Field Notes
San Joaquin County
February 2022

University of California
Agriculture and Natural Resources

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Local Field Trials Evaluating Management Options for Fusarium Diseases of Processing Tomato

Fusarium falciforme is a relatively new disease of tomato which has been causing problems in local fields for the past four years. It causes a crown and root rot that can lead to premature vine decline in many cases. My team, in collaboration with UC Davis Plant Pathologist Cassandra Swett and her team, is conducting studies to look at crop rotations, cultivar susceptibility, and chemical control. On campus, they are looking more closely at cultivar susceptibility as well as susceptibility of rotation crops and weeds. They are also developing tools such as molecular diagnostics and optimizing screening methods that might be useful to private breeding efforts. In 2021, my team conducted two field trials in local San Joaquin County commercial processing tomato fields that suffered from disease pressure from both Fusarium wilt race 3 and *Fusarium falciforme*. Both trials were established with mechanical transplanters and the local standard bed configuration of single row 60-inch centers with buried drip tape. In both cases, the trial area was managed by the cooperating grower similarly to the rest of the field.

The first trial was to evaluate fumigation and fungicide chemigation in a commercial field (cv. 'DRI319') which was naturally infested with Fusarium wilt race 3 and *Fusarium falciforme*. Plot size for disease and yield evaluations was a single 5-ft bed by 200 feet and the experimental design was a randomized complete block with four replications. For the fumigation application, K-Pam was injected into the drip system on 21 April, over a period of approximately six hours. Valves were installed on individual trial rows to close those rows off for the injection period (and opened at the correct time to control the rate for the half-rate treatment). The field was mechanically transplanted about one month later on 19 May. The following day, fungicides were injected into the tape at the head of each row. Repeat applications were made at 2, 4 or 6 weeks after transplanting, depending on the treatment. The plots were evaluated for disease in July (seven weeks after transplanting when symptoms were first observed) and in mid-August (approximately six weeks before harvest). Counts were made based on foliar symptoms of either Fusarium wilt or *Fusarium falciforme*. Without destructive sampling of the crown tissue and laboratory confirmation of the pathogen, it is not possible to distinguish the two diseases with any confidence. Thus, analyses are presented for the total incidence of Fusarium diseases and no attempt is made to draw any conclusions about the efficacy of the treatments on each Fusarium disease. On 27 September, a small section of each plot was harvested by hand, and fruit were graded and weighed. Disease incidence did not differ between treatments in July, but by mid-August differences were very clear (Table 1, pg. 2). Yield was significantly increased by the top five treatments (*P = 0.015*). K-Pam (metam potassium) at the 31-gallon rate was the most effective at reducing disease and increasing yield. Also effective was the 15.5-gallon rate of K-Pam as well as Rhyme (flutriafol) applied via chemigation at 0, 4, and 6 weeks.

The second trial was established to evaluate the yield performance of 15 commercial cultivars in the face of Fusarium disease pressure. Plot size was a single bed (5 feet) by 100 feet, and the experimental design was a randomized complete block with four replications. The trial was transplanted on 26 May and machine harvested on 9 Oct (136 days). The same 15-cultivar variety trial was also conducted in a commercial field in Fresno County with disease pressure from *Fusarium falciforme* and root knot nematode. Disease evaluations were conducted multiple times. At the San Joaquin site, both *Fusarium falciforme* and Fusarium wilt were apparent, thus complicating disease assessments as it is nearly impossible to undertake an accurate field diagnosis based on foliar symptoms without destructively sampling the vine. Thus, the disease evaluations are of the foliar symptoms of Fusarium disease. Overall, disease pressure was low, particularly for *F. falciforme*. At the Fresno site, there was no Fusarium wilt, but considerable *F. falciforme* pressure, as well as some damage from root knot nematode, the severity of which was also evaluated. At harvest, destructive sampling was used to determine which plants had crown rot symptoms and a subset of plants were sent to the diagnostic lab for confirmation. Among the entries, there were eight cultivars with resistance to Fusarium wilt race 3 ("F3 cultivars") and seven which were susceptible to race 3 ("F2 cultivars"). Although our primary goal was to evaluate cultivar performance when challenged by *Fusarium falciforme*, the presence of race 3 at the San Joaquin County trial necessitates

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Table 1. Impact of fungicide programs on tomato Fusarium disease incidence and severity and fruit yield in processing tomato.

