EFFECT OF HOST PLANT FERTILIZATION ON THE DEVELOPMENTAL BIOLOGY AND FEEDING PREFERENCE OF THE GLASSY-WINGED SHARPSHOOTER

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ABSTRACT

The main objective of this research was to evaluate the effect of host plant fertilization on the survival, immature development, adult fecundity, and the feeding of the glassy-winged sharpshooter (GWSS), a primary vector of *Xylella fastidiosa* (*Xf*). The development biology of GWSS was studied on cowpea plants, *Vigna unguiculata* treated with three fertilization regimes (NPK alone, urea alone, and a combination of NPK and urea) along with a non-fertilized control. Fertilization affected cowpea plant growth, the total protein content and the profile of free amino-acids in the xylem sap. The ultimate nymphal survivorship was significantly higher on fertilized plants than on control plants. In addition, newly emerged adult weight significantly increased with fertilization; specifically, GWSS nymphs reared on plants fertilized with urea yielded adults with the highest weight. NPK fertilization significantly reduced the nymphal development period for females but not for males. Females maintained on fertilized plants showed higher oviposition frequency and number of egg masses laid compared to unfertilized plants with highest oviposition potential recorded on urea treated plants. In addition, significantly bigger egg mass sizes were obtained from fertilized plants. Consequently, GWSS populations that developed on fertilized plants and more so on urea treated plants had a higher intrinsic rate of increase compared to those developing on unfertilized control plants. In choice tests, adult GWSS showed a preference for fertilized cowpea plants. The number of GWSS adults per plant and the proportion of plants infested were significantly higher for plants that received fertilization compared to the non-fertilized control plants. However, no feeding preference was recorded for nymphs.

INTRODUCTION

The pest status of glassy-winged sharpshooter (GWSS), *Homalodisca coagulata* (Say), has been exacerbated since its introduction, establishment, and continued spread in California. GWSS is a highly polyphagous xylem-feeder indigenous to the southern United States and to the northern Mexico (Turner and Pollard 1959). It effectively transmits the bacterium *Xylella fastidiosa*, a causal agent of economically important diseases of several agronomic, horticultural and landscape ornamental crops. The development of efficient rearing methods will greatly improve our knowledge of the pest biology and enhance implementation of adequate control programs. A simple method for rearing GWSS on cowpea plants has been developed (Sétamou and Jones 2005), but a rapid deployment of novel control methods required increased accessibility of GWSS to researchers.

So far, no artificial diet for rearing GWSS has been commercialized and most diets are at either at the development or formulation stages. Thus, rearing methods of GWSS rely heavily on the use of plants. Although nymphs and adults have different nutritional requirements and often required different host plants for their successful development (Brodbeck et al. 1996), Sétamou and Jones (2005) showed that cowpea or black-eyed pea (*Vigna unguiculata*) is a suitable host plant that supports the development of both immature and adults stages. But development of GWSS populations in laboratory colonies depends on many factors such as host plant quality. Plant nitrogen content has been identified as an indication of host plant quality for herbivorous insects (Mattson 1980). It is widely reported in the literature that nitrogen content of host plants influences the survival, development and reproduction of insects, particularly homopteran and also other insects orders (van Emden 1966). Nitrogen content of plants is directly related to the level of fertilization (Jauset et al. 1998).

In this project we are testing the effects of host plant fertilization on the bionomics of GWSS in order to find the most suitable host plant fertilization regimes for maximizing the production of GWSS. Two types of fertilizers, i.e., water soluble NPK (20-20-20) from Peter Professional® and agrillane urea (46-0-0) from Magic Carpet™ were used individually or in combination at the recommended doses for cowpea production to fertilize potted plants used in the experiments.

OBJECTIVES

1. Evaluate the effects of nitrogen fertilization on plant growth and on N content and free amino-acid composition of xylem exudates.
2. Determine the influence that fertilization of cowpea plants has on the survival, growth and development of both immature and adult GWSS.
3. Test whether GWSS exhibit any feeding and oviposition preferences for fertilized plants.

RESULTS

Objective 1 – Effect of fertilization on plant growth and chemistry

As expected NPK and urea fertilization of plants significantly increased their growth parameters. Plant height, stem diameter, number of leaves, and leaf thickness were higher for plants that received fertilization compared to the control plants. Although plants of different treatments in the experiments were not water-stressed and received the same irrigation regime, the total water potential of non-fertilized cowpea stems (-4.08 bars) was lower than those obtained for fertilized plants (-3.62 bars for NPK alone, -3.70 bars for urea-alone and -3.55 bars for a combination of NPK and urea). This suggests that fertilized plants were more succulent that control plants, thus facilitating xylem sap uptake by GWSS. Total N concentration of xylem fluid significantly increased with fertilization from 265 μg N g^{-1} in the control to 420-506 μg N g^{-1} in the fertilized plants. Studies are underway to determine the free amino-acid composition and levels in xylem fluids collected from the different treatments.

Objective 2 – GWSS biology as affected by host plant fertilization

Host plant fertilization significantly affected the ultimate nymphal survival of GWSS. Almost all nymphs reached the adult stage on fertilized cowpea plants whereas 15% of nymphs died on non-fertilized control plants (Table 1). Although nymphal development of male GWSS was not affected by the host plant treatment, the nymphal period of females was significantly reduced when host plant received NPK fertilization (Table 1). Similarly, the weight of newly emerged adult GWSS varied with host plant treatment. Both adult males and females emerging from fertilized plants were significantly heavier than their counterparts on control plants (Table 1). However, the sex ratio of adults obtained was not related to host plant treatments and did vary from a 1:1 sex ratio.

Table 1. Biological parameters of GWSS reared on cowpea plants treated with different fertilization regimes.

