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2022 Processing Tomato and Watermelon Pest Updates

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The 2022 projects that focused on pest and disease management included 1) understanding of the feeding and in-field distribution characteristics of beet leafhopper (BLH) and its vectored beet curly top virus (BCTV) in processing tomato fields; and 2) management of watermelon plant health and soil-borne fungal pathogens through grafting and biological fungicide. In addition, with the help from Drs. Cassandra Swett and Bob Gilbertson at UC Davis, we detected Fusarium wilt, Fusarium falciforme, BCTV, Fusarium root and stem rot, Fusarium crown rot, Rhizoctonia root rot, and Charcoal rot from samples of tomato, watermelon, and cantaloupe from grower's fields.

I. Beet leafhopper and beet curly top virus update

The seasons of 2021 and 2022 had dramatic differences in BLH and BCTV damage on processing tomatoes in the northern San Joaquin Valley. However, the results of 2021 and the initial observations in 2022 both indicated the number of BLHs caught on the yellow sticky cards was the most in June and July across monitoring locations. Overall, in 2022, there were much fewer numbers of tomato fields that reported curly top virus infection in Stanislaus County. Most fields we monitored and visited had percent infection within the acceptable range. Seasonal counts of virus-infected plants from all nine monitored locations showed that the average infection rate was only 3% in 2022; whereas more than half of the monitored fields had 10% BCTV incidence in 2021 (Tables 1a and b). Although we had a relatively low infection rate in 2022, there were still some fields with much more severe BLH damage, especially for those with large open areas (missing plants) and complex weed species surrounding them.

To further understand the feeding characteristics and infestation of the pests, we conducted the within-field spatial analysis; a statistical tool that depicts the spatial distribution of the infected plants in a field over a seasonal period. This is critical for helping determine whether the disease is aggregated within a particular area(s) of the field (e.g., field edge vs. interior) or randomly distributed throughout (Fig. 1). Although the

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spatial analysis of BLH population and number of BCTV-infected plants are still underway, our initial observations indicated the closer the monitored spot to the field edge, the more likely BLH will cause feeding damage/disease infestation. Another regularity from the within-field spatial monitoring was that plants adjacent to missing gaps were more prone to the attack of BLH regardless of location in a field. There were no reports of yield loss due to BLH/BCTV in 2022. Since the season of 2022 was light in terms of BLH and BCTV severity, we will continue the monitoring in the season of 2023 to inform some solid information regarding BLH activity, feeding characteristics, and within-field regularities.

Table 1a. The average BCTV infection rate (%) for each monitored tomato location (LOC) in Stanislaus County in 2021.

Field code	BCTV incidence		
	0-5%	**5-10%**	**>10%**
LOC1			√
LOC2	√		
LOC3		√	
LOC4			√
LOC5		√	
LOC6		√	
LOC7		√	
LOC8	√		
LOC9		√	
LOC10		√	

Table 1b. Information of BCTV infection for monitored tomato locations (LOC) in Stanislaus County in 2022.

Field Code	No. of diseased plants within 1,440 ft (4 rows × 360 ft)	% Infection	Total acreage
LOC1	44	3.06	68
LOC2	74	5.14	62
LOC3	16	1.11	68
LOC5	25	1.74	55
LOC7	32	2.22	82
LOC8	30	2.08	83
LOC9	64	4.44	100
		2.83 (Avg.)	518 (Total)

