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HOST RELATED VARIATION IN CARBOXYLESTERASE ACTIVITY OF THE WHITEFLY *Bemisia tabaci* (GENNADIUS) POPULATIONS ON CABBAGE AND GARDEN EGG

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ABSTRACT

The sweet potato whitefly *Bemisia tabaci* is a major pest of several crops including vegetables in Ghana. In this study, the effect of two host crops, cabbage and garden egg on *B. tabaci* carboxylesterase (CaE) activity, a major insecticide detoxification enzyme was observed in three vegetable growing sites. The *B. tabaci* populations on cabbage had higher CaE activity levels compared with garden egg populations. This observed difference in enzyme activity of *B. tabaci* on hosts was significant in two of the three sampled sites. The CaE activity levels of *B. tabaci* from the sampled sites also varied and were also significant. There was also a significant host site interaction effect on the CaE activity of *B. tabaci* populations. This provides useful information for integrated pest management formulation for each host crop in these specific vegetable growing areas.

Keywords: *Bemisia tabaci*, carboxylesterase, host crop, cabbage, garden egg.

INTRODUCTION

The sweet potato whitefly *Bemisia tabaci* is a globally distributed pest (Dinsdale *et al.,* 2010) that affects several crops and ornamental plants resulting in severe economic losses (Oliviera *et al.*, 2001; EPPO, 2004). It affects plants both directly and indirectly. Direct damage on plants is due to its feeding activity, by sucking phloem sap and this affects the development of the affected plants (Inbar and Gerling, 2008). It also excretes honey dew that encourages the growth of sooty mold on plants (Obeng-Ofori, 2007) thereby affecting photosynthetic ability. The secondary indirect damage is the transmission of several viruses to plants. It vectors over 100 plant viruses such as begomoviruses, carlaviruses, criniviruses, ipomoviruses and torradoviruses in a persistent or semipersistent manner (Jones, 2003; Navas-Castillo *et al.,* 2011).

Currently, *B. tabaci* is probably the most important insect pest of vegetables in Ghana (Obeng-Ofori, 2007; Avicor *et al.*, 2011) and this has been attributed to the widespread misuse of insecticides on vegetables such as cabbage, okra, pepper and tomato (Critchley, 1995). Globally, *B. tabaci* has developed resistance to a wide range of insecticide classes due to the intensive application of insecticides for their control (Bacci *et al.,* 2007; Horowitz *et al.,* 2007; Houndété *et al.,* 2010). Detoxification enzymes such as carboxylesterases (CaE) have been associated with insecticide resistance development (Owusu *et al.,* 1995; Li *et al.,* 2007; Alon *et al.,* 2008) and it has been reported that the activity levels of these enzymes in insects could be affected by their host (Liang *et al.,* 2007, Wang *et al.,* 2010; Xue *et al.,* 2010; Xie *et al.,* 2011).

In this study, the CaE activity levels of *B. tabaci* on two host plants in three vegetable growing areas in the city of Accra were studied to observe their host related effect and for the development of appropriate pest management practice for each host plant.

MATERIALS AND METHODS

Biological specimen and sampling sites

Adult whiteflies were collected from cabbage (*Brassica oleracea* L. var *capitata* L.) and garden egg (*Solanum melongena*) in farms at three vegetable growing sites within Accra, the capital city of Ghana namely Ashaiman, Dzorwulu and Haatso.

The whiteflies were reared for 3 generations on their respective host plants and the adults were used for the biochemical assay.

Biochemical assay

The method of determining CaE activity as described by van Asperen (1962) and slightly modified by Owusu *et al.* (1995) was used. Thirty (30) adult whiteflies were randomly sampled from each host for each site.

Preparation of enzyme

Homogenization of each adult whitefly was done in a pre-cooled glass well containing 0.3 ml of phosphate buffer (pH 7.0) and the homogenate used as enzyme source (Owusu *et al.,* 1995).

Measurement of CaE activity

Enzyme extract (100 ul) was added into a test tube containing 2.8 ml of phosphate buffer pH 7.0 and 100 µl of 30 mM α-naphthyl acetate. This reaction was incubated for 10 min at 40 °C. At the end of incubation, 0.5 ml of a solution mixture of sodium dodecyl sulphate-

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fast blue salt (SDS-FBS) was added to terminate the reaction and effect colour development. The optical density of each tube was measured at 600 nm on a Camspec M106 (Spectronic Camspec) spectrophotometer against a control.