	Application timings relative to transplant date								
Treatment	pre-plant 21 Apr	1 day 20 May	2 wk 5 Jun	4 wk 15 Jun	6 wk 29 Jun	Fusarium incidence (%) 6-Jul	13-Aug	Marketable yield (tons/acre)	Fruit biomass (tons/acre)
K-Pam (metam potassium)	31 gal					1.8	15.8 e	53.5 a	58.7 a
K-Pam (metam potassium) + experimental	31 gal	1 qt				3.0	18.8 de	48.6 ab	56.8 a
K-Pam (metam potassium)	15.5 gal					3.0	23.0 cd	41.2 abc	49.9 ab
Rhyme (flutrifol)		7 oz		7 oz	7 oz	6.0	23.8 bcd	41.1 abc	47.8 ab
K-Pam (metam potassium) + experimental	15.5 gal	1 qt				3.3	21.5 cde	40.5 bc	48.2 ab
experimental		1 qt				5.8	34.0 a	36.8 bcd	43.2 bc
Miravis (pydiflumetofen)		13.7 oz	13.7 oz	13.7 oz		3.5	27.5 abc	36.8 bcd	44.6 bc
Rhyme (flutrifol)		7 oz	7 oz	7 oz		6.5	28.5 abc	34.0 cd	40.0 bc
Non-treated control						4.3	30.3 ab	27.6 d	34.1 c
				Mean		4.1	24.8	40.0	47.0
				LSD		NS	7.03	12.69	12.09
				P-value		*NS*	*0.0004*	*0.015*	*0.008*
				CV %		*54.9*	*19.4*	*21.7*	*17.6*

Means in the same column followed by the same letter are not statistically different according to Fisher's LSD test.

that these two groups of cultivars be discussed separately. Among the F3 cultivars, the three which ranked highest in terms of yield at both sites were SV 9016, SV 9025, and SV 9019 (Table 2, pg. 3). These cultivars did commonly exhibit crown rot (incidences of 39 to 75%) but had a lower incidence of vine decline accompanying the crown rot (i.e. cultivar mean vine decline below trial mean). Among the F2 cultivars, yield performance varied greatly depending on the site. This makes sense, as the incidence of Fusarium wilt at the San Joaquin site was a major factor impacting yield. At the Fresno site, there was disease caused by *F. falciforme* and root knot nematode, and the top F2 cultivars were BQ 273, HM 5522, BQ 403, and H 1428. At the San Joaquin site, where it appears that Fusarium wilt was more of a driver of yield decline than was *F. falciforme*, the top-ranked F2s were HM 3887, SV 8011, and H 4707. As in 2020, HM 3887 ranked high at the San Joaquin site due to its tolerance of Fusarium wilt but ranked low at the Fresno site where there was no Fusarium wilt, and HM 3887 exhibited a high incidence of *F. falciforme* crown rot and vine decline. BQ 273 had high disease incidence and low yield at the San Joaquin site but ranked first at the Fresno site where it had the lowest incidence of vine decline due to *F. falciforme*, indicating that BQ 273 may be tolerant of *F. falciforme* vine decline but not tolerant of Fusarium wilt race 3.

In the long run, we anticipate that improved genetics (i.e., disease resistance) will be the solution for this new Fusarium disease. Until we have that disease resistance, we will need multiple strategies to reduce risk of losses to this disease. For now, the suggestion is to consider planting tolerant varieties, coupled with careful crop management to avoid stress. Chemical control may be warranted at some locations, depending on disease pressure and yield history. In the future, we hope to be able to make better recommendations about risk factors and especially about rotation crops that won't increase disease risk. We are grateful for the generous cooperation of Dino Del Carlo, Ron Sanguinetti and Morning Star. The variety evaluation work was financially supported by the California Tomato Research Institute, while the chemigation and fumigation work was supported by the manufacturers.

Brenna Aegerter, Vegetable Crops Farm Advisor

Table 2. Yield and soluble solids performance in fields naturally infested with *Fusarium falciforme* (both sites) and Fusarium wilt race 3 (San Joaquin site only).