Treatment	Proportion of adults emerged	Nymphal developmental period (days)		Adult Weight (mg)		Sex ratio (% Females)
		♂♂	♀♀	♂♂	♀♀	
Control	85.0 a	30.9 a	33.3 ab	29.6 c	37.4 c	44.2 a
NPK-only	98.3 b	28.8 a	30.6 b	32.1 b	40.1 b	50.8 a
Urea-only	96.7 b	31.1 a	34.9 a	34.5 a	43.0 a	46.6 a
NPK + Urea	96.7 b	32.1 a	31.4 b	32.4 ab	42.8 a	46.4 a
Statistic	G = 17.1, $P < 0.01$	$F_{sex} = 7.59$, $P = 0.006$ $F_{treat} = 4.45$, $P = 0.005$		$F_{sex} = 21.35$, $P < 0.0001$ $F_{treat} = 293.43$, $P < 0.0001$		$G = 3.2$, $P > 0.05$

[a] Means followed by the same small case letter within each column are not significantly different (P > 0.05), Student Newman Keuls test.

Adult female oviposition frequency and potential were dramatically improved with urea fertilization. GWSS developing on fertilized plants laid more egg masses on a weekly basis and the total fecundity of 10 females of GWSS females has almost doubled on urea treated plants compared to control plants (Table 2). In addition, the proportion of larger egg masses (containing > 10 eggs) was higher with fertilization (Figure 1).

Table 2. Oviposition parameters of GWSS adults[a] reared on potted cowpea plants treated with different fertilization regimes over the first 10-wk period.

Treatment	Weekly Percentage of plants with egg masses[b]	Weekly no. egg masse per pot	Total number of egg masses
Control	24.0 c	1.7 b	93
NPK-only	28.4 bc	1.9 ab	104
Urea-only	47.5 a	3.1 a	172
NPK + Urea	38.3 ab	3.2 a	161

[a] In each treatment, 10 pairs of adults were maintained per cage.

[b] Means followed by the same letter within each column are not significantly different (P > 0.05), Student Newman Keuls test.

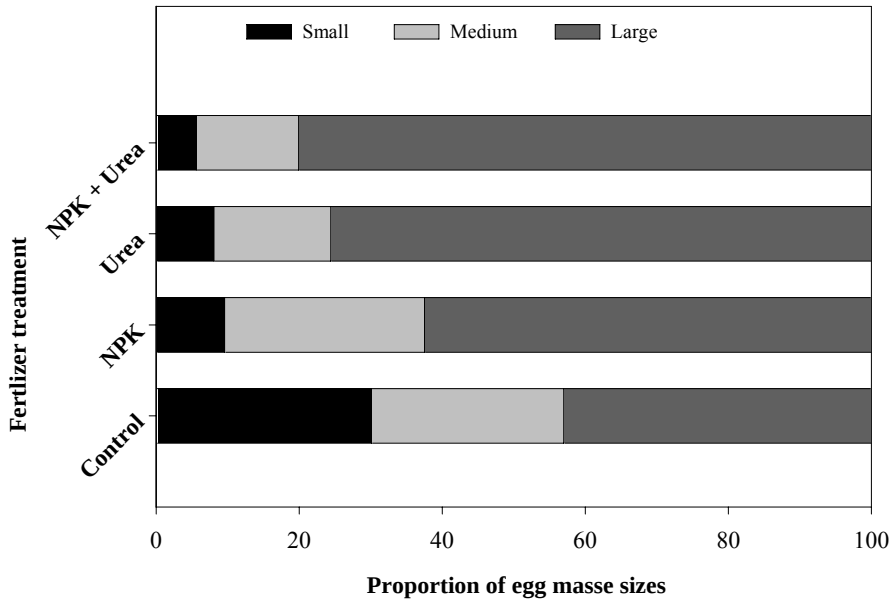

Figure 1. Distribution of egg masses laid by GWSS reared on plants treated with different fertilization regimes (Small = 1-5 eggs/mass, medium = 6-10 eggs/mass, and L => 10 eggs/mass).

Objective 3 – GWSS host plant preference

The host plant preference of GWSS nymphs and adults was studied in separate experiments. Two potted cowpea plants or each fertilization treatment (8 cowpea pots in total) were simultaneously provided to GWSS for assessing their host plant preference. Cowpea plants of different treatments were equally preferred by nymphs, whereas adult GWSS preferentially fed on fertilized plants. Both the proportion of plants selected for feeding and the number of adults per plant were significantly higher for fertilized plants (Table 3).

CONCLUSIONS

We have shown that cowpea plant growth parameters, water potential, and total N concentration of xylem fluid have been improved by NPK and urea fertilization. We will be analyzing the free amino-acid profile of xylem and this will improve our understanding of the effects that fertilization has on xylem chemistry and subsequently on the development biology of GWSS. The results obtained from this study showed that adequate fertilization dramatically improves the survival, growth, development and reproduction of GWSS. These findings can directly be used to improve the production of GWSS in laboratory. In addition, more insights can be gained on the GWSS-host plant interaction.

Table 3. Host plant selection and number of GWSS per plant in choice experiment with potted cowpea treated with different fertilizers.

Treatment	Nymphs		Adults	
	% plants infested	Mean no. GWSS per plant	% plants infested	Mean no. GWSS per plant
Control	42.0 a	2.5 a	35.5 a	2.0 a
NPK-only	41.8 a	2.6 a	49.5 ab	3.3 b
Urea-only	45.7 a	2.6 a	52.7 b	3.3 b
NPK + Urea	46.2 a	2.3 a	43.5 ab	2.6 ab

Means followed by the same letter within each column are not significantly different (P > 0.05), Student Newman Keuls test.

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