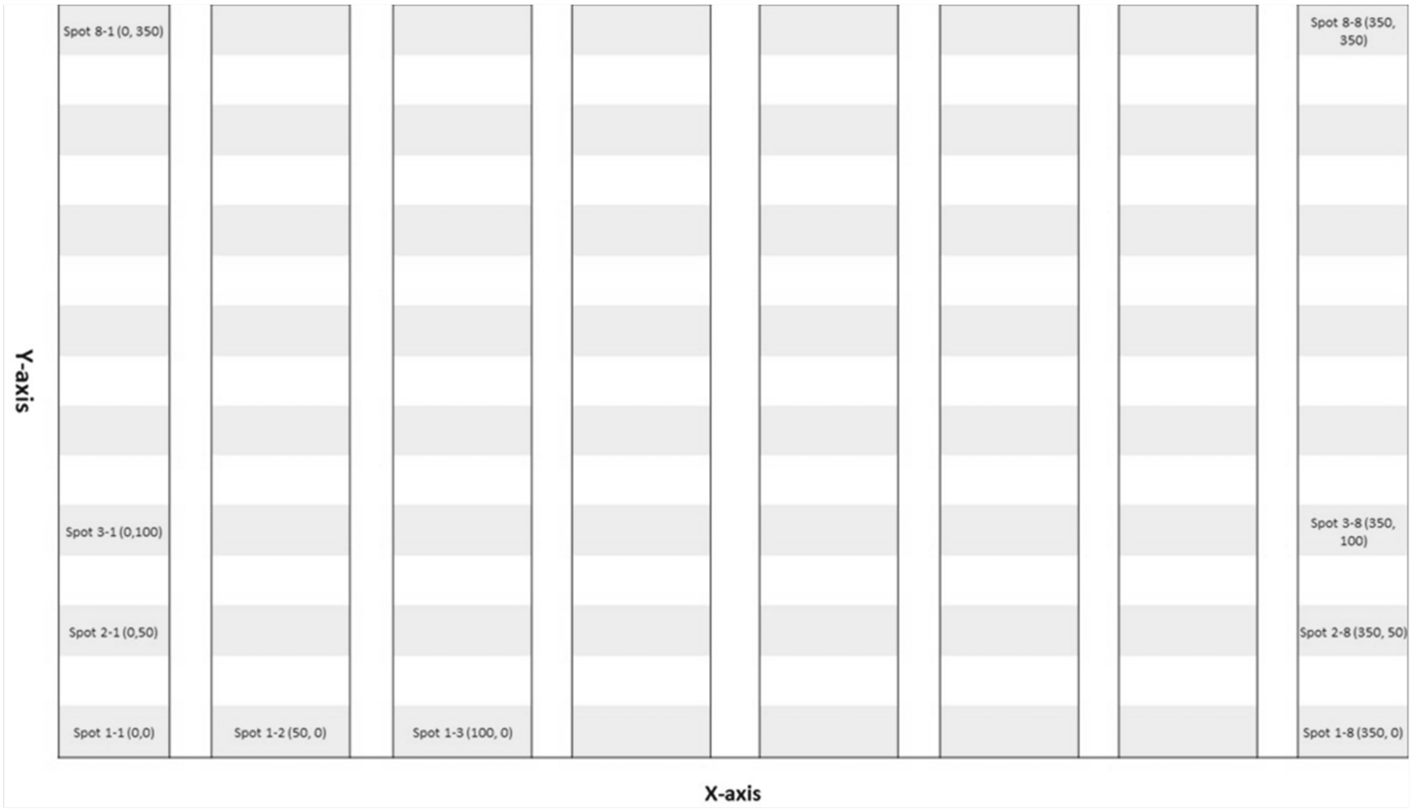

Figure 1. Configuration of the spatial grid-based analysis in 2022. We conducted the visual survey of the disease incidence and took sweep net samples in 64 sampling spots (8 x 8; grey grid area) by following a grid of 50 ft. x 50 ft distance. Figures in the parenthesis after spot ID are coordinates following the x- and y-axis. At each sample spot, we take samples within a 10-foot length from two consecutive rows.

II. Using grafting and Trichoderma biofungicide to manage watermelon productivity and plant health

In September 2021, I started a 3-year California Department of Pesticide Regulation (CDPR) project to look at the effects of grafting and Trichoderma biofungicide on reducing soil fumigation and improving watermelon productivity and plant health. I conducted the first-year field trial in San Joaquin County in 2022, which included a field variety grafted onto three rootstocks and inoculated with two Trichoderma products with two application ways. The products were either drenched once by soaking the transplant root balls a day before transplanting or applied through the drip lines four and eight weeks after transplanting (Fig. 2). We took vine health assessment, crop canopy coverage, fruit yield, quality, and disease sampling from all or selected treatment rows with the help from the grower and Dr. Cassandra Swett's Fungal Pathology Lab at UC Davis.

