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Ceratovacuna lanigera (Zehnt) Induces Biochemical Changes in Sugarcane

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Abstract: The wooly aphid *Ceratovacuna lanigera* (Zehnt) is one of the dreaded pests of sugarcane. The present investigation deals with the biochemical changes occurring during sugarcane wooly aphid infestation. At low infestation level chlorophyll a, b and total chlorophyll was reduced to 23, 08 and 18%, respectively as compare to healthy plant. At high infestation, level of chlorophyll a, b and total chlorophyll was further reduced to 40, 30 and 37%, respectively. On the contrary level of polyphenol was increased with the level of infestation and about 41% increase was observed at high infestation level. The juice quality analysis had shown that pest infestation also affect juice quality considerably.

Key words: Sugarcane, wooly aphid, biochemical changes, polyphenols, *Ceratovacuna lanigera*

INTRODUCTION

Sugarcane is an important cash crop of India (Ganeshaiah *et al*., 2003; Anonymous, 2003). Economy of the numbers of farmer families, especially in the Maharashtra and Utter Pradesh states of India depend on the sugarcane cultivation (Ganeshaiah *et al*., 2003). Sugarcane yield is affected by a variety of borer and sucking pests (Maizawan *et al*., 1995). Sugarcane Wooly Aphid (SWA) (*Ceratovacuna lanigera* Z.) is a sucking pest, generally colonizes at the lower surface of leaves and absorbs sap by damaging leaf tissues (Joshi and Viraktamath, 2004). It was reported to affect most of the popular varieties of sugarcane like Co 86032, Co419, Co8014, Co8011 and Co7527 etc. (Joshi and Viraktamath, 2004; Phukan *et al*., 1988). Excretion products of SWA mainly sugars accumulate on the leaf surface further complicating physiology of plant by supporting the growth of sooty mould fungus (Ghosh, 1988). At present, chemical pesticide is the most preferred option available for the control of insect pests (Anonymous, 2003). Although much appreciated due to their efficacy, chemical pesticide becoming less popular among the farmer community because of the associated environmental and health hazards as well as emergence of pesticide resistance among the pests.

Plants defend themselves against various insect pests, microbes (Knogge, 1996) and herbivores (Agrawal, 1998) attack through passive or pre-existing mechanism like structural barriers (waxy cuticle) (Agrawal, 1998; Jackson and Taylor, 1996; Osborne, 1996). Plant also exhibits induced cellular defense system to protect tissues (Baker *et al*., 1997; Alfano and Collmer, 1996). The induced defense system is also known as active defense system (Baker *et al*., 1997; Alfano and Collmer, 1996). Plants are known to synthesize a variety of compounds with diverse structures, commonly called as secondary metabolites (Baker *et al*., 1997). Majority of these secondary metabolites are produced in response to various insect pests and microbial attack (Baker *et al*., 1997; Alfano and Collmer, 1996; Osborne, 1996). A good numbers of identified secondary metabolites are belonging to the polyphenol group of

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compounds (Keen, 1992; Maleck and Dietrich, 1999; Mauricio *et al*., 1997). The level of phenolic compounds is correlated with pest or microbial resistance of plants. Plants with higher levels of phenolics are more resistant to insect pest, herbivores and microbial attack (Osborne, 1996).

Present study aimed at investigating the effect of *Ceratovacuna lanigera* attack on photosynthetic activity and defense. In present study we have made an attempt to identify the biochemical mechanism that leads to the reduction in yield and quality by sugarcane wooly aphid infestation.

MATERIALS AND METHODS

Collection of Plant Material

Plant material of sugarcane (healthy and infested) of variety Co 8014 used in this study was collected in the month of January 2007 from the Khadamba village of Ahmednagar district (MS), India. Depending on the level of infestation plants were categorized into four groups as follows (Fig. 1).