Protein content

Two millimeters of reagent B mixture (50 ml of 2% Na_2CO_3 in 0.1 M NaOH added to 0.5 ml each of $CuSO_4$ and $NaC_4O_62H_2O$ to obtain a total ratio of 50:1) was added to 0.1 ml of enzyme extract in a test tube and allowed to stand for 20 min. A 1:1 phenol: water mixture was prepared about 3 min to the end of the incubation period and 0.25 ml of this mixture was added to each test tube content at the end of the incubation period. The reaction was allowed to stand for another 20 min for colour development. Optical density readings were then taken at 750 nm against a control on a Camspec M106 (Spectronic Camspec) spectrophotometer.

Statistical Analysis

The data obtained was analyzed using SPSS v20 (IBM Corp, 2011). Analysis of differences in carboxylesterase activity was done by analysis of variance (ANOVA) and post hoc mean comparisons made with least significant differences (lsd) ($p<0.05$) .

RESULTS

CaE activity variation among hosts at the sites

The CaE activities of *B. tabaci* on the two host vegetables from the three sampled sites varied. The mean CaE activity of whiteflies among cabbage and garden egg at Ashaiman was significantly different ($N=60$, $df=1$, $p<0.001$). This pattern was the same for *B. tabaci* on host plants at Haatso ($N=60$, $df=1$, $p<0.001$). However at Dzorwulu, there was no difference in CaE activity among the hosts plants ($N=60$, $df=1$, $p=0.705$) (Figure-1). Overall, whiteflies on cabbage had higher CaE activity than those on garden egg (Figure-2) and this was statistically significant ($N=180$, $df=1$, $p<0.001$, $lsd=0.24$).

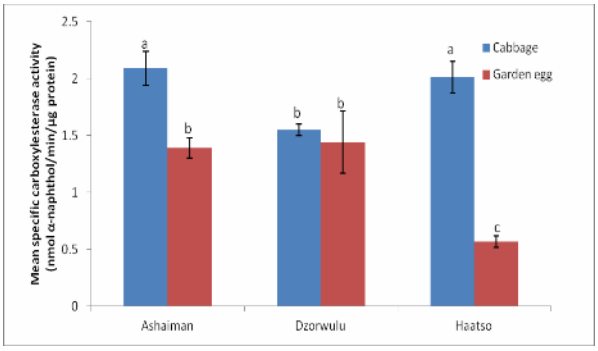

Figure-1. Mean specific carboxylesterase activity of whitefly on host plants in study sites.

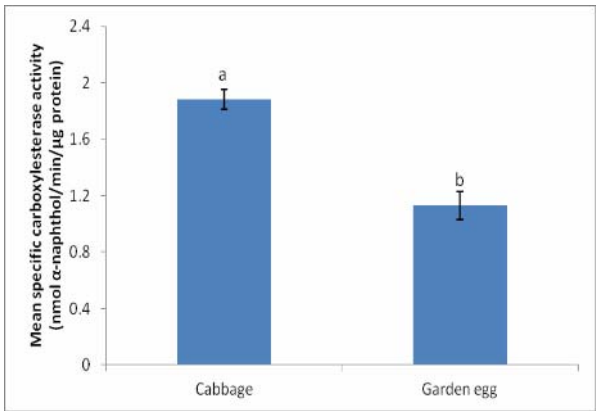

Figure-2. Mean specific carboxylesterase activity of whitefly on cabbage and garden egg.

Among the three sites, the mean difference in the CaE activity of the whitefly populations was significant ($N=180$, $df=2$, $p=0.009$, $lsd=0.29$). The highest mean activity levels were in populations from Ashaiman whilst the lowest was in Haatso populations. Populations from Ashaiman and Haatso were significantly different from each other but not from the Dzorwulu population (Figure-3).

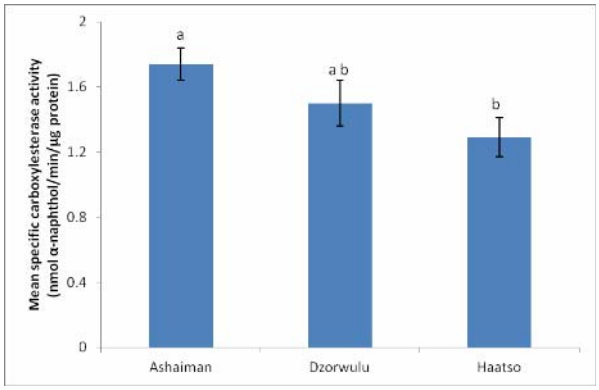

Figure-3. Mean specific carboxylesterase activity of whitefly in vegetable growing areas.

