Effects of Chloropicrin and 1,3-Dichloropropene Ratios on Weed Control in Strawberry

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Summary

The Ratio of chloropicrin (Pic) to 1,3-dichloropropene (1,3-D) can have a significant impact on pest control. In this project, we found that fumigation reduced yellow nutsedge tuber sprouting but fumigant ratio had no effect on purple nutsedge density, broadleaf and grass weed emergence in planting holes, and weed density in areas where the plastic was removed. We conclude that ratios of Pic and 1,3-D do not adequately manage broadleaf and grass weeds on their own and herbicides are needed to sustain adequate weed control.

Methods

Materials and Methods

An experiment was conducted in the fall of 2020 at the Gulf Coast Research and Education Center (27ºN, 82ºW) in Balm, Florida, to evaluate fumigant ratio for weed control in Florida strawberry. Soil type at the center is a Myakka fine sand (Sandy, Siliceous Hyperthermic Oxyaquic Alorthod) with a pH of 6.45, 0.68% organic matter and 92, 5.2, and 2.8% sand, silt, and clay, respectively. The field used in the experiment had a history of purple nutsedge (*Cyperus rotundus* L.) infestation.

The experiment was conducted as a randomized complete block design with four blocks. Plot size was 7.62 m of a single raised bed. Beds were spaced 1.22 m apart and were 0.81 m at the base, 0.71 m wide at the top and 30.5 cm tall. Beds were shaped with a standard fumigation rig (Kennco Manufacturing, Ruskin, FL, USA) and covered with TIF plastic mulch (Berry Plastics) on September 1, 2020. A single drip tape with emitters every 30 cm and a flow rate of 1.57 L min^{-1} was placed at the center of the bed just beneath the soil surface.

Fumigant treatments include 1) a nontreated control, 2) 100% Telone™ II (Corteva Agriscience Wilmington, DE), 3) 90% Telone™ II/10% chloropicrin (TriCal, Hollister, CA), 4) 80% Telone™ II/20% chloropicrin, 5) 60% Telone™ II/40% chloropicrin, 6) 40% Telone™ II/60% chloropicrin, 7) 20% Telone™ II/ Pic-Clor 80 (TriCal, Holloster, CA), 8) 10% Telone™ II/90% chloropicrin, and 9) 100% Tri-Pic 100 (Tri-Est, Inc, Hollister, CA). All fumigant combinations were applied at 250 lbs/acre(113.4 kg/acre). Plots were irrigated, fertilized, and managed for foliar pests as per industry standards in the region.

The number of purple nutsedge shoots that punctured the TIF plastic was counted within the planted area (22.9 meters of the bed) on October 7, 2020, January 4, and January 28, 2021. Twenty-five yellow nutsedge tubers were placed in 10 cm x 10 cm square organdy bags. One bag was buried 10 cm deep at the center of the bed in each plot on September 1, 2020. All bags were removed September 15, 2020. The number of yellow nutsedge tubers that germinated were recorded as a percentage of total tubers. Additional organdy bags of 25 seeds per bag of goose grass, cut leaf evening purslane and nightshade were buried 10 cm deep in the center of each plot on September 1, 2020. All bags were removed September 15, 2020, seeds were rinsed with 1% sodium hypochlorite solution, air dried, placed in petri dishes and incubated at 25°C for 14 days. The number of seeds that germinated were recorded as a percentage of total seeds per bag. Broadleaf weeds and grasses growing in the planting holes were counted on January 4, and January 28, 2021. Nutsedge, broadleaf and grass density were calculated on January 28, 2021 in 3-meter sections removed from the plastic mulch.

Data were analyzed using the Proc Mixed procedure in SAS (version 9.4; SAS Institute, Cary, NC). Block was considered a random variable and the repeated measures statement was utilized when data were collected over multiple dates.

