Field screening of tomato varieties resistant to Tomato Spotted Wilt Virus and Tomato Yellow Leaf Curl Virus in Hawaii

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Severe symptoms of TYLCV to tomato plant

Tomato production is one of the largest agriculture commodities within the Hawaiian Islands. Unfortunately insect transmitted plant viruses are affecting tomato plant health and yield for local production. Two detrimental plant viruses affecting locally grown tomatoes are Tomato Spotted Wilt Virus (TSWV) and Tomato Yellow Leaf Curl Virus (TYLCV). Tomato Spotted Wilt Virus (TSWV) has been prevalent within Hawaii since the 1920s, causing some cases of tomato production losses at 75-100% (Melzer, 2009). At least seven thrips species (*Thrips* spp.) can transmit TSWV (Whitfield et al, 2005) with symptoms including wilting, stunted growth, necrosis of foliage, and chlorotic or necrotic rings on foliage and fruit thus affecting the quantity and quality of plant products (Sherwood, 2003). Tomato Yellow Leaf Curl Virus (TYLCV) was detected in 2009 within Hawaii (Melzer, 2009), and is transmitted by a whitefly species, *Bemisia tabaci*. There are many different biotypes of *B. tabaci* with the most prevalent in Hawaii being Biotype B. Symptoms of TYLCV include stunted plant growth, chlorotic yellowing of leaves, and distortion of leaflets in a cupped down and inward shape or upward curling of the leaflet margins (Cohen and Lapidot, 2007). Therefore an assessment of commercially available varieties with resistance to TSWV and TYLCV was conducted to see fruit productivity and adaptability to the local environment within Hawaii.

Materials and Methods

Two open field trials were conducted in Waialua and Kahuku at Twin Bridge and Ho Farms, respectively. The Waialua field trial was conducted from 07/25/13-11/05/13 and the Kahuku field trial from 01/30/14-06/05/14. Fifteen commercially available tomato varieties (Table 1) were chosen for their individual or dual resistance to TSWV and TYLCV, along with a susceptible control. The trials tested five different types of tomato variety types and two different growth forms (Table 1). Field trials were arranged in a completely randomized design, 5 replicates per variety, and 7 plants per replicate. The field plot was 90 by 90 feet, with 5 feet in between row and 2.5 feet within row spacing. A weed mat 4 feet in width was placed in between rows for weed suppression. Tomato seeds were planted in plug trays and transplanted six weeks after

Table 1. Table of tomato variety characteristics and virus resistances

Company	Name	Variety type	Weight (Gr)	Growth	TSWV Resistance	TYLCV Resistance
UH Seeds	Kewalo	Globe	170-227	Determinate	Resistance	NONE
Vilmorin Seeds	V3051	Roma	130-160	Indeterminate	Resistance	Resistance
Hazera Seeds	Katya	Roma	150-170	Determinate	Resistance	Resistance
Hazera Seeds	Matty	Roma	120-170	Determinate	Resistance	Resistance
Hazera Seeds	Shanty	Roma	100-150	Determinate	Resistance	Resistance
Hazera Seeds	Inbar	Beef-stake	300-400	Determinate	Resistance	Resistance
Hazera Seeds	Rona	Grape	25-30	Indeterminate	Resistance	Resistance
Southern Seeds	Hathor	Cherry	20-25	Indeterminate	Resistance	Resistance
Genesis Seeds LTD.	Sarina	Cherry	None noted	Indeterminate	Resistance	Resistance
Nirit Seeds	72061	Globe	160-200	Indeterminate	Resistance	Resistance
OSU	Indigo Rose	Globe	28-57	Indeterminate	NONE	NONE
Nirit Seeds	75125	Grape	10-15	Indeterminate	Resistance	NONE
Nirit Seeds	72618	Roma	140-200	Indeterminate	NONE	Resistance
Nirit Seeds	72103	Roma	100-160	Indeterminate	Resistance	Resistance
Nirit Seeds	74956	Roma	130-190	Indeterminate	Resistance	Resistance

seeding. Two weeks after transplanting, The Disease Severity Index (DSI) from (0-4) was used to assess weekly visual symptoms of TYLCV and TSWV, ranging from 0 having no symptoms to 4 having severe virus symptoms. Rating scales used were by Friedmann et al (1998) and Canady et al (2001). DSI data collection ended once the harvest period began. A plant with a DSI rating of 2 and higher was assessed as a positive for TSWV or TYLCV infection. The number of infected plants divided by the total number of plants is shown as virus percentages for both field trials.