		Fresno County trial		San Joaquin County trial		Combined locations
Cultivar	**Fusarium resistance**	**Yield (t/ac)**	**Rank**	**Yield (t/ac)**	**Rank**	**Soluble solids (° Brix)**
SV 9016	F3	48.9	3	77.3 a	1	4.29
SV 9025	F3	50.3	2	70.3 abc	4	4.29
SV 9019	F3	45.0	5	75.2 ab	2	4.25
N 6428	F3	34.4	10	72.9 ab	3	4.40
BP 13	F3	38.5	8	70.0 abcd	5	4.37
HM 5522	F2, Fr	45.2	4	60.4 defg	12	4.31
BQ 273	F2	50.4	1	52.3 g	15	4.34
SV 8011	F2	36.9	9	66.3 bcde	8	4.35
H 1996	F3	34.4	11	68.1 abcde	7	4.35
H 1428	F2	39.8	7	60.0 efg	13	4.32
BQ 403	F2	42.2	6	54.4 fg	14	4.38
HM 3887	F2	24.9	15	69.4 abcd	6	4.36
SV 9011	F3	33.3	13	63.0 cdef	9	4.30
H 4707	F2	33.6	12	61.7 cdefg	10	4.30
H 1662	F3	32.5	14	61.2 cdefg	11	4.30
Mean		39.4		65.5		
Tukey HSD		NS		9.79		
P value		*0.1345*		< *0.0001*		
CV%		*50.50*		*5.82*		

Means in the same column followed by the same letter are not statistically different according to Tukey's HSD test.

Management of Botryosphaeria-Phomopsis and Mold of Walnut

The Botryosphaeriaceae fungi and Phomopsis species are now widely distributed in walnut orchards in almost all walnut -growing regions in California. A recent survey of numerous mature walnut orchards in San Joaquin County and a few in Stanislaus County showed Diaporthaceae (fungal family where the genus *Phomopsis* belongs) fungi to be the most prevalent fungal pathogens isolated from diseased walnut samples, and Botryosphaeriaceae fungi were only found occasionally.

In the second-year (2021) spore trap study results were consistent with those of the first-year study (https://cesanjoaquin.ucanr.edu/newsletters/Field_Notes_Newsletter90480.pdf) and showed that spores of Botryosphaeriaceae and Diaporthaceae spp. were mainly captured during and following rain events. We also confirmed the high aerial dissemination of spores following grinding/ shredding of infected branches on the orchard floor. This information is of great importance as it helps to identify production practices responsible for the spread of these fungal pathogens within walnut orchards. New management practices will be tested to assess the benefits of spraying fungicide right before shredding and/or after shredding of prunings, with the aim of possibly reducing infection of pruning wounds and thus lowering the Botryosphaeria and Phomopsis canker and blight diseases in walnut orchards.

Although Botryosphaeria and Phomopsis can cause walnut mold, most walnut mold develops because of infections by *Fusarium* and *Alternaria* species. Recent research conducted by Dr. Michailides and his team at the at the Kearney Agricultural Research and Extension Center showed that infections by these mold fungi might begin at bloom time. These new findings and the results of the spore trapping study, made us think of conducting a new spray program starting at bloom time, and verify its effectiveness in reducing the disease incidence.

In 2021, we established three trials in San Joaquin County in three different commercial mature Chandler orchards. Emphasis was placed on including triazole fungicides in our spray program, as we recovered high incidence of Diaporthaceae spp. from diseased samples collected from these orchards. In laboratory studies, we showed that triazole fungicides are the most effective in inhibiting growth of *Phomopsis* spp. Products selected for each field trial, application rates, and timing are shown in Table 1 (pg. 4). These trials were compared with a neighboring field where the grower followed his standard fungicide program.

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Table 1. Products and rates per acre used in this study to control Botryosphaeria/Phomopsis and mold in three trials in San Joaquin County.

	Treatment	Rate	14-Apr	6-May	31-Aug	20-Sep
Trial 1	Luna Experience + Serenade Opti	8.5 oz/ac + 20 oz/ac	Luna Experience + Serenade Opti	Luna Experience + Serenade Opti	Merivon + Tebuconazole	Rhyme
	Merivon + Tebuconazole	6.5 oz/ac + 8 oz/ac				
	Rhyme	7.0 oz/ac				
	Treatment	**Rate**	**14-Apr**	**23-Apr**	**1-Sep**	**11-Sep**
Trial 2	Luna Experience + Serenade Opti	8.5 oz/ac + 20 oz/ac	Luna Experience + Serenade Opti	Luna Experience + Serenade Opti	Merivon + Tebuconazole	Rhyme
	Merivon + Tebuconazole	6.5 oz/ac + 8 oz/ac				
	Rhyme	7.0 oz/ac				
	Treatment	**Rate**	**16-Apr**		**2-Sep**	**13-Sep**
Trial 3	Luna Experience + Serenade Opti	8.5 oz/ac + 20 oz/ac	Luna Experience + Serenade Opti		Merivon + Tebuconazole	Rhyme
	Merivon + Tebuconazole	6.5 oz/ac + 8 oz/ac				
	Rhyme	7.0 oz/ac				

