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Contrasting Plant Defense Responses against Insect Vectors from Two Feeding Guilds

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Introduction

Soybean aphid

- Soybean aphid (*Aphis glycines* Matsumura) is an invasive pest from China [1] (Fig. 1).
- Aphids cause up to 42% yield loss in soybean due to direct feeding and as a vector for plant viruses such as *Soybean mosaic virus* (SMV) [2].
- Aphids are phloem-feeding insects with piercing-sucking mouthparts [3].

Fig.1. Soybean aphid

Soybean thrips

- Soybean thrips (*Neohydatothrips variabilis*) is one of the most ubiquitous insect pests in soybean fields (Fig. 2).
- Recently, soybean thrips were shown to be vectors of a newly identified soybean disease, *Soybean vein necrosis virus* (SVNV) [4].
- Thrips are cell content feeders with piercing-sucking mouthparts [3]. The piercing-sucking apparatus in thrips is asymmetrical with the right mandible completely absent [5].

Fig. 2. Soybean thrips

Objectives

1. To determine plant defense signaling pathways that are activated in response to feeding by insect vectors from different feeding guilds (phloem feeding versus cell content feeding).
2. To evaluate the effect of plant defense elicitors of SA and JA pathways in conferring protection against the insect vectors from different feeding guilds.

Methods

Gene expression

- Plant tissues were collected at five sampling time points – 0h, 3h, 6h, 12h, and 24h post-release of insects. Gene expression analysis was performed using Reverse-transcriptase-Polymerase Chain Reaction (RT-PCR).

Elicitor spray

- Complete Randomized Block Design, with 4 treatments (JA, SA, JA+SA sprays, and water control) were applied to plants (Fig. 3).
- Experiments were repeated 2-4 times with 3-4 plants per treatment.

Methods

Fig. 3. Experimental workflow

JA, SA, JA+SA, or water were sprayed 24h pre-insect release.

Five adult thrips were released per plant. Population growth rate was recorded after 10 days.

Thirty adult aphids were released per plant. Population growth rate was recorded after 1 week.

Plant Defense Gene Expression

- The two main plant defense pathways that were analyzed in the study were: Salicylic acid (SA) -pathway and Jasmonic acid (JA) -pathway.
- The SA pathway is predominantly induced against pathogens and aphids. Whereas the JA pathway is activated in response to chewing-insects such as caterpillars [6].

In response to phloem feeding insect, A. glycines

- *GmPR1 (Pathogenesis-related protein-1)*, a marker gene for SA pathway was activated in response to feeding by aphid feeding and SMV-infection (Fig. 4A).
- *GmJAR1 (Jasmonic acid resistance-1)*, a marker for JA pathway, was activated briefly due to SMV infection (Fig. 4A).

In response to cell content feeding insect, N. variabilis

- *GmPR1* was up-regulated in response to feeding by SVNV-infected thrips within 3 hours and continued until 24 hours (Fig. 4B).
- *GmJAR1* was expressed at a greater level than *GmPR1* in response to SVNV-infected thrips feeding (Fig. 4B).

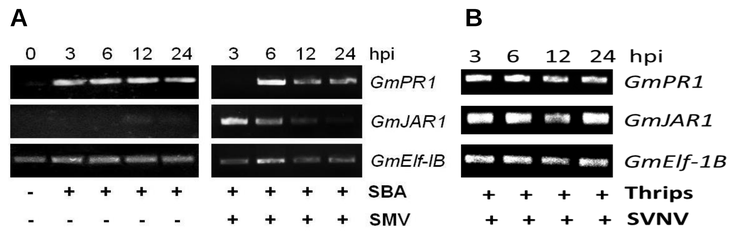

Fig. 4. Plant defense gene expression (RT-PCR) in response to feeding by A) soybean aphid and B) soybean thrips. *GmElf-1B* is the house-keeping gene.

Plant Defense Elicitor Sprays

In response to phloem feeding insect

- Methyl jasmonate (MJ) treatment significantly reduced aphid populations compared to SA treatment and control plants ($P<0.001$). This is contradictory to gene expression analysis that indicated activation of SA pathway in response to aphid feeding (Fig. 5A).
- It is possible that soybean aphids suppresses JA defenses via SA antagonistic crosstalk. This so called "decoy" strategy has been observed in other insect systems such as whiteflies and corn earworm.

In response to cell content feeding insect

- There was no significant difference in thrips population numbers due to the high variability in the data.
- Preliminary results suggest that JA spray reduced thrips populations compared to SA, JA+SA, and control plants. (Fig. 5B).
- SA spray may have a positive effect on thrips populations due to suppression of JA defenses.

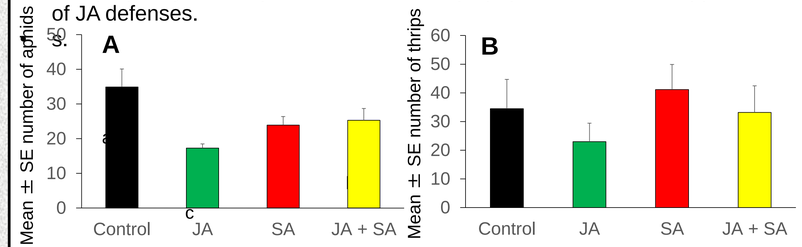

Fig. 5. Effect of plant defense elicitor sprays on A) soybean aphids and B) soybean thrips.

Conclusions

- Gene expression analysis indicated that phloem feeding insect (aphids) primarily activated SA pathway whereas cell content feeding insect (thrips) predominantly activated JA pathway.
- In contrast, plant defense elicitor spray results suggest that soybean aphids and soybean thrips resistance is regulated by JA-mediated defenses in soybean.

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