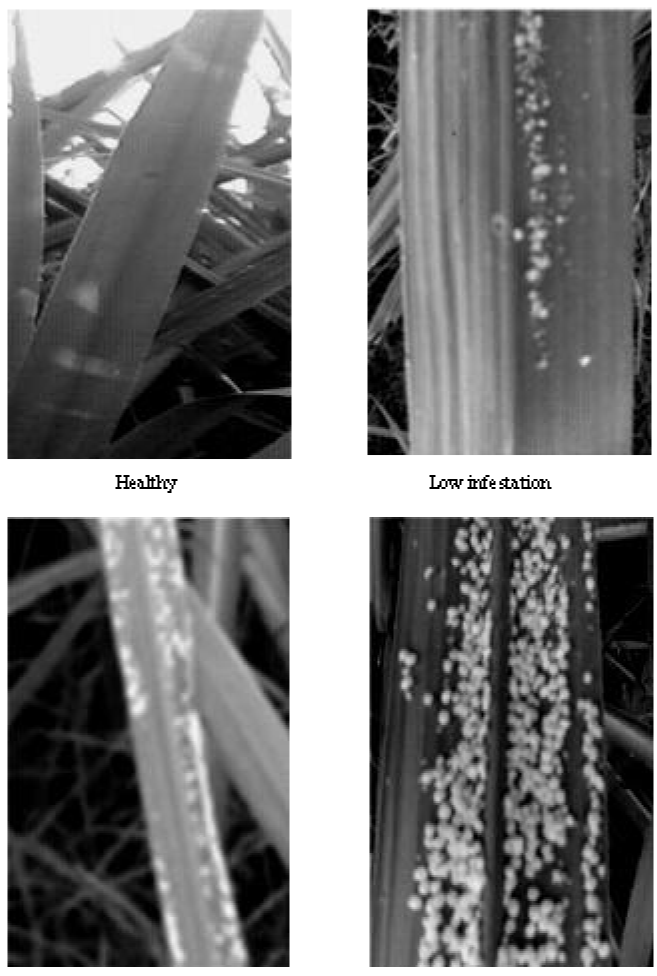

Fig. 1: Different groups of plant material of sugarcane used in the study

Group 1: High infestation (4-5 green opened leaves fully covered by pest).
Group 2: Moderate infestation (about 50% area of 1-2 green opened leaves covered by pest).
Group 3: Low infestation (about 10% area of 1-2 green opened leaves covered by pest).
Group 4: Healthy sugarcane (No infestation on any leaf).

Sugarcane samples (healthy and infested ones) were collected separately from the selected area. Stems were sent to the sugar factory for crushing and juice analysis and leaves were brought to the laboratory for biochemical analysis.

Extraction and Analysis

After cleaning of crusher, sugarcane stems of the above mentioned groups were crushed separately and juice was collected in different containers. Homogenous juice samples were analyzed in the laboratory of sugar factory for brix, pol reading, CCS% (Commercial cane sugar), purity of juice, reducing sugar and pH.

Leaves of above mentioned sugarcane samples were extracted for the Chlorophyll and polyphenol estimation. Chlorophylls were extracted in 80% acetone and polyphenols in water. The quantitative estimation of chlorophyll and polyphenols was carried out as per methods given by Sadasivam and Manickam (2004). Polyphenols were extracted from one-gram leaves of the above-mentioned samples separately in distilled water. Polyphenol content was estimated by Folin-Denis reagent using tannic acid as a standard (Sadasivam and Manickam, 2004).

RESULTS AND DISCUSSION

Results of our study have shown that SWA considerably affects photosynthetic ability of the sugarcane plants. About 37% reduction was observed in the total chlorophyll content in the high infestation group of sugarcane samples (Table 1). Loss of total chlorophyll was found to be infestation dependent i.e., increases with the level of infestation (Table 1). Chlorophyll content is directly proportional to the yield of sugar cane crop, since sugarcane is mainly cultivated for the sugar production and chlorophylls are indispensable sites of sugar biosynthesis in plants.

Sugarcane wooly aphid (*Ceratovacuna lanigera* Z.) (SWA) was first reported in India in 1958 as a minor pest, but become a major cause of loss in sugarcane yield in recent years (Joshi and Viraktamath, 2004). About 16% sugarcane crop was infested by this pest in the western Maharashtra region, known as sugar belt of India (Joshi and Viraktamath, 2004).

Sugarcane juice analysis showed that even at low infestation level quality of juice is affected considerably when compared to that of healthy plants. There is not much difference in the quality parameters studied, among the samples infested at different levels except juice purity. Purity of the juice of healthy samples was found to be 87% while it was reduced to 78% at low infestation and further reduced to 71% at high infestation level (Table 2). Modulation in the metabolic activities of plant due to the SWA could be adversely affecting juice quality in infested plants.

