Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 7 (4): 575-579, 2007
ISSN 1812-5654

Field Evaluation of a Novel Pyrrolizidine Alkaloid Attracticide for the Management of *Zonocerus variegatus* on Cabbage

[1]J.A. Timbilla, [2]B.W. Lawson and [2]K. Yeboah-Gyan
[1]Crops Research Institute, P.O. Box 3785, Kumasi, Ghana
[2]Department of Theoretical and Applied Biology,
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Abstract: Cabbage, *Brassica oleraceae* var. *capitata* is an important vegetable grown and consumed in Ghana. Apart from infestations of the lepidopterous *Plutella xylostella* and *Hellula undalis* resulting from continuous cultivation, a new pest *Zonocerus variegatus* has been reported to causing damage to the crop. The efficacy of a novel pyrrolizidine alkaloid (PA) based novel PA-attracticide developed from treating the roots of the neophyte, *Chromolaena odorata* which contains PAs with Carbofuran 3G for the management of *Z. variegatus* was tested using cabbage as a test crop in field caged plots. Field caged plots of cabbage artificially infested with *Z. variegatus* were treated with and without PA-attracticide in addition to a control treatment of caged cabbage plot with no insect and PA-attracticide. The experimental design was a RCB replicated three times in two ecological zones. The results showed that the establishment, leaf and head damage of cabbage was statistically the same in the PA-treated plots and the control treatment. These treatments, however, performed significantly better than the treatment without PA-attracticide. The results obtained holds promise for mitigating the menace of the grasshopper on cabbage using PA based attracticides.

Key words: *Brassica oleracea*, *Chromolaena odorata*, *Hellula undalis*, *Plutella xylostella*, *Pyrrolizidine alkaloids*, *Zonocerus variegatus*

INTRODUCTION

Cabbage, *Brassica oleraceae* var. *capitata* (L.) Alef. (Brassicaceae) is a very important vegetable for both the rural and urban inhabitants of Ghana. The crop has replaced many indigenous green vegetables and is now cultivated all year round (Timbilla, 1997). The continuous cultivation of the crop has, however, led to the proliferation, particularly of *Hellula undalis* (Fabricius) (Lepidoptera: Pyralidae), *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) and aphids, *Brevicoryne brassica* (L.) (Homoptera: Aphididae) (Timbilla, 1997).

Surveys conducted in 2003 revealed that late instar nymphs and adults of *Z. variegatus* cause economic damage to cabbage within a fortnight of attack (Timbilla, 2006). The damage was observed to primarily occur in cabbage fields close to hatching sites of both dry and wet season populations of *Z. variegatu* and up to 26 insects could be counted per plant. Damage attributed to vegetables including cabbage by *Z. variegatus* is documented in Ghana (Timbilla, 1997; Afreh-Nuamah, 2004).

A number of sex pheromone attracticides are available for the management of lepidopteran pests of vegetables including cabbage (Mitchel and Mayers, 2001; Mayers and Mitchell, 2002; Reddy *et al*., 2002; Cork *et al*., 2003; Badenez-Perez *et al*., 2004; Trimble *et al*., 2004). However, no known attracticides are available for the management of orthopteran pests, particularly, a peculiar insect such as *Z. variegatus*.

Recent chemoecological studies by Boppré (1991) have revealed that *Z. variegatus* is strongly attracted to volatile derivatives (PAs) from the dry roots and fresh flowers of *C. odorata* which contain pyrrolizidine alkaloids. It is thought that a pest management strategy could be developed based on the ‘hunger’ of *Z. variegatus* for PAs (Boppré and Fischer, 1994; Fischer and Boppré, 1997).

This study was conducted to assess the effectiveness of the pyrrolizidine alkaloids in the root of *C. odorata* used in combination with Carbofuran® 3G as attracticide bait for the management of *Z. variegatus* on cabbage field.

MATERIALS AND METHODS

Cultivation of cabbage seedlings: The experiment was conducted on field plots located in Cape Coast and

Corresponding Author: J.A. Timbilla, Crops Research Institute, P.O. Box 3785, Kumasi, Ghana
Tel: 00233 243 463795 Fax: 00233 51 60396

Kumasi. Cape Coast has coastal savannah vegetation and Kumasi occurs in the moist Semi-deciduous forest zone. The trial in Cape Coast was conducted from August-November, 2003 and the one in Kumasi from February-May, 2004.