Data were collected from the trials during harvest time, and compared to those collected from the grower's standard fungicide program, by counting blighted walnut fruits, thus checking the incidence of Botryosphaeria, Phomopsis, and mold pathogens. Following the first year experiment, the spray program starting at bloom time provided a significant disease reduction for the three trials, compared to the grower's standard fungicide program (Fig. 1, 2 and 3). Blighted walnut fruits were recorded twice; first record at three weeks before shaking trees (pre-shaking) and a second record right after shaking the trees (post-shaking) for each trial. More information about our procedures can be found in the full report, available at the Walnut Research Reports Database: https://ucanr.edu/sites/cawalnut/. Results showed no significant difference between the three trials in terms of disease reduction, suggesting that the spray in early May in trial 1 and 2 could be eliminated from the spray program when dry weather condition occur during bloom time. Further research to reduce the number of sprays (e.g. only one bloom-spray), will be conducted during 2022.

Mohamed T. Nouri, Orchard Systems Advisor

Themis J. Michailides, Department of Plant Pathology, UC Davis

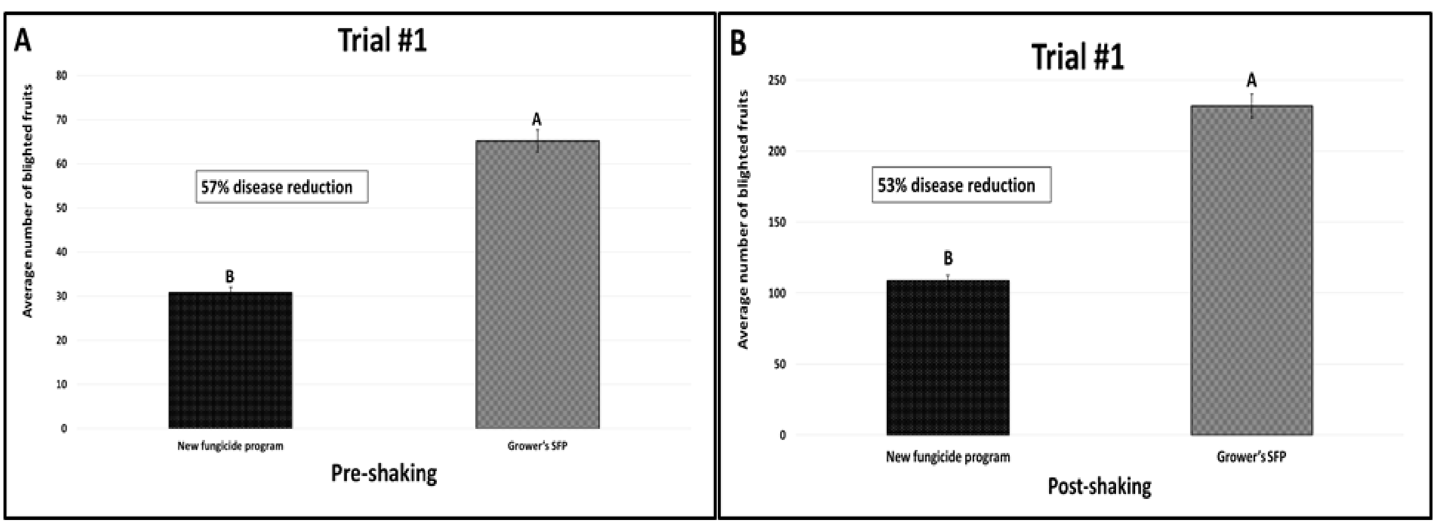

Fig. 1. Trial 1: Efficacy of bloom-time, before hull split, and early hull split spray program on blighted fruit and fruit with mold compared with the Grower's standard fungicide program. Specific program: 1) bloom spray (Luna Experience + Serenade Opti); 2) Three weeks after the 1st bloom spray (Luna Experience + Serenade Opti); 3) 3-4 weeks before hull split (Merivon + Tebuconazole); and 4) early hull split (Rhyme). **A.** Pre-shaking data collection and **B.** Post-shaking data collection.