The overall results indicated that the effects of grafting on preventing vine collapse and maintaining fruit yield were much stronger than those of biological fungicides. In the meantime, the synergistic effects of grafting and biofungicide provided some but limited benefits to plant health compared to the single factor of grafting (Fig. 3). For fruit yield, using biological fungicides did not offer a greater watermelon yield compared to the corresponding controls. However, yield enhancement was well observed for plots using grafted watermelon plants (Table 2). Plants showing symptoms of vine collapse were excavated on August 20 and shipped to Dr. Cassandra Swett's Fungal Pathology Lab at UC Davis for pathogen identification. Based on the symptomatology and further diagnosis using molecular tools, the primary diseases were tentatively Falciforme crown rot and decline caused by Falciforme species complex – *F. noneumartii* and Charcoal rot caused by *Macrophomina phaseolina*.

Take-home message from the first-year results:

- **Timing of chemigating Trichoderma microorganisms through sub-surface drip lines is crucial.** Trichoderma species will unlikely inoculate if crop roots are absent or low in volume at or below drip tapes. Therefore, applying these biofungicides before root grows down to the drip line could cause poor inoculation.
- **If chemigation occurs with an irrigation event, it is highly recommended that the chemigation begin at the last part (e.g., one third) of the irrigation.** This can limit the length of flushing drip lines and prevent the microbes from draining before they inoculate roots.
- **Root ball soaking is perhaps impracticable for large-scale producers.** Watermelon growers may request the greenhouse to apply multiple times through overhead misting and tray drenching until the transplants are shipped.
- **Grafting onto the hybrid squash rootstocks were tested to be an effective way to reduce the threat of soil fungal pathogens.** Selecting proper rootstocks becomes vitally important as each rootstock was bred and marketed with possibly different disease resistance packages.

Note: Funding for this project has been provided in full or in part through a Grant awarded by the Department of Pesticide Regulation. The contents may not necessarily reflect the official views or policies of the State of California.

Figure 2. Chemigation of the Trichoderma-containing biofungicides into watermelon rows. Photo taken on June 18, 2022 (30 days after transplanting).

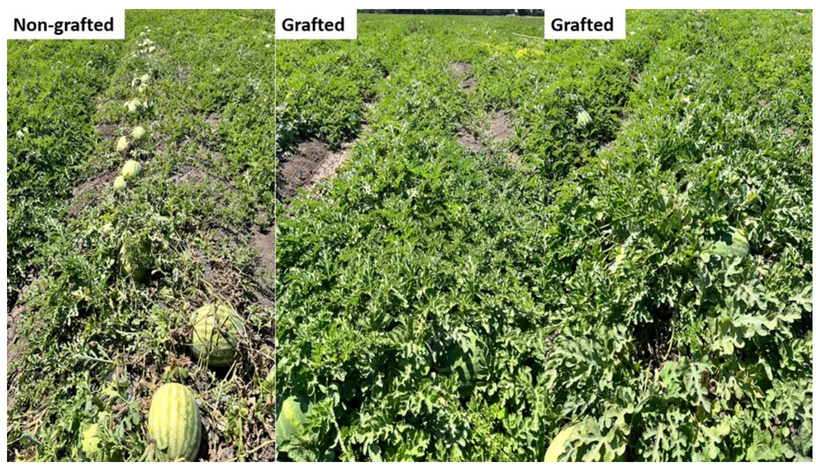

Figure 3. Left: rows grown with non-grafted, non-inoculated plants; Middle: rows grown with grafted but non-inoculated plants; Right: rows grown with grafted and inoculated plants. Photo taken on August 2, 2022 (76 days after transplanting).