During the harvest period, fruits were collected weekly from all replications, sorted and weighed to assess yield productivity of each variety. The field trial cropping durations, including transplanting-flowering, flowering, and harvest period for the Waialua and Kahuku trials are displayed in Figures 1 and 2, respectively. In both trials, smaller tomato varieties flowered two weeks before bigger tomato varieties, and thus fruit production and harvest occurred earlier. Harvest started at different times, but all varieties generally had a three-five weeks harvest period that varied from field trials due to seasonal differences.

Fruits were sorted into six different categories: Marketable, Damaged/Injured, Mite, Splotchy, Fruit Fly, and Hemiptera yield. Fruits were sorted by these six categories since these were the most common traits observed. Marketable fruit refers to saleable to fruits, while Damaged/Injured is not, due to the lack of aesthetic qualifications. The pests causing fruit damage determined the Mite, Fruit Fly and Hemiptera categories. And the Splotchy category could signify possible virus symptoms, by expressing splotchy patches on the fruit.

Fertilizer applications and chemical treatments for pests and pathogens were adjusted to meet the individual needs of each field trial. Therefore for the Waialua trial, Sustane fertilizer was

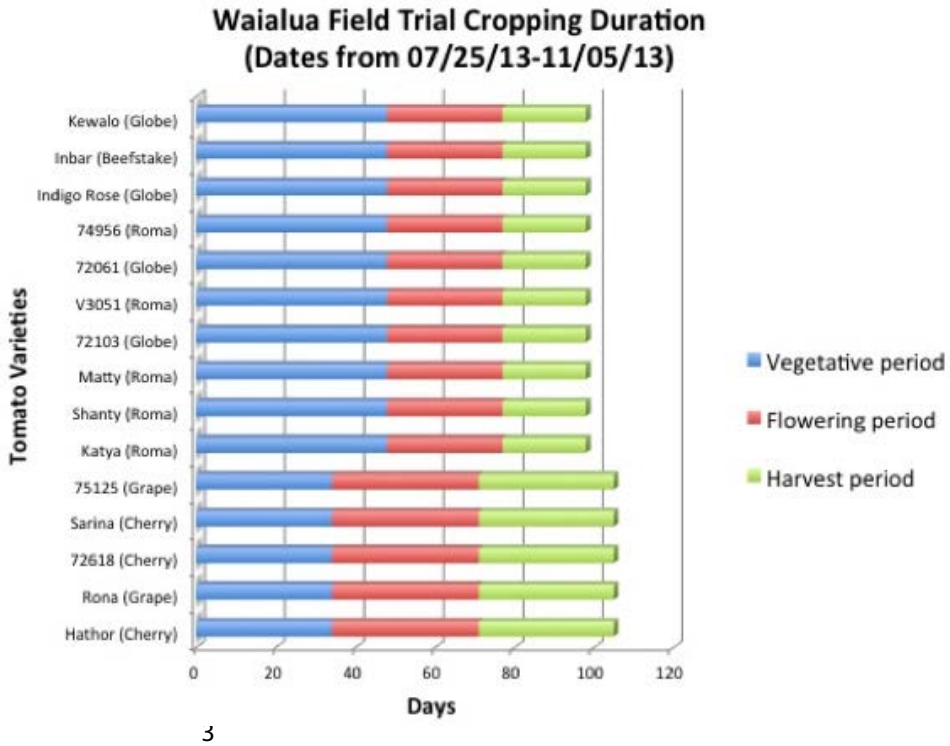

Figure 1. Waialua Field Trial Cropping Duration divided into time frames: Vegetative, Flowering, and Harvest periods.

