead heart, where there were differences in the degree of borer damage among the varieties (Table III).

Incidence of dead heart varied by a factor of three between the least (GT29) and most (FN39) damaged varieties; GT29, YT55, YT60, and LC05-136 were less damaged than the control, whereas none was more damaged. Accordingly, the sugarcane varieties were classified to four resistance grades: GT29 and YT55 were shown to be resistant; YT60, GT31, and LC05-136 were shown to have moderate resistance; YZ03-194, YZ05-51, YZ06-407, YZ05-49, and FN38 were susceptible; and, FN39 and DZ03-83 were highly susceptible.

Table IV. Summary of degree of resistance to borer damage in the sugarcane varieties.

Degree of resistance	Variety	Incidence of dead heart	Borer damage index
MR	YT60, GT31, GT29, LC05-136, YT55	2.34-6.92%	0.33-0.65
S	YZ06-407, YZ05-51, ROC22, YZ05-49, YZ03-194, FN38	8.10-11.39%	0.76-1.06
HS	FN39, DZ03-83	12.33-16.70%	1.33-1.56

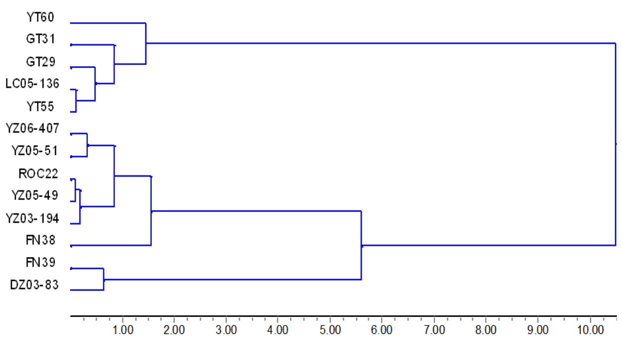

Fig. 1. Cluster diagram of resistance to borer damage at the seedling stage in the sugarcane varieties.

Cluster analysis of damage to planted and ratoon seedlings showed that the sugarcane varieties were grouped into three grades of resistance grades (Table IV, Fig. 1). Varieties grouped as those with moderate resistance (YT60, GT31, GT29, LC05-136, and YT55) had low incidence of dead heart, with a borer damage index between 0.33 and 0.65; susceptible varieties (YZ06-407, YZ05-51, ROC22, and YZ05-49) had moderate incidence of dead heart and a borer damage index that ranged between 0.76 and 1.06; and, highly susceptible varieties (FN39 and DZ03-83) had a high incidence of dead heart and a borer damage index of 1.33-1.56.

Discussion

Identification of borer resistance in sugarcane varieties is important in the identification of potential varieties for use in integrate pest management strategies. Our study of resistance to damage by two sugarcane borer species in new sugarcane varieties showed variability among the varieties, as has been reported elsewhere (Showler and Castro, 2010; Wu *et al*., 2015; Nikpay, 2016; Lin, 2016). Resistance of sugarcane to borer damaged has been shown to be associated characteristics of the hose plant, including surface firmness of the internode (David, 1984), fiber content (Rutherford *et al*., 1993), wax powder on cane stalk (Rutherford and Van, 1996), silica cell content (Keeping and Meyer, 2006), and nutrient content, such as amino acids, tannin acid, and flavonoids (Reay *et al*., 2003; Keeping and Meyer, 2006). Resistance has also been shown to be affected by planting environment, sugarcane variety, and species and density of borer (Lin *et al*., 2015). We evaluated resistance planted cane and ratoon cane in two different years and suggest that between-year differences in resistance of some varieties reflects inter-year differences in environmental factors and borer density.

In this study, YT60, GT31, GT29, LC05-136, and YT55 were classified as resistant, while FN39 and DZ03-83 were classified as susceptible to damage caused by the borers *S. inferens* and *T. schistaceana* to planted and ratoon seedlings. It is important that resistance at other growth stages and to other species of borer are studied in the future.

Since the seedling growth stage is a key period for borer population establishment and subsequent accumulation within a field, the cultivation of sugarcane varieties that offer high resistance to borer damage could regulate and control populations of these pests (Pfannenstiel and Meaggher, 1991; Meagher *et al*., 1996; Reay *et al*., 2005) and have little or no conflict (Kogan, 1994), but synergy (Ntanos and Koutroubas, 2000) with other control measures.

Acknowledgments

This work was supported by grants from the Technology Innovation Talents Cultivation Object in Yunnan Province (2017HB085), the Earmarked Fund for Sugar Crop Research System (CARS-170303), and the Earmarked Fund for Yunnan Province Agriculture Research System (YNGZTX-4-92).

