Tree and Forestry Science and Biotechnology ©2010 Global Science Books

The Effect of Insecticides against the Root Mealybug (*Cataenococcus ensete*) of *Ensete ventricosum* in Southern Ethiopia

Eyob Tadesse[1] • Ferdu Azerefegne[2] • Tamiru Alemu[2] • Guy Blomme[3*] • Temesgen Addis[4]

[1] Wolaita Sodo University, Faculty of Agriculture, Plant Science Department, P.O.Box. 138, Ethiopia
[2] Hawassa University, College of Agriculture, P.O.Box 05, Awassa, Ethiopia
[3] Bioversity International Uganda office, P.O.Box 24384, Kampala, Uganda.
[4] Southern Agricultural Research Institute (SARI), Awassa Research Center, P.O.Box 06, Awassa, Ethiopia

Corresponding author: * G.BLOMME@CGIAR.ORG

ABSTRACT

The effect of six commercially available insecticides was evaluated for the control of the enset root mealybug, *Cataenococcus ensete* (Williams and Matile-Ferrero) (Hemoptera: Pseudococcidae) under greenhouse and farmers' field conditions. In the greenhouse study, pared and boiled water treated seedlings of *E. ventricosum* were planted in 10 L pots and infested at 2 months after planting with 25 third-instar *C. ensete* per plant. Each insecticide was diluted to a 1/500 concentration and applied at a rate of 660 ml of diluted solution per pot. In the farmers' field study, the number of adult *C. ensete* before insecticide application was estimated by sampling a 20 × 20 × 20 cm soil volume at one side of the plant. Each plant was drenched with 1.7 L of diluted insecticide solution. The results showed a significant difference ($p<0.05$) in *C. ensete* mortality amongst the treatments. Diazinon 60% EC and Chlorpyrifos 48% EC caused at least 98% mortality both under field and greenhouse conditions. Applications of Endosulfan, Dimethoate, Fenitrothion and Malathion resulted in a 74, 65, 77 and 83% mortality in the greenhouse experiment and a 51, 65, 51 and 50% mortality in the field trials, respectively. The efficacy of a double application of Malathion, Fenitrothion, Endosulfan and Dimetohate was inferior to a single application of either Chlorpyrifos or Diazinon. Therefore a single application of Diazinion or Chlorpyrifos is recommended. However, it is advisable/imperative that farmers continuously monitor infestation levels in their enset plots by assessing adult root mealybug numbers in soil samples dug out adjacent to the corms and repeat insecticide applications when a mealybug population build up is observed.

Keywords: Chlorpyrifos, Diazinon, Dimethoate, Endosulfan, Fenitrothion, Malathion, mortality

INTRODUCTION

Enset belongs to the order Scitamineae, the family Musaceae, and the genus *Ensete*. Two wild *Ensete* species are found in Asia, while four wild species are present in sub-Saharan Africa and Madagascar (Baker and Simmonds 1953; Simmonds 1958). Wild enset plants are commonly grown as ornamental plants. Cultivation of *Ensete ventricosum* (Welw.) as a food crop (mainly as fermented corm and pseudostem starch) is restricted to Ethiopia (Baker and Simmonds 1953; Bezuneh and Feleke 1966; Westphal 1975). It is a staple and co-staple food for more than 20 million Ethiopians, providing more than 65% of the caloric requirements of the country (Brandt *et al.* 1997; Azerefegne *et al*. 2009).

A high quality fiber is extracted from the leaf sheaths of *E. ventricosum* (Bezuneh and Feleke 1966), while residues from processing are an important source of animal feed especially during the dry season (Bezuneh and Feleke 1966). The corm and pseudostem of several *E. ventricosum* clones are also known to have medicinal properties for both cattle and humans (Nida 1996; Brandt *et al.* 1997; Fujimoto 1997; Hölscher and Schneider 1998). In addition, enset has an important cultural and social value.

The most important economic feature of *E. ventricosum* is its high productivity per unit area (49.0 tons ha^{-1} $year^{-1}$) as compared to cereals (0.7-2.5 tons ha^{-1}) and tubers and other root crops (8.1-13.7 tons ha^{-1}) (Clifton 1996).