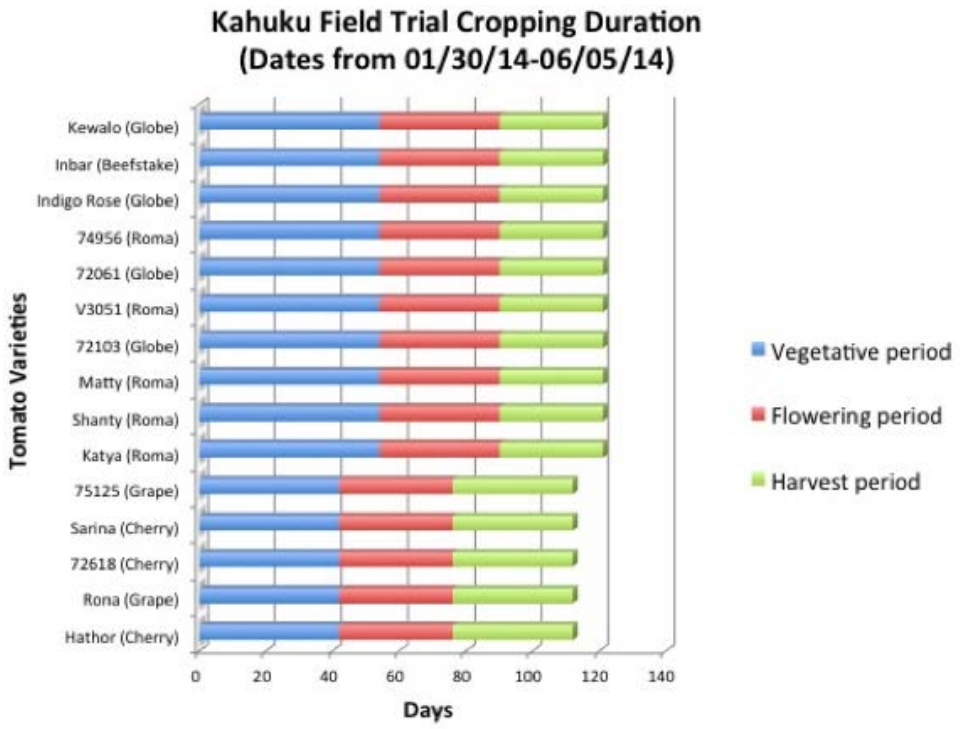

Figure 2. Kahuku Field Trial Cropping Duration divided into time frames: Vegetative, Flowering, and Harvest periods.

applied 18 lbs per row and in the Kahuku trial a bone meal was applied 24 lbs per row. Chemical treatments in the Waialua trial, consisted of Kumulus sulfur treatments for mite populations only. Spray dates were as followed: 9/23/13 & 9/30/13, at a rate of 4 ounces per 4 gallons of water for each day of treatment. The Kahuku trial was treated for late blight, tomato pinworm, and melon fly. Koicide was sprayed for late blight at a rate of 2.5 pounds for 1800 square feet on 04/01/13 and 04/30/13. A total of 75 tomato pinworm spirals were deployed on 04/12/14 at a rate of five spirals per row. Also four cuelure traps were deployed on 04/14/14 containing 5 mg of liquid cue lure per trap to capture melon fly.

Results

The Kahuku trial cropping duration had a longer vegetative and flowering period due to seasonal differences (Figure 2) compared to the Waialua trial (Figure 1). Since the experiment was transplanted at the beginning of the year there was slightly colder weather, which slowed down vegetative growth as well as

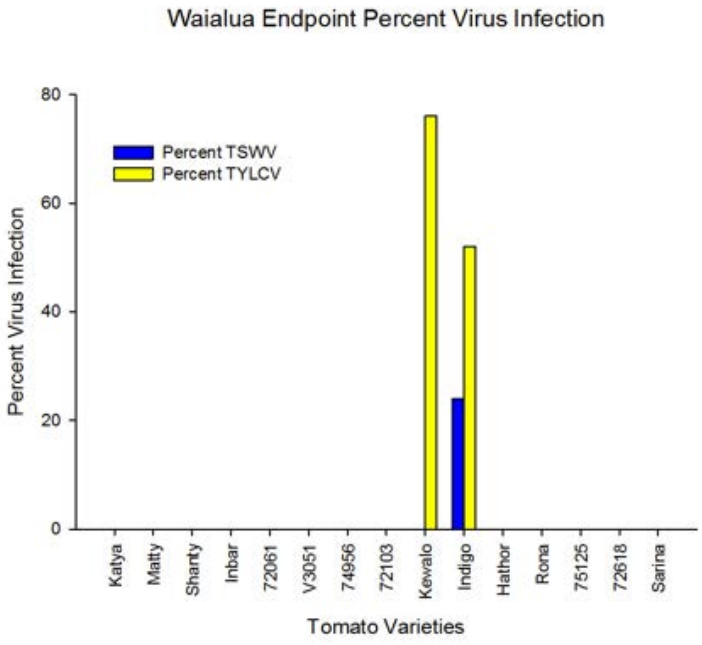

Figure 3. Waialua Endpoint Percent Virus Infection for TSWV and TYLCV

prompted infections of late blight throughout the trial. Therefore the Kahuku trial had an extended cropping duration compared to the Waialua trial; small and big varieties took a week and three weeks longer, respectively.