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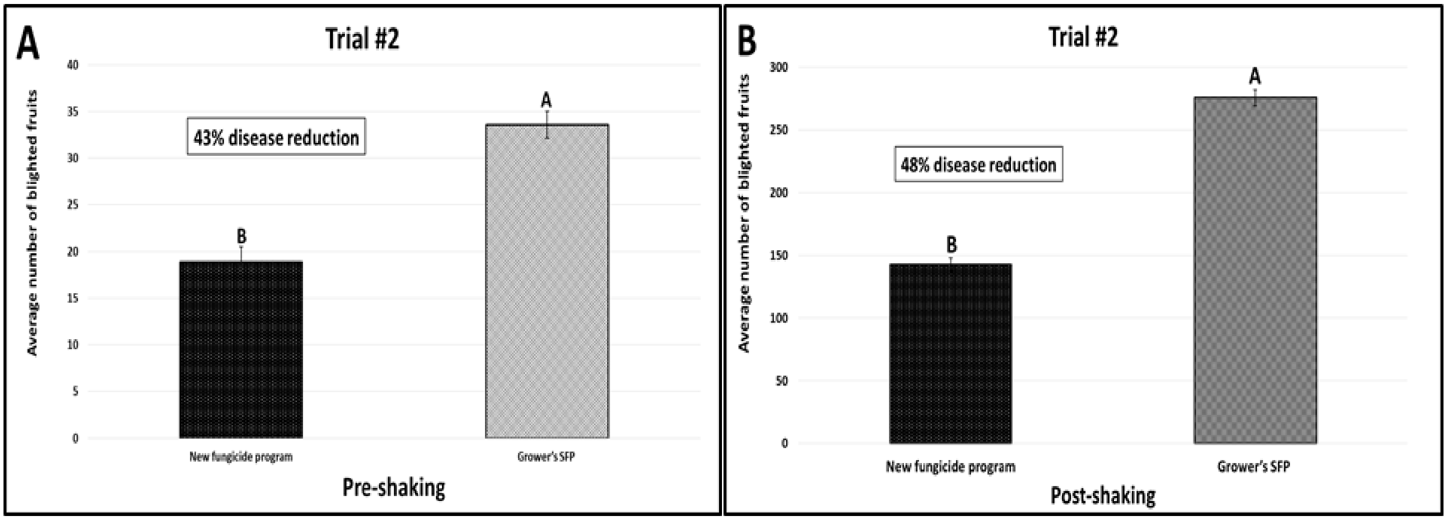

Fig. 2. Trial 2: Efficacy of a bloom-time, before hull split, and early hull split spray program on blighted fruit and fruit with mold compared with the Grower's standard fungicide program. Specific program: 1) bloom spray (Luna Experience + Serenade Opti); 2) Three weeks after the 1st bloom spray (Luna Experience + Serenade Opti); 3) 3-4 weeks before hull split (Merivon + Tebuconazole); and 4) early hull split (Rhyme). **A.** Pre-shaking data collection and **B.** Post-shaking data collection.