Product	First harvest	Second harvest	Third harvest
Tricho-1	29.0 ± 1.71 A	37.5 ± 1.94 A	39.2 ± 1.64 A
Tricho-2	29.4 ± 1.07 A	35.6 ± 0.95 A	37.6 ± 0.92 A
Control-1	28.3 ± 2.88 A	38.2 ± 1.68 A	39.6 ± 1.73 A
Rootstock			
COB	34.5 ± 1.49 A	45.0 ± 1.57 A	47.1 ± 1.40 A
FLEX	24.6 ± 2.24 B	32.4 ± 1.73 B	33.7 ± 1.74 B
RS841	32.8 ± 2.68 A	44.1 ± 2.97 A	47.0 ± 2.64 A
Control-2	24.2 ± 0.83 B	25.9 ± 0.86 C	26.8 ± 0.98 C

Tricho-1 and Tricho-2 represent the two different Trichoderma products.
COB, FLEX, and RS841 are the three rootstocks used in this project (Cobalt, Flexifort, and RS841).
Control-1 refers to the average cumulative yield from all non-inoculated watermelon plants.
Control-2 refers to the average cumulative yield from all non-grafted watermelon plants.
Cumulative yield values followed by different letters indicate a significant yield difference between treatments based on the Least Significant Difference at $P < 0.05$.

Table 2. Cumulative watermelon yields (tons per acre ± standard error) at each harvest when plants were inoculated with two Trichoderma biofungicides and grafted onto three rootstocks.

Updates on Irrigation Management Using CropManage

Applying irrigation and nitrogen based on crop demands is key to maintaining vegetable productivity and conserving water, especially under continuous drought conditions. Since 2020, I have been evaluating the adaptability of the online irrigation and fertilization decision-support tool CropManage, to optimize irrigation application in watermelon. In 2021 and 2022, I added processing tomato to the crop list and conducted the first-year project in Crows Landing, CA, with collaborations of California Tomato Research Institute and Kagome, Inc. Similar to the watermelon study, the goal is to assess the adaptability of CropManage in informing tomato irrigation and N fertilization management by comparing grower standard irrigation scheduling with recommendations made by CropManage (Fig. 4). The introduction of CropManage and how this tool works was reported in the vegetable industry journal (https://vegetableswest.com/2021/12/01/read-november-december-2021-issue/).

Figure 4. Finished layout of the flow meter and dataloggers that were established at the main pump from the 2022 study.

The trial results indicated the grower took what CropManage (CM) recommended as an important indicator when making decisions on when and how much water should be applied. The cumulative irrigation curve clearly showed a parallel trend between the grower's actual water application and CM-recommended amount (Fig. 5). Another indicator that demonstrated the adaptation of the CM was the alignment between the actual crop canopy growth and the CM on-board model (Fig. 6). Since the CM provides real-time irrigation recommendations based on crop ET and crop coefficient, which are all closely related to canopy development, this alignment strengthened the adaptability of CM to inform reliable irrigation practices.

Unlike irrigation recommendations, there was a big difference between the grower's actual N fertilization and the system data. With an ample amount of soil residual nitrate measured at the beginning of the season, the CM did not recommend physical N fertilization until the eighth week after transplanting compared to a steady increase of N fertilization by the grower four weeks after transplanting (Fig. 7). In addition, in-season whole-plant and soil N measurements did not facilitate any adjustment of N fertilization. At the end of the season, there was a difference of 110 lbs. of N per acre between the actual application and system recommendation (Fig. 7). Due to the variation between the grower's application and N recommendations by the CM, we will continue the assessment in 2023 to better modulate and guide irrigation and fertilization management in processing tomato.