At the end of the Waialua trial virus percentages were about 20% infection of TSWV & 50% infection for TYLCV in the susceptible control, Indigo Rose (Figure 3). Kewalo had over 70% infection for TYLCV only, being that Kewalo is resistant to TSWV (Figure 3). At the end of the Kahuku trial we observed TYLCV infection only with Indigo Rose and Kewalo having 30% and 50% infection, respectively (Figure 4).

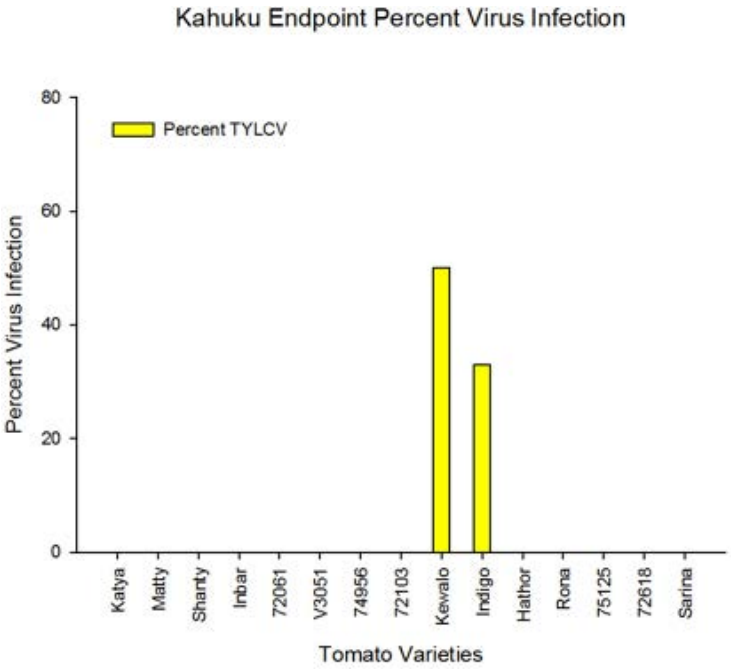

Figure 4. Kahuku Endpoint Percent Virus Infection for TSWV and TYLCV

Hathor and Rona were the two varieties that produced the highest marketable yield throughout both trials (Figure 5). These two varieties along with the remaining smaller tomato varieties 72618, Sarina, 75125 generally had higher yields than the bigger tomato varieties: Katya, Shanty, Matty, 72103, V3051, 72061, 74956, Indigo Rose, Inbar, and Kewalo. In the Waialua trial Katya, Shanty, and Matty were the highest yielding bigger tomato varieties. Unfortunately the Kahuku trial was infected with late blight in the middle of the cropping season and even though plants were treated, it caused a decline in tomato production for these varieties. Big tomato varieties 72103 and V3051 were globe and roma types that generally had the same marketable yield in

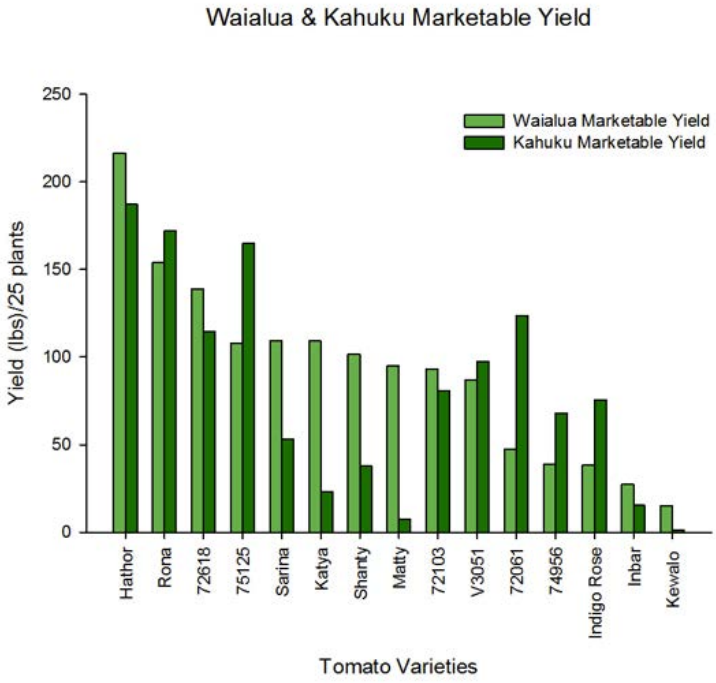

Figure 5. Field trials Waialua and Kahuku Marketable Yield for all tomato varieties.