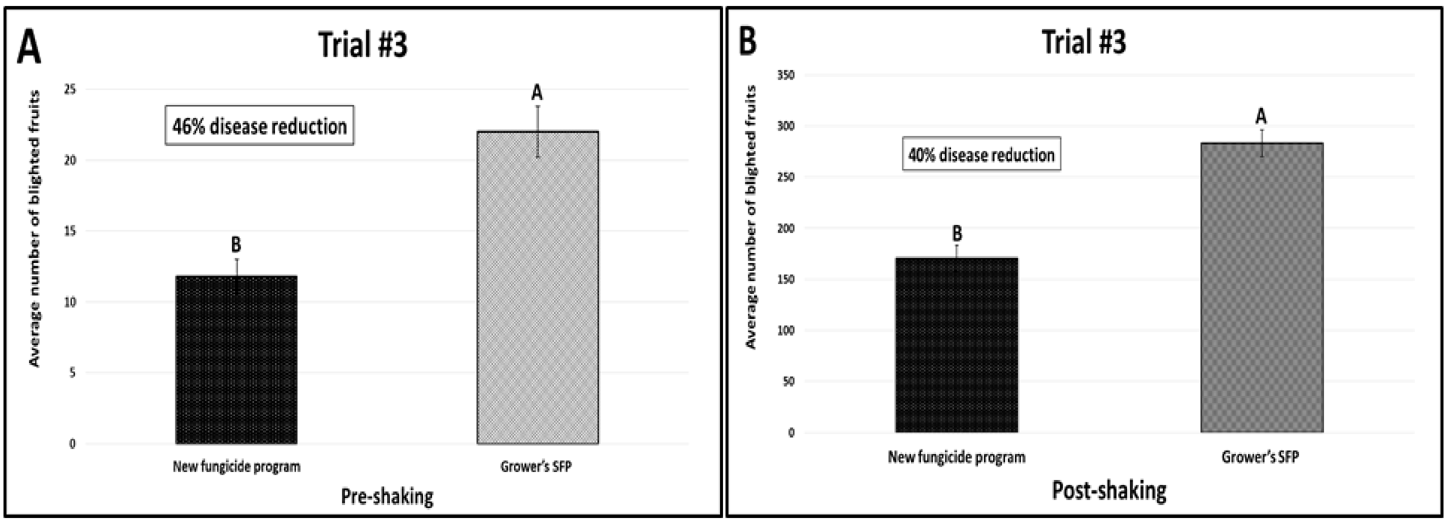

Fig. 3. Trial 3: Efficacy of a bloom-time, before hull split, and early hull split spray program on blighted fruit and fruit with mold compared with the Grower's standard fungicide program. Specific program: 1) bloom spray (Luna Experience + Serenade Opti); 2) 3-4 weeks before hull split (Merivon + tebuconazole); and 3) early hull split (Rhyme). **A.** Pre-shaking data collection and **B.** Post-shaking data collection.

2021 Rice Research Updates

Variety Trial

Last year, we reinstituted the San Joaquin County Delta rice variety trial, after a four-year break. San Joaquin County is one of twelve locations of the statewide trial that evaluates commercial varieties and advanced breeding lines. San Joaquin County is a test site for very early maturing varieties because the Delta is cooler than other rice growing regions of the state. The trial was drill-seeded on April 16th at a rate of 150 lb/acre and harvested on October 7th.

Statewide results are available from the UC Rice webpage (https://rice.ucanr.edu/Reports-Publications/Agronomy_Papers/). Table 1 (pg. 6) shows the San Joaquin County results. Among the entries, M-206 is the most commonly planted variety in the Delta, followed by M-105. The average yield across all commercial varieties and advanced lines was 10,129 lb/ac. When interpreting the results, the CV, or coefficient of variation, is a measure of variability in the data in relation to the mean. The LSD (.05), or least significant difference at 95%, is used to compare means of different varieties. When the difference between two varieties exceeds the LSD value, we are 95% certain that the two varieties performed differently; the results are not due to random chance.

Herbicide Trial

From 2019-2021, we conducted trials to evaluate the efficacy of a new herbicide product called Loyant (florpyrauxifen-benzyl; group 4 herbicide; Corteva

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Table 1. 2021 San Joaquin County very early rice variety test (advanced lines and varieties).

Variety	Grain Type	Grain Yield at 14% Moisture (lbs/ac)	Rank	Grain Moisture at Harvest (%)	Seedling Vigor (1-5)	Days to 50% Heading	Lodging (0-100)	Plant Height (cm)
L-208	L	11540	1	13	4.8	104	0	76
17Y2087	S	10780	2	14	4.8	114	0	84
CH-202	S	10760	3	13	4.7	109	13	80
19Y4000	M	10710	4	14	4.7	109	0	84
M-105	M	10700	5	14	4.8	106	0	87
19Y1071	L	10670	6	13	4.8	116	0	91
17Y1087	L	10350	7	13	4.9	108	0	77
M-206	M	10090	8	14	4.8	111	0	87
M-211	M	9940	9	14	4.8	119	10	87
18Y3151	M	9230	10	14	4.8	122	0	89
19Y3088	M	9220	11	14	4.8	123	0	85
18Y2070	S	9100	12	12	4.7	109	31	94
CJ-201	L	8590	13	13	4.8	116	0	79
MEAN		10129		13	4.8	113	4	84
CV		7		4	1.3	1	317	4
LSD (.05)		966		1	0.1	2	18	4

Agriscience) in Delta drill-seeded rice. Loyant is registered in rice growing states in the southern US but would be a new chemistry in California. Previous company trials have indicated that Loyant provides good control of broadleaf weeds (e.g. ducksalad, redstems), smallflower umbrella sedge, and ricefield bulrush. Results from the 2019 and 2020 Delta trials indicate that Loyant has efficacy on grass weeds in the drill-seeded system, like watergrass and barnyard grass (*Echinochloa* spp.). The objective of the 2021 trial was to assess the efficacy of Loyant on yellow nutsedge (*Cyperus esculentus*) (Figure 1).