Statement of conflict of interest

The authors have declared no conflict of interest.

References

Berry, S.D., Leslie, G.W. and Spaull, V.W., 2010.

B. Entomol. Res., **100**: 373-385. https://doi.org/10.1017/S0007485309990319

David, H. and Joseph, K.J., 1984. *Proc. Sugarc. Technol. Assoc. India,* **48**: 43-58.

Gan, Y.M., Zeng, J., Cai, W.W., Wu, S.R., Wu, Y.L., Zhang, S.Z. and Yang, B.P., 2013. *Chinese J. trop. Agric*., **33**: 53-56.

Gong, H.L., Li, J.Y., Sun, D.L., Liu, S.M., Huang, Z.X. and An, Y.X., 2011. *Guangdong agric. Sci*., **38**: 18-21.

Heinrichs, E.A., 1985. *Genetic evaluation for insect resistance in rice*. International Rice Research Institute. Los Banos, Philippines. pp. 356.

Huang, Y.K. and Li, W.F., 2011. *Colored atlas of diseases, insect pests and weeds of modern sugarcane*. China Agriculture Press, Beijing. pp. 1-6.

Keeping, M.G. and Meyer, J.H., 2006. *J. appl. Ent*., **130**: 410-420. https://doi.org/10.1111/j.1439-0418.2006.01081.x

Kogan, M., 1994. In: *Plant resistance in pest management* (eds. R.L. Metcalf and W.H. Lickmann). John Wiley and Sons Ltd, New York. pp. 73-128.

Lin, Z.L., 2016. *Sugar Crops China*, **38**: 10-13.

Lin, Z.L., Fu, H.Y., Gao, S.J., Xu, L.P. and Xu, J.H., 2015. *Sugarc. Canesugar*, **5**: 11-16.

Liu, B., Zhu, Y.Q., Sengonca, C., Mao, N.H., Lin, K.M. and Wu, C.Q., 2004. *Agrochemicals*, **43**: 492-496.

Luo, Z.M., Huang, Y.K., Li, W.F., Lu, W.J. and Wang, X.Y., 2009. *Zool. Res*., pp. 105-109.

Meagher, R.L., Irvine, J.E., Breene, R.G., Pfannenstiel, R.S. and Gallomeagher, M., 1996. *J. econ. Ent*., **89**: 536-543. https://doi.org/10.1093/jee/89.2.536

Nikpay, A., 2016. *Acta entomol. Sin*., **59**: 785-790.

Ntanos, D.A. and Koutroubas, S.D., 2000. *Field Crops Res*., **66**: 63-71. https://doi.org/10.1016/S0378-4290(00)00063-0

Pfannenstiel, R.S. and Meaggher, R.L., 1991. *Florida Entomol*., **74**: 300-305. https://doi.org/10.2307/3495310

Reay, J.F.P.F., Showler, A.T., Reagan, T.E., Legendre, B.L., Way, M.O. and Moser, E.B., 2005. *Environ. Ent*., **34**: 1558-1565. https://doi.org/10.1603/0046-225X-34.6.1558

Reay J.F.P.F., Way, M.O., Sétamou, M., Legendre, B.L. and Reagan, T.E., 2003. *J. econ. Ent*., **96**: 1929-1934. https://doi.org/10.1093/jee/96.6.1929

Rutherford, R.S. and Staden, J.V., 1996. *J. chem. Ecol*., **22**: 681-694. https://doi.org/10.1007/BF02033578

Rutherford, R.S., Meyer, J.H., Smith, G.S. and Staden, J.V., 1993. *Proc. South Afr. Sugarc. Technol. Assoc*., **67**: 82-87.

Shang, X.K. and Huang, C.H., 2010. *J. Anhui agric. Sci*., **38**: 20064-20066.

Showler, A.T. and Castro, B.A., 2010. *Crop Prot*., **29**: 415-421. https://doi.org/10.1016/j.cropro.2009.07.014

White, W.H., Viator, R.P., Dufrene, E.O., Dalley, C.D., Richard, E.P. and Tew, T.L., 2008. *Crop Prot*., **27**: 1256-1261. https://doi.org/10.1016/j.cropro.2008.03.011

Wu, S.R., Yang, N.B., Xiong, G.R., Cai, W.W., Zhang, S.Z. and Yang, B.P., 2015. *Jiangsu agric. Sci*., **43**: 100-102.

Yu, Y.S., Xue, S., Wang, F. and Wu, J.C., 2008. *Chinese Bull. Ent.,* **45**: 15-20.