both trials, despite late blight infection. Even though variety V3051 showed late blight resistance, it did have the highest unmarketable yield due to other factors in both trials (Figure 6 & 7). Kewalo, which was susceptible to TYLCV only, was the lowest yielding tomato variety in both trials. The susceptible control Indigo Rose generally had a lower yield than the other tomato varieties.

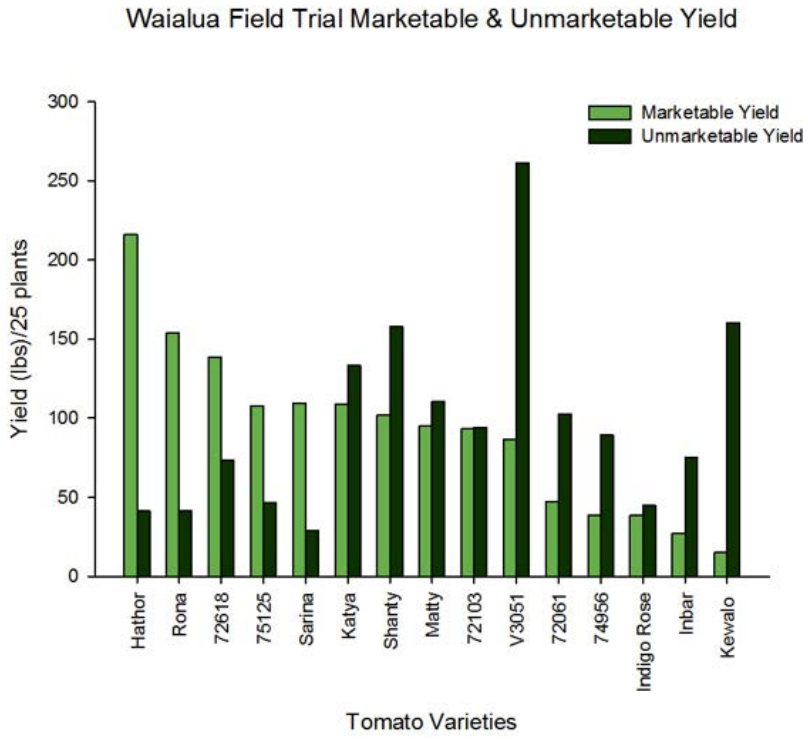

Figure 6. Waialua Unmarketable Yield comprised of five different categories; Damaged/Injured, Mite, Splotchy, Fruit Fly and Hemiptera Yield.

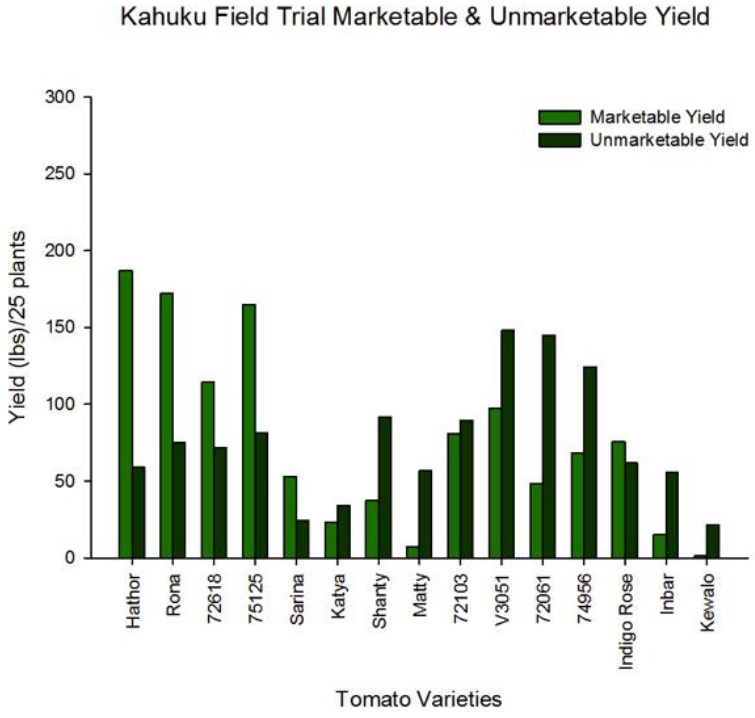

Figure 7. Kahuku Unmarketable Yield comprised of five different categories; Damaged/Injured, Mite, Splotchy, Fruit Fly and Hemiptera Yield.