All three years of the trial are described in a full report (https://ucanr.edu/sites/deltacrops/Rice/). In 2021, we observed minor crop injury with all treatments in the form of leaf tip burning, but symptoms were no longer visible two weeks after treatment. No other injury symptoms were observed. In terms of weed control, the best treatment for yellow nutsedge in this trial was the grower standard program. Several Loyant treatments performed statistically similar to the grower standard herbicide program and better than the Prowl ("control") treatment (Table 2, pg. 7). Loyant alone performed statistically worse than the grower standard program in this trial. While Loyant is registered for yellow nutsedge in other states, lack of moisture can impact efficacy. The delay in establishing the permanent flood may have affected its efficacy in this trial.

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Figure 1. The most prevalent weeds in the 2019 and 2020 trials were A) watergrass and barnyard grass (*Echinochloa* spp.) and B) sprangletop (*Leptochloa fusca*). The most prevalent weed in the 2021 trial was C) yellow nutsedge (*Cyperus esculentus*).

Table 2. Percent weed control, expressed as percent of the plot area, was estimated on 7-day intervals from 14 days after treatment (DAT) to 35 DAT. An untreated area of the field had approximately 1-4 sedges per square foot.

Herbicide Program (Treatment)	Weed Control (%) 14 DAT	21 DAT	28 DAT	35 DAT
Loyant	53 bc	34 bcd	34 b	34 bc
Loyant/Clincher	46 c	27 cd	13 bc	19 c
Loyant/Granite	84 ab	79 a	76 a	71 a
Loyant/RebelEX	80 abc	71 ab	68 a	66 ab
Grower standard	97 a	97 a	98 a	91 a
Prowl/control	0 d	0 d	0 c	0 c
Loyant/SuperWham	66 abc	58 abc	68 a	66 ab
Average	61	52	51	50
Coefficient of Variation (%)	10	13	13	13
Significance of treatment effect (P value)	<0.0001	<0.0001	<0.0001	<0.0001

** The aforementioned information on products and practices is for educational purposes only and does not constitute an endorsement or recommendation by the University of California.*

Conclusion

The purpose of these trials is to help support the Delta rice industry, which has a different production system than that of the Sacramento Valley. Special thanks go to Eugene Muzio and Trey Carlson for their cooperation. If you have questions about these trials or about Delta rice production, please don't hesitate to reach out to me, and good luck in 2022!

Michelle Leinfelder-Miles, Delta Farm Advisor

UC ANR Announcements and Calendar of Events

UCCE Virtual Statewide Walnut Series 2022
Tuesday, February, 22, 2022: Pests and Diseases
Wednesday, February, 23, 2022: General Orchard Management
8:00am-12:30pm (both days)
For more information and to register, please visit https://ucanr.edu/sites/WalnutSeries/
Contact: Mohamed Nouri, mnouri@ucanr.edu

California Olive Oil Day
Thursday, March 3, 2022
9:00am-12:30pm
Lunch – Provided by the OOCC. Please RSVP to anne@agamsi.com.
For more information, please visit http://www.oliveoilcommission.org/wp-content/uploads/2022/02/2022-OOCC-Olive-Oil-Day-Agenda-Final.pdf
Contact: Mohamed Nouri, mnouri@ucanr.edu

Principles of Fruit and Nut Tree Growth, Cropping and Management (virtual)
March 7-11, 2022
Please visit https://registration.ucdavis.edu/Item/Details/785 for information and to register. Questions can be directed to fruitsandnuts@ucdavis.edu

Golden State Dairy Management Conference – Save the Date!
Wednesday, March 23, 2022
Modesto, CA
For more information, please visit https://ucanr.edu/sites/CAdairyconference/
Contact: Jennifer Heguy, jmheguy@ucanr.edu

Airblast 2022: Spray Application and Modeling Conference
May16-18, 2022; 8am-3pm. This is a 3-day virtual event via Zoom. Register at https://ucanr.edu/sites/ASAM/Registration/
For more information visit https://ucanr.edu/sites/ASAM/

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