Cabbage seeds of the variety oxylus were nursed on two field beds, measuring 2×1 m close to each experimental site. The nursery beds were sterilized by burning wooden pieces gathered on each bed for about 30 min and allowed to cool overnight. The seeds were then drilled with a wooden stick along lines, spaced 15 cm apart on the beds, covered with a thin layer of sand and adequately watered. The plots were then covered with palm fronds to preserve moisture for germination.

The palm fronds were removed after 10 days and the seedlings were thinned out to a population of about 500 healthy seedlings per bed. Subsequently, the seedlings were covered with a nylon mosquito mesh (1 mm^2 size) built to the specifications of the plots to protect them from insect damage and watered as and when necessary until they were ready for transplanting onto the experimental plots.

Experimental plot: The seedlings were transplanted at 4 week onto field plots measuring 2.1×0.75 m at 0.45×0.45 m within and between rows with a plant population of 10 per plot. This was done in the evening to avoid heat shock to the seedlings. The treatments were as follows:

- Cabbage seedlings with only *Z. variegatus*
- Cabbage seedlings with *Z. variegatus* exposed to PA-attracticide
- Sole cabbage seedlings with no *Z. variegatus* and no attracticide (control)

Each treatment plot was covered with a nylon mesh and the insects were introduced 2 week after transplanting. The experiment was conducted in a randomised complete block design with 3 replications. Data was taken from all the 10 plants in each treatment plot. The attracticide treatment was replaced 3 times at 3 weekly intervals. Insects used for the experiment were collected as early hatchlings from the field and reared on cassava foliage in the laboratory following the method of Cobbinah and Tuani (1992) till they reached the 3rd instar stage.

Fifty 3rd instar nymphs of *Z. variegatus* were counted into Kilner jars and introduced into each plot except for the control. The attracticide consisted of 300 g weight of the dry chopped roots of *C. odorata* soaked in 1.0% (w/v) Carbofuran® 3G solution and dried in the sun for 3 h (Timbilla, 2006). The bait consisted of a hexagonal wire mesh (about a cm wide) containing the attracticide and placed 10 cm above the soil, at two positions (the 1st and 2nd third) in each treatment plot. Weeds were controlled by hand picking by opening the sides of the net at 3 and 6 weeks after transplanting. Data on surviving cabbage plants was taken at the end of each experiment. Leaf damage of each individual plant per plot was estimated using a 1-5 point scale (Timbilla, 1997) presented below, at weekly intervals after the introduction of the insects. The yield of the plants as indicated by weight of head was also measured at harvest.

Damage score scale:

- 0-5% leaf defoliation
- 6-15% ,,
- 16-25% ,,
- 26-50% ,,
- >50% ,,

Additionally, damage of cabbage head (using the same scale above) and data on surviving nymphs were determined when the experiment was terminated. The trapped insects in the nets were removed and counted before harvesting.

Data analysis: All count data was transformed by the formula $y = \sqrt{(x + 0.5)}$ and subjected to One-Way Analysis of Variance (ANOVA) using GraphPad Prism® statistical package version 4.00 (GraphPad Prism® 4.00, 2003). Mortalities encountered in the treatment with cabbage and only *Z. variegatus* were corrected with Abbott's correction formula (Abbott, 1925).

RESULTS

Cabbage leaf damage: The estimated damage done to the crop by *Z. variegatus* is presented in Fig. 1. The results clearly indicated that significant damage was done by *Z. variegatus* in the treatment without attracticide.

The damage was more pronounced from the 6th and 3rd week for the trials conducted at Cape Coast and Kumasi, respectively. The mean leaf damage score recorded at the end of the trials at Cape Coast were 4.3, 2.8 as against 1 and 5.0, 2.7 and 1 at Kumasi for treatments without attracticide, treatment with attracticide and the control, respectively ($p<0.05$).