However, the sustainability of *E. ventricosum* is threatened by a number of factors including diseases, and insect and vertebrate pests. Among these, bacterial wilt caused by *Xanthomonas campestris* pv *musacearum*, and the enset root mealybug, *Cataenococcus ensete* (**Fig. 1**) (William and Matile-Ferrero) (Homoptera: Pesudococcidae) which attacks the roots and corm of *E. ventricosum* are the most important (Addis *et al*. 2008a).

Fig. 1 Enset root mealy bugs on roots and corm of a young enset plant.

C. ensete is a major pest in south and southwestern

Received: 18 December, 2009. Accepted: 28 April, 2010.

Short Communication

Ethiopia (Addis *et al.* 2008a). It has been reported from Wonago (38°12'E, 6°12'N, 1,763 masl) as a new record for Ethiopia (Tsedeke 1988). Although the insect has long been known to attack enset in Gedeo, Sidama, Gurage, Kembata Tembaro, Hadyia, Keffa and Bench zones and Amaro and Yem districts, it has become a serious threat to *E. ventricosum* production only in recent years (Addis *et al.* 2008a). All growth stages of *E. ventricosum* are susceptible to root mealybugs. However, an infestation is most damaging on 2-4 year old plants. Infested plants exhibit stunted growth and older leaves desiccate. Infested plants have fewer healthy roots compared to non-infested ones and can easily be uprooted (Addis *et al.* 2008a). A large number of farmers who had previously grown enset are now growing other crops such as maize, due to the high incidence of mealybugs in enset growing regions (Tadesse 2006).

C. ensete is mainly disseminated with planting materials (Azerefegne *et al.* 2009). Clean planting materials need to be used when establishing a new plantation. So far, no effective management method has been developed against *C. ensete* for field established plants. This study therefore assessed the efficacy of some selected commercially available insecticides against *C. ensete* on plants growing in a greenhouse and in farmers' fields.

MATERIALS AND METHODS

Greenhouse experiment

This experiment was conducted at the Awassa Agricultural Research Center Awassa, Ethiopia. Two year old 'Genticha' plants were obtained from Wonago, southern Ethiopia. The corms of these plants were pared (Tenkouano *et al.* 2006) and subsequently immersed in boiling water for 10 sec in order to remove any *C. ensete*. The treated 'Genticha' plants were planted in 10 L plastic pots filled with soil (Nitisol) obtained in the Wonago district. Soil had been placed in the pots one month before planting to make sure that it did not contain any *C. ensete*. Enset root mealybugs cannot survive for more than 25 days in the absence of host plants (Addis *et al.* 2008a). The plants were watered at weekly intervals.

At 2 months after planting, third instar nymphs were carefully brushed (using a Camel brush) of roots and corms of infested *E. ventricosum* plants dug out in the Wonago area. Twenty five mealybugs were released per plant on the corm next to emerging young roots. The roots were subsequently covered with soil.

The insecticides were applied one week after infesting plants with the mealybugs. The six different insecticides used against enset root mealybugs in green house condition are presented in **Table 1**. The insecticides were diluted at a rate of 1:500 L of water and applied by drenching 660 ml of solution per pot. The drenching rate of 0.330 L/5 L of soil volume was adopted from a method used by Hara *et al.* (2001). For each insecticide treatment there were five plants. The enset plants in the untreated control were drenched with the same amount of water. The efficacy of the insecticides was assessed by counting the surviving insects 8 days after insecticide application.

Field experiments

This experiment was conducted on 15 adjacent farms located in Wonago district, southern Ethiopia. Three year old 'Genticha' plants infested with *C. ensete* were selected and tagged. Adult *C. ensete* were counted prior to the insecticide application in a 20 × 20 × 20 cm soil volume sample taken adjacent to one side of the corm of each plant (Addis *et al.* 2008b). *E. ventricosum* plants with 26 to 31 adult root mealybugs in the sampled soil volume were used for the experiment. Three plants were used for each insecticide treatment per farm. On each of the 15 farms, one plant per insecticide treatment was assessed at 15, 30 and 45 days after application.