Constitutive or induced defense mechanisms are the tools used by plant against insect or pathogen attack (Mauricio *et al*., 1997; Buell, 1998). Among these defense mechanisms, inducible defense plays

Table 1: Effect of sugarcane wooly aphid on chlorophyll content in sugarcane leaves

	Chlorophyll content at different level of infestation (mg g^{-1} of tissue)*			
Type of chlorophyll	Healthy	Low	Moderate	High
Chlorophyll-a	5.41±0.12 (0)	4.27±0.13 (23)	3.63±0.01 (34)	3.19±0.10 (40)
Chlorophyll-b	3.31±0.21 (0)	3.08±0.33 (08)	2.37±0.21 (22)	2.28±0.07 (30)
Total chlorophyll	8.73±0.28 (0)	7.36±0.19 (18)	6.00±0.23 (30)	5.48±0.15 (37)

*Values in parenthesis indicate % loss in chlorophyll content an important role in conferring disease resistance (Maleck and Dietrich, 1999). Inducible defense exhibit several advantages over constitutive defense (Agrawal, 1998). It will be activated only during the attack of pathogen or pest, saving investment of metabolic energy (Agrawal, 1998). It may reduce the chances of developing resistance among the pest and pathogens due to its limited exposure (Agrawal, 1998; Baldwin and Preston, 1999). Induced mechanisms are known to involve biosynthesis of novel molecules as well as up regulation of existing defense molecules (Baker *et al*., 1997; Keen, 1992) Phenolics are one of the major groups of compounds involved in both the types of plant defense systems (Hartley and Lawton, 1991). Results of our study also showed that the level of polyphenols increases considerably with the level of infestation (Fig. 2, 3). About 41% increase in polyphenol content was observed at high infestation level (Fig. 2). Positive correlation between insect resistance and presence of secondary metabolites was observed in some plants (Telang *et al*., 2003; Giri, *et al*., 2003; Tamhane *et al*., 2005).

Table 2: Sugarcane juice quality analysis

Infestation	Normal	Low	Moderate	High
Brix (%)	15.79±0.74	12.28±0.93	12.50±0.50	11.13±1.07
CCS (%)	9.53±0.60	6.38±0.48	6.67±0.33	5.34±0.53
Pol (%)	14.32±0.61	9.25±1.11	9.27±0.37	8.08±0.08
Purity	86.76±1.38	77.50±0.58	76.79±0.74	70.93±0.93
Reducing sugar	0.60±0.00	0.58±0.00	0.55±0.01	0.57±0.07
pH	5.66±0.20	5.66±0.11	5.43±0.15	5.10±0.10

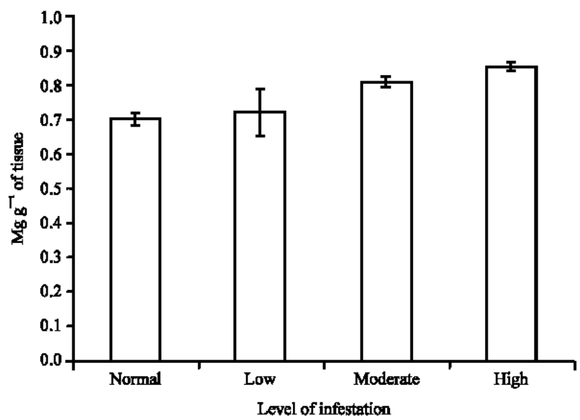

Fig. 2: Polyphenol content of sugarcane leaves at different levels infestation

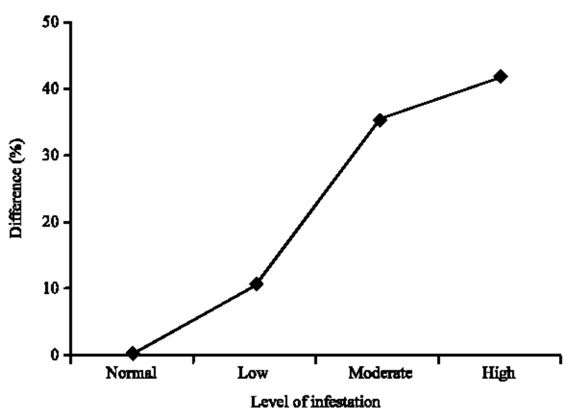

Fig. 3: Induction of polyphenol biosynthesis in sugarcane by *Ceratovacuna lanigera* Z. infestation

Further studies on the detailed biochemical changes that are occurring during SWA infestation are currently in progress in our laboratory will provide an insight in to the SWA infestation process.

CONCLUSION

Results of present study have shown that Sugarcane Wooly Aphid infestation largely affects photosynthetic ability of sugarcane plant thus affecting yield. In addition to this it was found that SWA infestation modulate metabolic activities in sugarcane (e.g., induction of polyphenol biosynthesis), which could be associated with the poor juice quality.

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