Surviving plant population: The surviving cabbage plants at the end of trial 1 conducted in Cape Coast was 36.7, 73.3 and 100% in respect of the treatments without attracticide, with attracticide and control (Fig. 2). The percentage surviving plants on the control treatment was significantly higher than the treatment with attracticide which was also significantly higher than the treatment without attracticide ($p<0.05$).

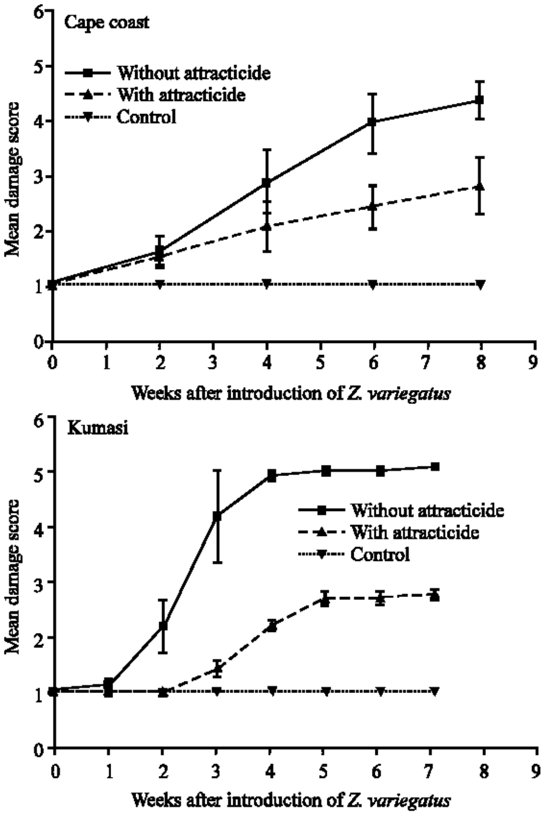

Fig. 1: The damage done to cabbage by *Z. variegatus* caged with and without *C. odorata* attracticide and sole cabbage Control, Cape Coast and Kumasi. Bars indicate standard error of means

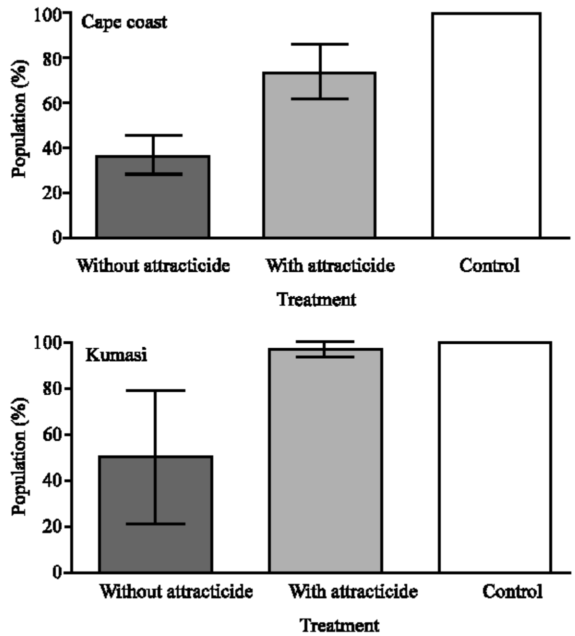

Fig. 2: Surviving cabbage plants caged with *Z. variegatus* and with or without *C. odorata* attracticide and a sole cabbage control 8 weeks after attracticide application at Cape Coast and Kumasi. Bars indicate standard error of means

In trial 2, planted in Kumasi, the surviving plants at the end of the experiment in the control and treatment with attracticide were statistically the same i.e., 100.0 and 96.7%, respectively ($p<0.05$) (Fig. 2). These two treatments, however, recorded significantly higher plant population than the treatment without attracticide which recorded a plant population of 49.0% ($p<0.05$).

Yield of cabbage head: The mean yields recorded for trial 1 (Cape Coast) were 0.9, 1.0 and 1.2 kg per cabbage head for treatments without and with attracticide and control, respectively (Table 1) with yield on the control treatment being significantly heavier than on the treatment without attracticide ($p<0.05$).