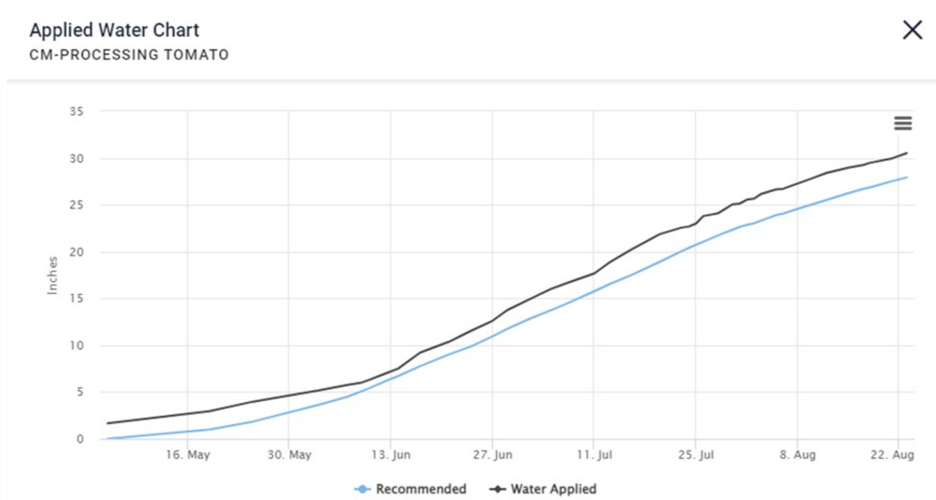

Figure 5. The chart of the cumulative applied water (inches) vs. CM-recommended amount throughout the season.

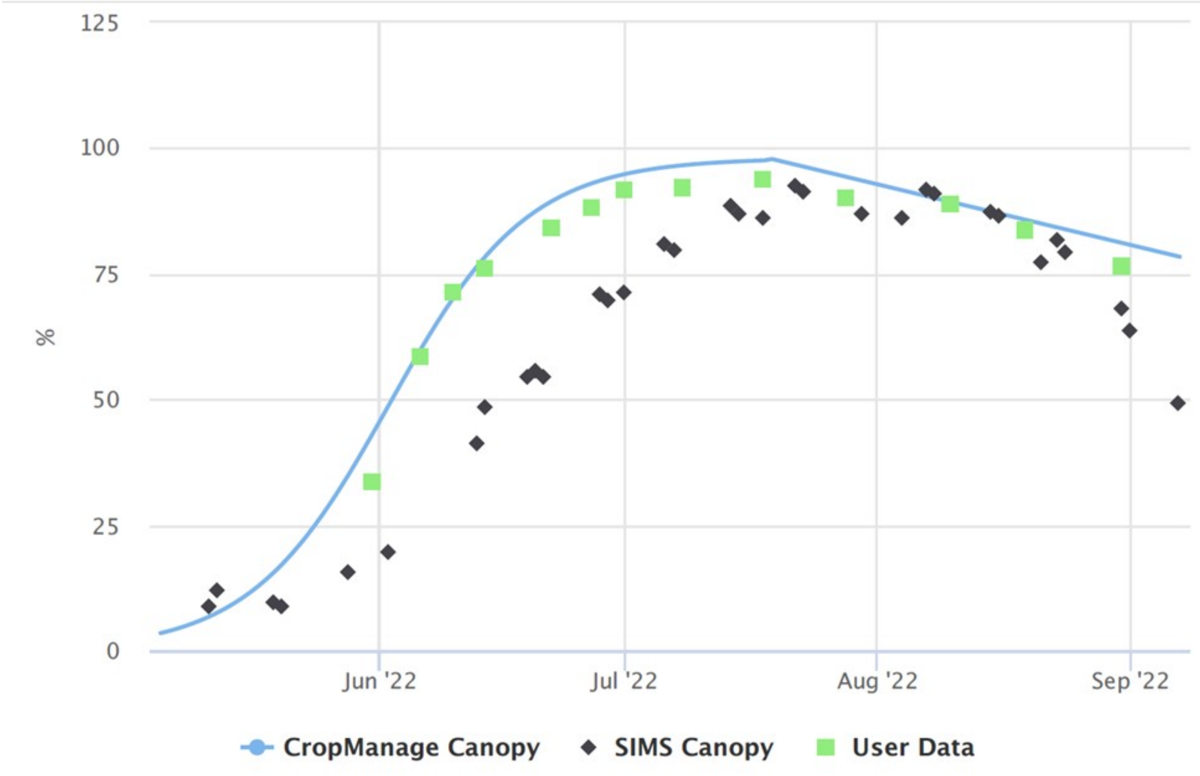

Figure 6. The chart of the measured % canopy coverage vs. CM system on-board model.
SIMS: NASA's Satellite Irrigation Management Support for crop canopy measurement.
User data: in-field measurement using the canopy sensor.