Host site interaction effect on CaE activity

Farmer management practices on host crops in each site especially insecticide application could impact on the insecticide status and potentially the CaE activity of the whitefly populations. The host-site interaction effect on whitefly populations was significant ($N=180$, $df=2$, $p<0.001$, $lsd=0.41$), with CaE activity of whitefly cabbage populations at Ashaiman and Haatso being significantly different from Dzorwulu cabbage populations but not from each other (Figure-1). CaE activity of Haatso whitefly populations on garden eggs were the least among all the populations and significantly different from garden egg populations from Ashaiman and Dzorwulu.

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DISCUSSION

In the natural environment, there is a routine interaction between host plants and phytophagous insects (Whitham *et al.,* 2006) which affects both organisms in these different trophic levels. Plants produce toxic compounds and defensive proteins which affect the physiology of these insect pests in response to the herbivorous feeding behavior of the insects (Howe and Jander, 2008). As a typical co-evolutionary arms race mechanism, the insects alter the activity levels and structure of their detoxification enzymes to counteract plant defenses such as toxins (Howe and Jander, 2008; John and Graeme, 2008), thus the host plants inducing variation in the activity levels of detoxification enzymes and hence affecting insecticide susceptibility.

The CaE activity observed in the *B. tabaci* populations on cabbage was higher than populations on garden eggs and this variation in CaE activity was significant in two sites. Though this variation was not significant in the Dzorwulu site, the mean activity levels of *B. tabaci* cabbage populations was higher than garden egg populations. The relationship between host plant induction effect and CaE activity as well as insecticide status in herbivorous insects has been reported in some insects. Xie *et al.* (2011) observed that CaE activity of *B. tabaci* populations after a 3-year host induction on cabbage was the highest compared to the other hosts (poinsettia, cucumber, cotton and tomato) and significantly differed from populations on tomato, cotton and poinsettia.

In a susceptibility study, *B. tabaci* populations on cotton were significantly more tolerant to deltamethrin, omethoate and abamectin compared to populations on cucumber after being reared on their respective host in a greenhouse for about 9 generations, however the population on cucumber and cotton had higher CaE activity levels as compared to those on vegetable marrow and pumpkin (Liang *et al.,* 2007). Similar host plant inductive effect on insecticide sensitivity was also reported by Castle *et al*. (2009), whereby populations reared on plants from the genus brassica were significantly tolerant to bifenthrin and endosulfan in comparison with cantaloupes and cotton population in the field. Variations in detoxification enzymes activity in the oriental tobacco budworm *Helicoverpa assulta*, the tobacco cutworm *Spodoptera litura*, the beet armyworm *S. exigua,* and the tea mosquito bug *Helopeltis theivora* on different hosts have also been observed (Wang *et al.,* 2010; Xue *et al.,* 2010; Zhang *et al.,* 2011, Saha *et al.,* 2012). The host plant effect on insect CaE activity could vary depending on the insect species as shown by Liang *et al.* (2007) in which *B. tabaci* had a significantly higher activity compared to *Trialeurodes vaporariorum* reared on the same host. However, studies on host plant induction effect on activity levels of detoxification enzymes and insecticide susceptibility are not so simplified since responsiveness to insecticides could be affected by inherent factors such as the presence and densities of bacteria symbionts in *B. tabaci* (Kontsedalov *et al.,* 2008; Ghanim and Kontsedalov, 2009).

Across the three study sites, CaE activity levels of *B. tabaci* varied significantly and this could be due to the pest management system at these sites. Chemical control is the dominant management practices against the whitefly in these sites, however, farm records on insecticide application schedules were inconsistent (Avicor *et al.,* 2011). The interactive effect between site and host plants was significant showing that the CaE activity of local whitefly populations could vary differently and thus management strategies should be both crop and area specific. This information is useful to augment and help in managing local populations of *B. tabaci* on their respective hosts. This is relevant in drawing up integrated pest management (IPM) practices for each host crop in a specific vegetable growing area.

CONCLUSION

Thus different host plants can influence the activity levels of CaE in *B. tabaci* and hence affect their susceptibility to insecticides. Further studies on the host induced activity of other detoxification enzymes in these populations will add to the current knowledge and serve as an aid for managing and controlling *B. tabaci* on these specific host crops.

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