The amount of insecticides to be applied per plant was determined by estimating the volume of soil inhabited by the majority of *C. ensete* (i.e., within a 20 cm radius and 20 cm soil depth around the corm) using the formula to calculate the volume of a cylinder ($V= \pi r^2 h$; V= volume, π= 3.14, r= 20 cm and h= 20 cm). 1.7 L of insecticide solution was applied once to the root collar area of each pant. The same insecticides tested in the green house were used on enset root mealybugs under farmer field conditions (**Table 2**). The enset plants in the untreated control were drenched with the same amount of water. The number of live *C. ensete* was recorded at 15, 30 and 45 days after treatment by taking a 20 × 20 × 20 cm soil volume sample adjacent to the corm but on the opposite side to where the pre-treatment sample was taken. The mortality rates were calculated from the pre- and post-treatment counts of adult root mealybugs.

A second similar experiment was conducted to evaluate the effect of two subsequent insecticide applications. The second insecticide application was carried out 2 weeks after the first application. Mealybug numbers were assessed (as explained above for the single application trial) at 15, 30 and 45 days after the second application.

Data from both the greenhouse and field experiments were analyzed using GenStat statistical software (GenStat 2003). For the greenhouse experiment, Abbot's Formula was applied to correct mortality rates (Abbot 1925). Prior to analysis *C. ensete* mortality data was arcsine transformed. Means were separated using Tukey's HSD test ($P<0.05$).

RESULTS AND DISCUSSION

Greenhouse experiment

Application of Diazinon and Chlorpyrifos resulted in a 100 and 98% mortality rate, respectively (**Table 1**). Although the effect of the other insecticides was significantly different from the untreated control, these insecticides only resulted in a <84% mortality rate (**Table 1**).

Field experiments

Chlorpyrifos and Diazinon were equally effective against the mealybugs in the single application field experiment. Over 90% of adult mealybugs had died at 14 days after application. The mortality rate increased over time with 98% mortality at 45 days after application (**Table 2**). Malathion, Dimethoate, Endosulfan and Fenitrothion were less effective (**Table 2**). In line with the single application trials,

Table 1 Mortality of *Cataenococcus ensete* on enset seedlings treated with different insecticides in a green house experiment.

Treatments	Observed mean mortality (%)	Corrected mortality (%)
Diazinon 60% EC	100. ± 0.0 a	84.13 a
Chloropyrifos 48% EC	97.6 ± 1.0 a	80.23 a
Malathion 50% EC	83.2 ± 1.9 ab	67.30 b
Fenitrothion 50% EC	76.8 ± 2.3 b	60.89 b
Endosulfan 50% EC	74.4 ± 4.1 b	58.53 b
Dimethoate 40% EC	64.8 ± 3.4 b	48.87 c
Control (untreated)	16.0 ± 3.5 c	---
CV	16%	

Means followed by the same letter within a column are not significantly different from each other according to Tukey's HSD test ($P <0.05$).

Table 2 Mortality of *Cataenococcus ensete* on enset plants after a single treatment with different insecticides under farmers' field conditions.

Treatments	Mean mortality (%)		
	15 days	30 days	45 days
Diazinon 60%EC	96.5 ± 1.4 a	97.7 ± 1.2 a	98.1 ± 1.1 a
Chlorpyrifos 48%EC	93.7 ± 1.9a	95.4 ± 1.3 a	97.9 ± 1.2 a
Malathion 50%EC	75.3 ± 1.6 b	67.4 ± 2.2 b	49.7 ± 1.6 c
Endosulfan 50%EC	61.3 ± 2.7 c	58.9 ± 1.9 c	50.8 ± 3.0 c
Dimethoate 40%EC	53.5 ± 1.4 c	60.2 ± 1.9 c	64.8 ± 2.9 b
Fenitrothion 50%EC	61.9 ± 3.7 c	55.1 ± 1.9 c	51.0 ± 1.8 c
CV (%)	14.7	8.2	11.5

Means followed by the same letter within a column are not significantly different from each other according to Tukey's HSD test ($P <0.05$).

Table 3 Mortality of *Cataenococcus ensete* on enset plants after a double treatment (the 2nd treatment was applied 2 weeks after the 1st treatment) using different insecticides under farmers' field condition.