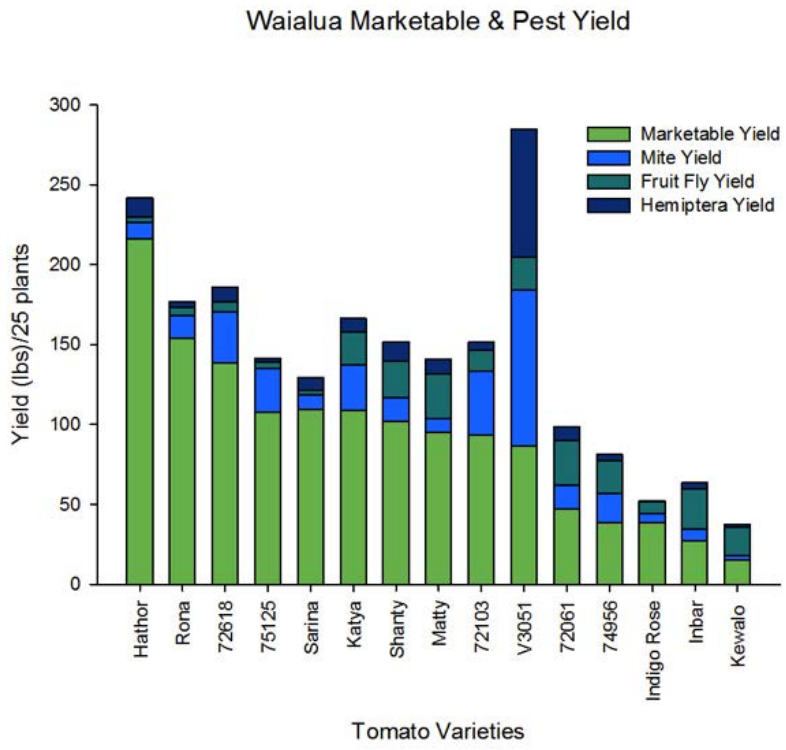

Figure 8. Waialua Marketable Yield with Pest yield comprised of Mite, Fruit Fly, and Hemiptera yield.

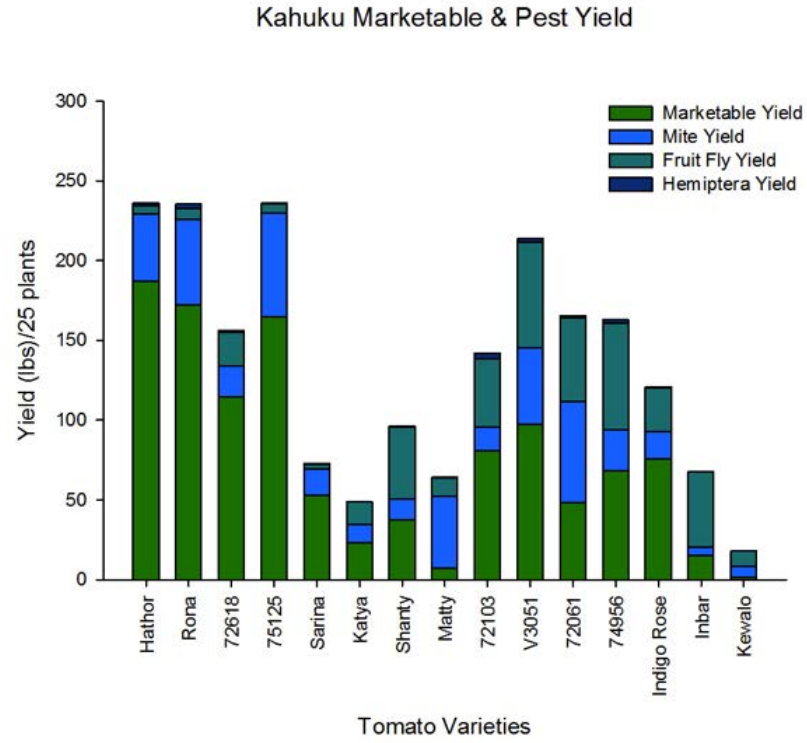

Figure 9. Kahuku Marketable Yield with Pest yield comprised of Mite, Fruit Fly, and Hemiptera yield.

