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Sustainable Strategies to Combat the Papaya Ringspot Virus

Sarah E. Brewer and Alan H. Chambers*

Tropical Research and Education Center, University of Florida/IFAS, 18905 SW 280th St., Homestead, FL, 33031

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The papaya ringspot virus (PRSV) is a limiting factor for papaya production. All papayas are susceptible to PRSV, except where resistance has been genetically engineered. Studies conducted in Hawai'i suggest that the use of transgenic PRSV-resistant accessions as border rows may prevent aphid-mediated transmission of the virus to susceptible interior plants, potentially expanding the range of varieties that can be cultivated profitably. A field trial to evaluate this technique was carried out at the Tropical Research and Education Center (TREC) in Homestead, Florida. In this experiment, we found that the use of virus-resistant border rows did not meaningfully impede transmission of PRSV to the susceptible cultivar 'Red Lady'.

Viral diseases are a significant impediment to papaya production worldwide, including domestic growing regions of southern Florida, Puerto Rico and Hawai'i. The most significant of these is papaya ringspot virus (PRSV), which dramatically reduces yield and can lead to plant stunting or death. Current strategies to combat PRSV in papaya are limited and consist primarily of copious insecticide applications to control the aphid vector, rogueing and replanting of infected fields, or cultivation of transgenic, PRSV-resistant varieties. Engineered PRSV resistance has been the most effective control strategy, but it has limitations. Fruits of genetically engineered crops can be difficult to market due to the stigma surrounding genetically modified organisms (GMOs). Furthermore, there are few PRSV-resistant varieties available, which limits growers' choices. We therefore sought to expand the range of options available to local papaya growers by evaluating the use of PRSV-resistant border plantings to protect susceptible papaya varieties, an approach recently pioneered by researchers at the USDA-ARS in Hawai'i with promising preliminary results (Matsumoto et al., 2014). The strategy relies on the non-persistent manner in which aphids transmit PRSV. The rationale is that infectious vectors are likely to feed first on resistant plants at the perimeter of the field. In the process, the proboscis and stylus are cleansed of the virus, preventing subsequent transmission. We have evaluated the efficacy of this new PRSV-management technique under southern Florida's distinct growing conditions using regionally relevant papaya accessions.

Materials and Methods

The field trial was established in Spring 2020 at University of Florida's Tropical Research and Education Center (TREC) in Homestead, FL. On 21 Jan. 2020, seeds were sown into trays filled with 1 part Pro-Mix BX Mycorrhizae to 1 part perlite, top-dressed with 14–14–14 slow release fertilizer, and kept in the greenhouse for 9 weeks followed by a one-week acclimation period. Seedlings were transplanted outdoors on 30 Mar. 2020. PRSV-resistant border plants were derived from open-pollinated (OP) seeds of the University of Florida breeding line S40-2228 (Davis and Ying, 2004). 'Red Lady 786 F1 Hybrid' from Known-You Seeds was used as the susceptible cultivar. The field plot consisted of 21 rows of raised beds with 37 plants in each row. Spacing was 5 ft within-row and 12 ft between rows. Liquid 3–0–10 (N–P–K) fertilizer was supplied daily with irrigation at a rate of 0.25 lb N per acre per day for the first 8 weeks, 0.5 lb N per acre per day for the next 4 weeks, and 1 lb N per acre per day subsequently. Glyphosate was applied as-needed to control weeds.

The experiment included two treatments with four replicates each in a randomized row-column design (see Fig. 1 for field diagram). Treatment A consisted of 6 susceptible 'Red Lady' plants surrounded by 3 additional rows of 'Red Lady' seedlings on all sides. Treatment B consisted of 6 susceptible 'Red Lady' plants surrounded by 3 rows of PRSV-resistant OP S40-2228 seedlings. Each replicate plot was surrounded by one additional row of 'Red Lady' plants on all sides. These plants were artificially inoculated with PRSV on 20 July and again on 3 Aug. 2020 to ensure disease pressure throughout the field.

Results

Six months after trial establishment, plants were 5–6 ft tall and bore mature green fruits, but none had yet begun to ripen. Classic PRSV symptoms were evident throughout the field including mosaic, chlorosis, and distorted leaves, as well as ring spots on the surface of green fruits (Fig. 2). The 6 interior plants within each replicate plot were visibly scored for presence or absence of PRSV symptoms on 27 Sept. 2020 (Table 1). PRSV symptoms were apparent on at least 1 of the 6 plants in every replicate, regardless of border row treatment. Overall, more than 40% of monitored plants were visibly infected across both treatments.

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*Corresponding author. Email:ac@ufl.edu

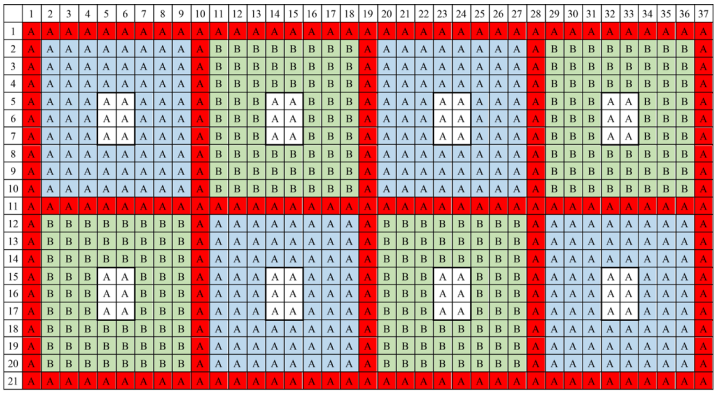

Fig. 1. Field diagram. Each cell represents one papaya plant. 'A' denotes PRSV-susceptible 'Red Lady'. 'B' denotes a PRSV-resistant plant of line OP S40-2228. Blue shading represents Treatment A borders ('Red Lady'). Green shading represents Treatment B borders (transgenic line OP S40-2228). White shading represents the six interior 'Red Lady' plants monitored for PRSV within each plot. Red shading represents artificially inoculated 'Red Lady' papayas.

Fig. 2. PRSV symptoms on leaves (left) and fruit (right) of 'Red Lady' papaya plants.

Table 1. Number of plants with PRSV symptoms after six months. The 6 'Red Lady' plants in the center of each plot were visually scored (presence /absence) for PRSV symptoms. The number of symptomatic plants as of 27 Sept. 2020 is recorded below.

	Number of symptomatic plants per replicate plot				Total	Overall %
Border Row Type	1	2	3	4	Symptomatic Plants	Symptomatic Plants
Treatment A:						
Susceptible borders	4	1	3	3	11 of 24	46%
Treatment B:						
Resistant borders	5	3	1	1	10 of 24	42%

Conclusions

The use of PRSV-resistant papaya in border rows did not prevent transmission of the virus to the susceptible cultivar 'Red Lady'. There are numerous reasons why a border row management strategy may have been successful in Hawai'i but not in our experience. These include the presence of an older planting of PRSV-infected papaya field within 50 ft of our trial, frequent high wind conditions in Homestead (which may disperse the aphid vector widely), and the early stage at which we transplanted seedlings to the field.

Literature Cited

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