Evaluation of crop-safety of PICKET system on California-grown processing tomatoes
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Matt Fatino, Mohsen Mesgaran, and Brad Hanson. University of California, Davis.

Broomrapes (*Phelipanche spp.)* are parasitic weeds native to the Middle East. The biology of broomrape makes its control via conventional weed control practices very difficult. Broomrape seeds germinate after receiving a signal from a suitable host plant and quickly attach to the host roots via a specialized structure known as a haustorium. Most of the broomrape lifecycle is spent below the soil surface. The above ground portions of the plant lack chlorophyll and quickly produce a large amount of seed, which are highly persistent in the soil seedbank. Broomrape is not currently common in California, but is an "A-listed" noxious weed and has been detected in several processing tomato fields in recent years.

A study was conducted at the UC Davis Department of Plant Sciences Field Research Facility near Davis, CA to evaluate the crop-safety of the Israeli-developed PICKET decision support system for control of branched broomrape (*Phelipanche ramosa)* in processing tomato. The PICKET decision support system relies on a thermal time model (Growing Degree Days) to predict broomrape phenological stages. Based on these predictions, ALS inhibitor herbicides are applied at very low rates at times intended to target specific broomrape life stages and attachment to the host crop.

The soil composition at this site was 28.6% loamy alluvial land and 71.4% Reiff very fine sandy loam. The site did not contain broomrape; this experiment focused on crop safety (0.5X, 1X, 2X rates) of herbicides used in the Israeli system that are not currently registered for use in tomato in the United States. Plots were 40 feet long on 60-inch beds with one plant line in the center of the bed. 'Heinz 1662' processing tomato transplants were planted at a12-inch spacing within the row. Each bed had two 5/8-inch drip lines with 0.16 GPH emitters spaced every 12 inches; one line was ran the full length of the beds and was used for crop irrigation and fertigation, the second line was terminated at the end of each plot and used to apply the chemigation herbicide treatments. The experiment was conducted twice (see below) to represent common planting dates in the region. Plots were arranged in a randomized complete block design with four replications per planting date.

PPI applications of sulfosulfuron were made on April 24 and May 29, 2019 in the early- and late-planted experiment respectively, one day before transplanting. PPI herbicides were applied using a backpack sprayer and three-nozzle boom delivering 30 GPA with AIXR 1103 nozzles at 28 PSI. PPI treatments were mechanically incorporated to 3 inches after application. Tomatoes were mechanically transplanted with a single-row transplanter on May 2, 2019 and May 30, 2019. Drip herbicide injections were made through the terminated irrigation line using a 4.5 gallon per minute 12-volt electric pump and 30-gallon tank. Treatments were applied to four plots at once, with a total carrier volume of 25.4 gallons per treatment resulting in approximately 4.2 gallons per plot. The PICKET system's thermal time model is based off growing degree days (GDD), and called for applications at 400, 500, 600, 700, and 800 GDD depending on treatment (Table 1). Foliar imazapic treatments were made on July 16, 2019 and August 15, 2019 and 21

days post (August 6, 2019 and September 6, 2019) with a backpack sprayer delivering 30 GPA with AIXR 1105 nozzles at 20 PSI. Phytotoxicity data (percent affected plants) were taken. One-meter square sections of row were harvested on September 4, 2019 (Early) and September 19, 2019 (Late) and fresh weights were recorded (Tables 2,3). Percent phytotoxicity and yield (kg) data was analyzed using an analysis of variance followed by a Tukey-HSD tests (P=0.05).

Table 1. Growing Degree Day targets and actual application dates.

Planting	Growing Degree Day Target	Application Date
Early	PPI	24-Apr-19
Early	400	5-Jun-19
Early	500	7-Jun-19
Early	600	11-Jun-19
Early	700	13-Jun-19
Early	800	20-Jun-19
Early	Foliar	16-Jul-19
Early	Foliar 21 Days POST	6-Aug-19
Late	PPI	29-May-19
Late	400	13-Jun-19
Late	500	20-Jun-19
Late	600	24-Jun-19
Late	700	28-Jun-19
Late	800	3-Jul-19
Late	Foliar 1	15-Aug-19
Late	Foliar 21 days POST	6-Sep-19

*. Cumulative Growing Degree Days (GDD) were calculated after planting date by using the formula $GDD = \sum(\bar{T} - T_b)$, where $\bar{T}$ is mean daily temperature and T_b is the base temperature set at 10 ℃ (50 degrees Fahrenheit). Both experiments use the same plot randomization.

Table 2. Early planting phytotoxicity and yield fresh weight.