Treatment without attracticide was statistically the same as the one with attracticide which was also statistically the same as the control (Table 1).

In trial 2 (Kumasi), the yields were very low but followed a similar pattern in the order 0.3, 0.5 and 0.5 kg plant^{-1} in respect of treatments without and with attracticide and control (Table 1). Treatment with

Table 1: Yield of cabbage under artificial infestation of *Z. variegatus* caged with and without *C. odorata* attracticide and sole cabbage control

Location	Without attracticide (kg plant^{-1}±SE)	With attracticide (kg plant^{-1}±SE)	Control (kg plant^{-1}±SE)
Cape coast	0.9±0.31	1.0±0.21	1.2±0.20
Kumasi	0.3±0.26	0.5±0.15	0.5±0.22

n = 10

Table 2: Head damage score of cabbage caged with *Z. variegatus* and with and without *C. odorata* root attracticide and sole cabbage control

Location	Without attracticide (Mean±SE)	With attracticide (Mean±SE)	Control (Mean±SE)
Cape coast	4.3±0.578	1.9±0.751	1.0±0.0
Kumasi	4.8±0.231	1.4±0.200	1.0±0.0

attracticide and control were statistically the same and both were significantly higher than the plots without attracticide ($p<0.05$) (Table 1).

Head damage of cabbage: At Cape Coast, cabbage head damage scores were 4.3 and 1.9 for treatments without and with attracticide, respectively, with the former being significantly higher than the latter treatment ($p<0.05$). However, the treatment with attracticide recorded a statistically higher head damage than the control treatment which did not suffer any damage ($p<0.05$) (Table 2).

Cabbage head damage score of 4.8 was recorded for the treatment without attracticide in the trial conducted in

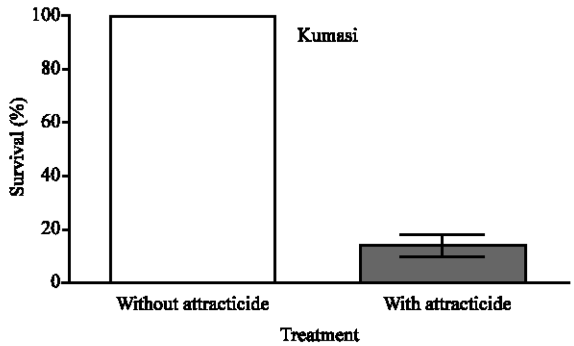

Fig. 3: Survival of *Z. variegatus* caged with and without *C. odorata* root attracticide, 8 week after attracticide application. Bars indicate standard error of mean

Kumasi which was significantly higher than the score of 1.3 for the treatment with attracticide ($p<0.05$) (Table 2). Cabbage head damage score for treatment with attracticide was significantly higher than the control treatment ($p<0.05$).

Survival of *Z. variegatus*: Results from trial 2, conducted in Kumasi, indicated a percentage survival of 14.0% of *Z. variegatus* in the treatment with attracticide. This was significantly lower, compared with the corrected survival in the treatment without attracticide which was originally 8.3% ($p<0.05$) (Fig. 3).

DISCUSSION

The results of the experiments have demonstrated clearly that the PA-attracticide developed trap could be used to reduce damage caused by *Z. variegatus* to the crop plants. The bait lured the insects from the plants on which they were caged, thus reducing the damage done. The construction of the bait is simple, non-hazardous, of low-cost and could easily be produced at the cottage level. The bait could, therefore, be used to help control the damage of the insect to crops such as cabbage which is often cultivated on small scale.

The head damage score above 4.0 observed in the treatment without attracticides, equivalent to damage between 25 and 50% is ranked below marketable standard (Timbilla, 1997) and confirms the assertion that *Z. variegatus* can cause serious crop loss if they are not controlled. Cabbage is known to suffer serious attack by *H. undalis* and *P. xylostella* which sometimes cause total yield loss (Anonymous, 1992). Thus any feeding damage by *Z. variegatus* will increase its potential threat to the cabbage industry.

On the other hand, the score of less than 2.0 for the treatment with attracticide indicates a damage below 15% which is acceptable by elite consumers who are conscious of pesticide contamination of vegetables (Timbilla, 1997).