Treatment	Mean mortality (%)		
	15 days	**30 days**	**45 days**
Diazinon 60% EC	100.0 ± 0.0 a	100.0 ± 0.0 a	99.1 ± 0.9 a
Chlorpyrifos 48% EC	98.4 ± 1.6 a	98.9 ± 1.1 a	99.2 ± 0.8 a
Malathion 50% EC	87.1 ± 2.1 b	78.3 ± 2.6 b	64.9 ± 4.2 bc
Endosulfan 50% EC	73.4 ± 0.6 c	61.0 ± 1.4 c	52.8 ± 0.7 c
Fenitrothion 50% EC	71.4 ± 1.6 c	62.2 ± 3.1 c	54.1 ± 1.1 c
Dimethoate 40% EC	67.3 ± 1.0 c	75.6 ± 1.1 b	74.7 ± 1.6 b
CV (%)	9.4	21.0	9.8

Means followed by the same letter within a column are not significantly different from each other according to Tukey's HSD test (P <0.05).

Chlorpyrifos and Diazinon were most effective in controlling the mealybugs in the double application experiment (**Table 3**). The single and double applications of Chlorpyrifos and Diazinon caused nearly a 100% mortality of *C. ensete* (**Tables 2, 3**). In addition, first instar nymphs were not observed during the time of data collection. In contrast, a continuous increase of the mealybug population was observed on the control plants (**Table 4**).

In accordance with our observations, Harra *et al*. (2001) reported > 95% mortality rate of coffee root mealybugs when applying 48% Chlorpyrifos. The authors also indicated that commercially available insecticides like Diazinon, Fenitrothion, Malathion, Imidachloprid, Dimethoate or Formathion may also provide control of coffee root mealybugs.

The standard planting density of enset is 1.5 m × 1.5 m with a total population of 4,444 enset plants per ha (Diro 1997). The cost incurred for a one time application of one ha of enset plants with Chloropyrifos, Diazinon, Fenitrothion, Malathion and Endosulfan was respectively 240, 150, 90, 90 and 90 USD.

CONCLUSIONS

The insecticides Diazinon and Chloropyrifos provided the best control of *C. ensete* compared to the other insecticides with at least a 98% mortality rate regardless of the number of applications. The efficacy of a double application of Malathion, Fenitrothion, Endosulfan and Dimetohate was inferior to a single application of either Chlorpyrifos or Diazinon. Therefore a single application of Diazinion or Chlorpyrifos is recommended. However, it is advisable/imperative that farmers continuously monitor infestation levels in their enset plots by assessing adult root mealybug numbers in soil samples dug out adjacent to the corms and repeat insecticide applications when a mealybug population build up is observed. The use of agro-chemicals should however not stand alone. Appropriate cultural practices and possibly bio-control should also be explored for an integrated approach in controlling enset root mealy bugs.

ACKNOWLEDGEMENTS

The authors thank the Flemish Association for Development Co-operation and Technical Assistance (VVOB) for its financial assistance.

REFERENCES

Abbott WS (1925) A method of computing the effectiveness of insecticides. *Journal of Economic Entomology* **18**, 265-267

Addis T, Azerefegne F, Blomme G, Kanaujia K (2008a) Biology of the enset root mealybug, *Cataenococcus ensete* and its geographical distribution in Southern Ethiopia. *Journal of Applied Biosciences* **8**, 251-260

Addis T, Azerefegne F, Blomme G (2008b) Density and distribution of enset root mealybug. *African Crop Science Journal* **16**, 67-74

Azerefegne F, Addis T, Alemu T, Lemawork S, Tadesse E, Gemu M, Blomme G (2009) An IPM guide for enset root mealybug (*Cataenococcus ensete*) in enset production. Bioversity International, Uganda and France offices, 18 pp

Baker R, Simmonds NW (1953) The genus *Ensete* in Africa. *Kew Bulletin* **3**, 405-416

Bezuneh T, Feleke A (1966) The production and utilization of the genus *Ensete* in Ethiopia. *Economic Botany* **20**, 65-70

Brandt SA, Anita S, Clifton H, Terrence MCJ, Endale T, Mulugeta D, Gizachew WM, Gebre Y, Masyoshi S, Shiferaw T (1997) *The "Tree against Hunger": Enset-based Agricultural Systems in Ethiopia*, American Association for the Advancement of Science, Washington, DC, USA, 56 pp

Clifton H (1996) Yield of *Ensete ventricosum* a concept. In: *Proceedings of Enset-Based Sustainable Agriculture in Ethiopia*, 13-20 December 1993, Institute of Agricultural Research in Ethiopia, Addis Ababa, Ethiopia, pp 15-35

Diro M (1997) Effect of propagation method and corm type on number and growth of enset (*Ensete ventricosum*). Msc thesis, Alemaya University of Agriculture, Alemaya, Ethiopia, 59 pp