Early Planting					Percent Phytotoxicity							Yield (kg/m^2)
Trt. No	**Treatment**	**Rate**	**Application**	**GDD Appl.**	**21-May-19**	**6-Jun-19**	**20-Jun-19**	**3-Jul-19**	**17-Jul-19**	**31-Jul-19**	**14-Aug-19**	**4-Sep-19**
1	Untreated Check				35.0a	13.4a	3.5a	0.0a	0.0a	0.0a	0.0a	20.2a
2	Treflan Matrix	2.57 pt/a 1 oz prod/a	PRE POST		25.0a	5.1a	0.8a	0.0a	0.0a	0.0a	0.0a	24.3a
3	Sulfosulfuron (Outrider) Imazapic (Cadre)	0.535 oz ai/a 0.0685 oz ai/a	PPI CHEM x5	400, 500, 600, 700, 800	22.5a	4.2a	0.0a	0.0a	0.0a	0.0a	0.0a	21.1a
4	Sulfosulfuron (Outrider) Imazapic (Cadre)	0.535 oz ai/a 0.0685 oz ai/a	PPI CHEM x2	400,600	52.5a	19.3a	7.5a	0.0a	0.0a	0.0a	0.0a	16.8a
5	Imazapic (Cadre)	0.0343 oz ai/a	POST x2		55.0a	24.4a	3.4a	3.8a	0.0a	0.0a	0.0a	17.9a
6	Sulfosulfuron (Outrider) Imazapic (Cadre)	1 oz ai/a 0.137 oz ai/a	PPI CHEM x5	400, 500, 600,700,800	22.5a	5.1a	0.6a	0.0a	0.0a	0.0a	0.0a	21.1a
7	Sulfosulfuron (Outrider) Imazapic (Cadre)	1 oz ai/a 0.137 oz ai/a	PPI CHEM x2	400, 600	25.0a	11.4a	6.1a	5.0a	0.0a	0.0a	0.0a	21.1a
8	Imazapic (Cadre)	0.0685 oz ai/a	POST x2		40.0a	16.1a	0.6a	1.3a	0.0a	0.0a	0.0a	20.1a

* Means were analyzed using ANOVA and Tukey-HSD tests (P-value=0.05); means sharing the same column and letter show no significant difference. Percent phytotoxicity was measured as percent of plot with any phytotoxicity symptoms. PPI: preplant incorporated, POST: post emergent, CHEM: chemigation

Table 3. Late planting phytotoxicity and yield fresh weight means.

Late Planting					Percent Phytotoxicity								Yield (kg/m^2)
Trt. No	**Treatment**	**Rate**	**Application**	**GDD Appl.**	**6-Jun-19**	**20-Jun-19**	**3-Jul-19**	**17-Jul-19**	**31-Jul-19**	**14-Aug-19**	**28-Aug-19**	**10-Sep-19**	**19-Sep-19**
1	Untreated Check				1.3a	5.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	21.9a
2	Treflan Matrix	2.57 pt/a 1 oz wt/a	PRE POST		0.0a	1.3a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	20.7a
3	Sulfosulfuron (Outrider) Imazapic (Cadre)	0.535 oz ai/a 0.0685 oz ai/a	PPI CHEM x5	400, 500, 600, 700, 800	0.0a	3.8a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	22.1a
4	Sulfosulfuron (Outrider) Imazapic (Cadre)	0.535 oz ai/a 0.0685 oz ai/a	PPI CHEM x2	400,600	0.0a	3.8a	10.0a	0.0a	0.0a	0.0a	0.0a	0.0a	18.4a
5	Imazapic (Cadre)	0.0343 oz ai/a	POST x2		0.0a	5.0a	5.0a	0.0a	0.0a	0.0a	0.0a	0.0a	21.5a
6	Sulfosulfuron (Outrider) Imazapic (Cadre)	1 oz ai/a 0.137 oz ai/a	PPI CHEM x5	400, 500, 600,700,800	0.0a	2.5a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	22.9a
7	Sulfosulfuron (Outrider) Imazapic (Cadre)	1 oz ai/a 0.137 oz ai/a	PPI CHEM x2	400, 600	0.0a	3.8a	2.5a	0.0a	0.0a	0.0a	0.0a	0.0a	21.3a
8	Imazapic (Cadre)	0.0685 oz ai/a	POST x2		0.0a	3.8a	2.5a	0.0a	0.0a	0.0a	0.0a	0.0a	22.4a

***** Means were analyzed using ANOVA and Tukey-HSD tests (P-value=0.05); means sharing the same column and letter show no significant difference. Percent phytotoxicity was measured as percent of plot with any phytotoxicity symptoms. PPI: preplant incorporated, POST: post emergent, CHEM: chemigation

There were no significant differences in phytotoxicity among treatments. Some phytotoxicity was recorded in the early planting but was likely a result of glyphosate drift from a neighboring field rather than a treatment-related effect; the plants affected grew out of initial injury. (Fig. 1, 2) Tomato yield ranged from 16-24 kg per square meter and there were no significant differences in tomato yield among treatments (Fig. 3, 4). After one field season and experiment, the PICKET decision support system seems to have reasonable crop safety on California processing tomato systems. This experiment will be repeated in 2020 at the UC Davis field site. An efficacy experiment will be conducted if an infested site and cooperator can be secured. A rotational study is also being conducted on the potential residual effects of the herbicides applied with the PICKET system on crops commonly rotated with tomato in this production region.