The literature reports on work done on the management of lepidopteran pests of cabbage with attracticides (Mitchel, 2002; Khrimian *et al*., 2002; Millar *et al*., 2002) with promising results for their potential use (Jacobson *et al*., 1976; Baur *et al*., 1998; Reddy and Guerrero, 2000; Badenes-Perez *et al*., 2004). Unfortunately, however, there is no basis for comparison of the available literature with this novel PA-attracticide developed since the behaviour of *Z. variegatus* is completely different and secondly the mode of action of pheromone attracticides is different from the PA-attracticide which depend on gustatory response and not contact as in the case of pheromone traps.

The suggested use of attracticides in the management of *Z. variegatus* in cabbage fields is compatible with the current management of the crop with biological and chemical insecticides and this will be more compliant in the foreseeable future when pheromone attracticides catch up with farmers in the sub region. Perhaps a few poisoned roots scattered in and around infested fields could substantially reduce the pest population below damaging levels during their entry and exit of the cultivated land.

In a study on cabbage, the cost of applying Karate® 2.5 EC to control lepidopteran pests sprayed at weekly intervals according to farmer practice on a similar plot size as used in the present study was \$8.9 (Timbilla, 2006). In the present study, the cost of preparing a 300 g weight of PA-attracticide with Carbofuran® 3G is estimated at \$0.02. With the same plot size, it will require (2×\$0.02.00×3 plots) yielding \$0.12 in addition to the cost of the metal mesh, estimated at \$0.56 each for each plot. Thus, the overall cost for usage of the PA-attracticide is estimated at \$1.8.

Notwithstanding the fact that it would require a higher concentration of chemical insecticide to control *Z. variegatus* on a similar plot, the comparison with lepidopteran pests still makes the usage of the PA-attracticides cheaper. Also, considering the environmental hazards posed to operators, consumers and beneficial arthropods attributed to the use of chemical insecticides, PA-attracticides are specific and thus environmentally friendly, adding to its advantage as a cheaper, environmentally friendly and novel way of managing the grasshopper.

It is concluded from the results of this study that PA-attracticides hold promise in mitigating the menace of *Z. variegatus* in infested cabbage and other vegetable fields.

ACKNOWLEDGMENTS

The authors are very grateful to Prof. Dr. Michael Boppré and O.W. Fischer, both of the Forstzoologisches Institut, Freiburg, Germany for their useful comments during preparation of this manuscript.

REFERENCES

Abbott, W.S., 1925. A method of computing the effectiveness of an insecticide: J. Econ. Entomol., 18: 265-267.

Afreh-Nuamah, K., 2004. The status of IPM in Ghana. [online] http://www.ag.vt.edu/all/Proceedings/ghana.htm (November 3, 2004).

Anonymous, 1992. Management of Diamondback Moth and Other Crucifer Pests. Talekar, N.S. (Ed.), Proc. 2nd Int. W' shop. AVRDC. Shanhua, Taiwan, pp: 603.

Badenes-Perez, F.R., A.M. Shelton and B.A. Nault, 2004. Evaluating trap crops for diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae). J. Econ. Entomol., 97: 1365-1372.

Baur, M.E., H.K. Kaya, B.E. Tabashnik and C.F. Chilcutt, 1998. Suppression of diamondback moth (Lepidoptera: Plutellidae) with an entomopathogenic nematode (Rhabditida: Steinernematidae) and *Bacillus thuringiensis* Berliner. J. Econ. Entomol., 91: 1089-1095.

Boppré, M., 1991. A non-nutritional relationship of *Zonocerus variegatus* (Orthoptera) to *Chromolaena odorata* (Asteraceae) and general implications for weed management. BIOTROP Spec. Publ., 44: 153-157.

Boppré, M. and O.W. Fischer, 1994. *Zonocerus* and *Chromolaena* in West Africa: A Chemoecological Approach Towards Pest Management. In: New Trends in Locust Control. Krall, S. and H. Wilps (Eds.), GTZ GmbH, Eschborn. Germany, pp: 107-126.