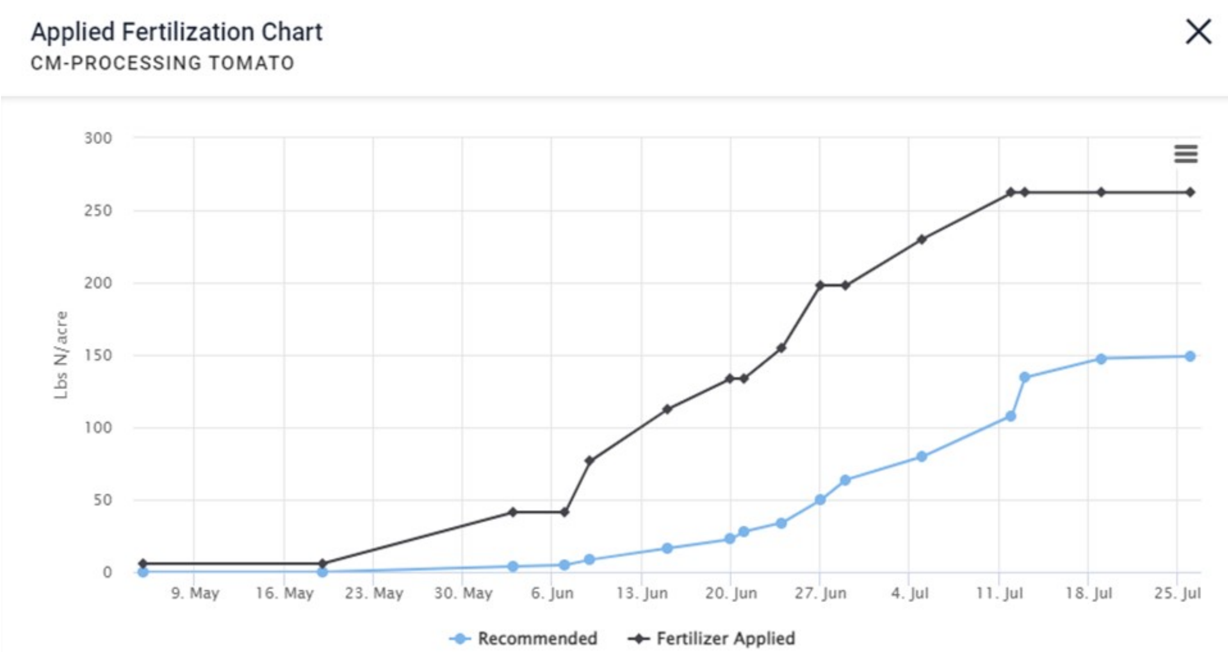

Figure 7. The chart of the cumulative N application (lbs. per acre) vs. CM-recommended amount throughout the season.

Pictures of Pest-infested Plants from Grower's Fields in the 2022 Season Followed by the (Tentative) Diagnosis

Beet curly top virus on processing tomato (note the pre-mature red fruit)

Falciforme crown rot and decline on watermelon caused by Falciforme species complex – *F. noneumartii* or Charcoal rot caused by *Macrophomina phaseolina*

Fusarium root and stem rot on cantaloupe caused by *Fusarium oxysporum* f. sp. *radices cucumerinum*

Falciforme crown rot and decline on watermelon caused by Falciforme species complex – *F. noneumartii* or Charcoal rot caused by *Macrophomina phaseolina*

Fusarium crown rot on watermelon caused by *Fusarium*

Spider mite damage on watermelon leaf