Fujimoto T (1997) Enset and its varieties among the Malo, Southwestern Ethiopia. In: Fukiui K, Kurimoto E, Shigeta M (Eds) *Ethiopia in Broader Perspective. Paper of 13th International Conference of Ethiopian Studies* (Vol III), 12-17 December 1997, Kyoto, Japan, Shokodo Book Seller, Kyoto, pp 867-888

GenStat (2003) VSN International. GenStat (7th Edn), Lawes Agricultural Trust

Hara AH, Nino-Duponte RY, Jacobsen CM (2001) Root mealybugs of quarantine significance in Hawaii. Cooperative Extension Service, CTAHR, University of Hawaii, Manoa. 4 pp. Available online: http://www.ctahr.hawaii.edu/oc/freepubs/pdf/IP-6.pdf

Hölscher D, Schneider B (1998). Phenylphenalenones from *Ensete ventricosum. Phytochemistry* 49, 2155-2177

Nida W (1996) The Gurage perception of enset. In: Abate T, Hiebsch C, Brandt S, Gebremariam S (Eds) *Enset-Based Sustainable Agriculture in Ethiopia. Proceedings of the International Workshop on enset*, 13-20 December 1993, Institute of Agriculture Research Addis Ababa, Ethiopia, pp 132-137

Simmonds NW (1958) *Ensete* cultivation in the Southern highlands of Ethiopia: A review. *Tropical Agriculture* **35**, 302-307

Tadesse E (2006) Evaluation of some synthetic and botanical insecticides against the enset root mealybug (*Cataenococcus ensete*) (*Homoptera: pseudococcidae*) William and Matile-Fererro in Southern Ethiopia. MSc thesis, Hawassa University, Awassa, Ethiopia, 67 pp

Tenkouano A, Hauser S, Coyne D, Coulibaly O (2006) Clean planting materials and management practices for sustained production of banana and plantain in Africa. *Chornica Horticulturae* **46**, 14-18

Tsedeke A (1988) *Insect and Mite Pests of Horticultural and Miscellaneous Plants in Ethiopia*, Handbook, Addis Ababa, Ethiopia, 115 pp

Westphal E (1975) *Agricultural System in Ethiopia*, Center for Agricultural Publishing and Documentation, Wageningen, 278 pp

Table 4 Number of surviving mealybugs on enset roots after a single and double treatment using different insecticides under farmers' field conditions (Mean ± se).

Treatment	Single application			Double application#		
	15 days	**30 days**	**45 days**	**15 days**	**30 days**	**45 days**
Diazinon 60% EC	0.9 ± 0.4 c	0.50 ± 0.3 c	0.75 ± 0.4 d	0.0 ± 0.0 d	0.0 ± 0.0 d	0.3 ± 0.3 d
Chlorpyrifos 48% EC	1.1 ± 0.4 c	1.57 ± 0.5 c	0.50 ± 0.3 d	0.3 ± 0.3 d	0.2 ± 0.2 d	0.4 ± 0.4 d
Malathion 50% EC	4.0 ± 0.5 bc	7.70 ± 1.0 b	7.90 ± 1.0 bc	2.7 ± 0.8 c	3.8 ± 0.5 c	6.5 ± 1.6 bc
Endosulfan 50% EC	7.3 ± 1.8 b	7.25 ± 1.8 b	9.60 ± 2.5 b	4.0 ± 0.8 bc	8.7 ± 1.7 b	8.2 ± 1.8 b
Fenitrothion 50% EC	7.1 ± 1.5 b	8.00 ± 0.8 b	5.50 ± 1.3 c	5.3 ± 0.0 bc	7.3 ± 1.9 bc	8.3 ± 1.3 b
Dimethoate 40% EC	7.9 ± 0.9 b	9.20 ± 2.2 b	9.20 ± 1.3 b	6.7 ± 1.4 b	5.7 ± 1.0 bc	3.7 ± 0.5 c
Control	34.2 ± 5.2 a	58.9 ± 12.1a	53.6 ± 12.6 a	54.0 ± 9.9 a	51.0 ± 10.8 a	62.5 ± 12.4 a

#: the 2nd treatment was applied 2 weeks after the 1st treatment;
Means followed by the same letter within a column are not significantly different from each other according to Tukey's HSD test (P <0.05)