Cobbinah, J.R. and G.K. Tuani, 1992. Antifeedant effect of *Jatropha curcas* L. seed oil and extracts on the variegated grasshopper, *Zonocerus variegatus* L. (Orthoptera: Acridae). J. Univ. Sci. Tech., 12: 136-139.

Cork, A., S.N. Alam, F.M. Rouf and N.S. Talekar, 2003. Female sex pheromone of brinjal fruit and shoot borer, *Leucinodes orbonalis* (Lepidoptera: Pyralidae): trap optimization and application in IPM trials. Bull. Entomol. Res., 93: 107-113.

Fischer, O.W. and M. Boppré, 1997. Chemoecological Studies Reveal Causes for Increased Population Densities of *Zonocerus* (Orth.: Pyrgomorphidae) and Offer New Means for Management. In: New Stategies in Locust Control. Krall, S., R. Peveling and D. Ba Diallo (Eds.), Birkhauser Verlag Basel. Switzerland, pp: 267-282.

GraphPad Prism® 4.00, 2003. GraphPad Software, San Diego, California, USA. www.graphpad.com.

Jacobson, M., V.E. Adler, A.N. Kishaba and E. Priesner, 1976. 2-Phenylethanol, a presumed sexual stimulant produced by the male cabbage looper moth, *Trichoplusia ni*. Experientia, 32: 964-966.

Khrimian, A., J.A. Klun, Y. Hijji, Y.N. Baranchikov, V.M. Pet'ko, V.C. Mastro and M.H. Kramer, 2002. Syntheses of (Z,E)-5,7-dodecadienol and (E,Z)-10,12-hexadecadienol, Lepidoptera pheromone components, via zinc reduction of enzyme precursors. Test of pheromone efficacy against the Siberian moth. J. Agric. Food Chem., 50: 6366-6370.

Mayers, M.S. and E.R. Mitchell, 2002. (Z)-7-dodecenyl acetate: A supernormal stimulus of *Trichoplusia ni* (Hubner) (Lepidoptera: Noctuidae) sex pheromone behaviour. J. Environ. Sci. Health B., 37: 161-172.

Millar, J., J.S. McElfresh and F. de Assis Marques, 2002. Unusual acetylenic sex pheromone of grape leaffolder (Lepidoptera: Pyralidae). J. Econ. Entomol., 95: 692-698.

Mitchell, E.R. and M.S. Mayers, 2001. *Spodoptera exigua*: Mating disruption, measurement of airborne concentration of pheromone and use of specialist receptor cell responses for comparison to female pheromone emission. J. Environ. Sci. Health B., 36: 467-488.

Mitchell, E.R., 2002. Promising new technology for managing diamondback moth (Lepidoptera: Plutellidae) in cabbage with pheromone. Environ. Sci. Health B., 37: 277-290.

Reddy, G.V. and A. Guerrero, 2000. Behavioural responses of the diamondback moth, *Plutella xylostella*, to green leaf volatiles of *Brassica oleracea* subsp. *capitata*. J. Agric. Food Chem., 48: 6025-6029.

Reddy, G.V., J.K. Holopainen and A. Guerrero, 2002. Olfactory responses of *Plutella xylostella* natural enemies to host pheromone, larval frass and green leaf cabbage volatiles. J. Chem. Ecol., 28: 131-43.

Timbilla, J.A., 1997. Integrated pest management of the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae) in Ghana. MPhil Thesis, Kwame Nkrumah Univ. Sci. Tech. Kumasi, Ghana, pp: 125.

Trimble, R.M., A.M. El-Sayed and D.J. Pree, 2004. Impact of sub-lethal residues of azinphos-methyl on the pheromone-communication systems of insecticide-susceptible and insecticide-resistant obliquebanded leafrollers *Choristoneura rosaceana* (Lepidoptera: Tortricidae). Pest Manage. Sci., 60: 660-668.

Timbilla, J.A., 2006. Management of the African Grasshopper, *Zonocerus variegatus* (L.) Orthoptera: Pyrgomorphidae) in Ghana. The role of *Chromolaena odorata*. Ph.D Thesis, Kwame Nkrumah Univ. Sci. Tech. Kumasi, Ghana, pp: 174.