For the smaller tomato varieties such as Hathor, Rona, 72618, 75125, and Sarina; the marketable yield was generally greater than the unmarketable yield for both Waialua and Kahuku trials (Figure 6 & 7, respectively). For the bigger tomato varieties the opposite trend was observed; the unmarketable yield was generally greater than the marketable yield (Figure 6 & 7). The categories Mite, Fruit Fly, and Hemiptera (Figure 8 & 9), were the most important unmar-


Hathor (cherry) tomato variety


Roma (grape) tomato variety


V3051 (roma) tomato variety


Sarina (cherry) tomato variety


72103 (globe) tomato variety ty


72618 (cherry) tomato variety


75125 (grape) tomato variety


Indigo Rose (globe) tomato variety


72061 (globe) tomato variety


74956 (roma) tomato variety


Shanty (roma) tomato variety


Inbar (beefsteak) tomato variety


Katya (roma) tomato variety


Matty (roma) tomato variety


Kewalo (globe) tomato variety

ketable categories. A regular commercial treatment for the damaging pests can potentially reduce the unmarketable yield in these categories.

Discussion

Ho Farms (Kahuku) is a commercial farm, dedicated exclusively to grow tomatoes. Twin Bridge Farms (Waialua) is also a commercial farm, but tomato is not the main crop and they grow them in low acreage. Since more tomatoes are grown at Ho Farms, there is a breeding area for key pests such as fruit flies causing more yield loss in Kahuku than in Waialua. Therefore differences in yield due to contrasting infestations of pests were noticeable between the two field sites. . In both trials bigger tomato varieties had more yield lost to fruit fly damage than smaller tomato varieties. Also during the Waialua trial, mite infestations were visible in earlier periods of the trial and therefore treated. But the Kahuku trial had mite infestations occurring in the middle of the harvesting period, and therefore was not treated since the trial was close to completion. It maybe possible that the higher marketable yield observed in the Waialua trial compared to the Kahuku trial was due to a more effective treatment of mites.

In our field trials, smaller tomato varieties generally had less unmarketable yield due to pests and a higher marketable yield compared to bigger tomato varieties. Under virus pressure Hathor and Rona were the highest yielding indeterminate cherry and grape varieties, respectively. Unmarketable yield due to mites was higher in Kahuku than in Waialua, possibly due to the fact that this site was not treated for mites . Katya, Shanty, and Matty were higher yielding determinate roma varieties in the Waialua trial, but were highly susceptible to late blight, which occurred in Kahuku. Big tomato varieties 72103 and V3051 are indeterminate globe and roma varieties that exhibited resistance to the tested viruses and late blight. These varieties had similar yields in both trials. Despite the resistance to viruses and late blight, V3051 was highly susceptible to pests such as mites, fruit fly, and hemiptera.

These field trials were conducted to test the productivity of tomato varieties under TSWV and TYLCV pressure. Since these viruses are vectored by insects, chemical treatments were kept to a minimal to increase the spread of viruses, and test the full potential of these varieties under local conditions. The projected marketable yield of these varieties with regular spraying cycles are unknown. Therefore if farmers use their standard practices of treating these pests, there is potential for a higher marketable yield for individual varieties. The harvest periods for all varieties in the trials were from three-five weeks, which is a reduced time frame compared to a regular farmer's cropping duration. Harvest period can be extended beyond this range, which can lead to more yield for farmers.

Kewalo and Indigo Rose were visually symptomatic with TSWV and/or TYLCV in both trials and were the two lowest yielding tomato varieties. All other tomato varieties did not exhibit visual symptoms for TSWV or TYLCV. Testing will be conducted with DAS-ELISA and PCR to

confirm virus presence/absence in relation to visual symptoms. Further data will be analyzed to see the brix and pH readings of fruit from different tomato varieties, along with shelf life and taste preference of consumers. Favorable resistant varieties identified in this study will be further tested with different organic treatments, to see the overall productivity of certain lines under virus pressure.

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