Results

Purple nutsedge density increased over time ($p<0.0001$) with the population averaged over all fumigant treatments at 2 shoots/m^2 on October 7, 3 shoots/m^2 on January 4 and then a rapid increase to 30 shoots/m^2 by January 28. Despite this increase mid-season, differences between fumigant treatments did not change and no consistent correlation with fumigant ratio and nutsedge density averaged over time was observed (Table 1). In fact, none of the fumigant treatments differed significantly from the nontreated control. This is not entirely surprising, as many studies over time have shown that various ratios of Pic and 1,3-D have inconsistent efficacy on nutsedge.

The number of broadleaf weeds in the planting holes decreased over time from 2713 to 1208 broadleaves/ha between January 4 and January 29 ($p=0.0008$). Though not significant, a similar trend was observed with grasses with 476 grass/ha on January 4 and 352 grasses/ha on January 28. Total weeds in the planting holes decreased by 51% over this time period ($p=0.0021$) from 3189 to 1560 weeds/ha. The reason for this decrease is unknown but could be due to the rapid increase in nutsedge density. Averaged over time, none of the fumigant ratios decreased weed density in the planting holes compared to the nontreated control (Table 1). Though not significant, broadleaf weed density tended to decrease with increasing Pic content up to 90% Pic. Previous research has demonstrated that Pic can decrease weed densities in vegetable crops.

Fumigation reduced yellow nutsedge tuber sprouting by 76-100% (Table 2). There were no significant differences between the various fumigant ratios but sprouting tended to be lower at higher 1,3-D percentages. No consistent trend was observed with common purslane whereas fumigations with higher 1,3-D ratios tended to reduce black nightshade germination more effectively than fumigation at higher Pic ratios.

No significant differences in broadleaf, grass, or nutsedge density were observed in areas where the plastic was removed after crop transplant (Table 3).

Overall, we conclude that in this study fumigant ratio had no effect on nutsedge density throughout the bed, broadleaf or grass weeds emerging in the planting hole, or germination of seeds in the bed during fumigation. Fumigation did reduce yellow nutsedge tuber sprouting but the ratio had no effect on efficacy. There were also patterns indicating that higher 1,3-D ratios were more effective at killing weed seeds but the differences were not significant and further research is needed. This research demonstrates that fumigates can reduce nutsedge density but herbicides are needed in conjunction with fumigants to achieve adequate broadleaf weed control.

Table 1. The effects of chloropicrin (Pic) and 1,3-dichloropropene (1,3-D) ratios on nutsedge shoot number penetrating the plastic mulch and broadleaf and grass weeds emerging in the planting holes in a strawberry field at GCREC in 2020-2021.

Fumigant Ratio	Purple nutsedge	Broadleaf weeds	Grass weeds	Total Weeds
	--#/m^2--	-----------------#/ha-----------------		
Nontreated Control	10	3393	435	3828
100% 1,3-D; 0% Pic	10	2277	670	2946
90% 1,3-D; 10% Pic	6	2891	748	3638
80% 1,3-D; 20% Pic	11	2243	212	2455
60% 1,3-D; 40% Pic	20	1239	67	1306
40% 1,3-D; 60% Pic	12	1306	223	1529
20% 1,3-D; 80% Pic	13	1908	446	2355
10% 1,3-D; 90% Pic	14	859	324	1183
0% 1,3-D; 100% Pic	9	1529	603	2132
P-value	0.4051	0.8909	0.6647	0.1440

Table 2. The effects of chloropicrin (Pic) and 1,3-dichloropropene (1,3-D) ratios on sprouting of yellow nutsedge tubers as well as the germination of common purslane and black nightshade seeds buried in the fumigated beds in a strawberry field at GCREC in 2020-2021.

Fumigant Ratio	Yellow Nutsedge	Common Purslane	Black Nightshade
	----------------------%-------------------		
Nontreated Control	84 a[1]	10	27 a
100% 1,3-D; 0% Pic	1 b	0	1 b
90% 1,3-D; 10% Pic	2 b	0	4 b
80% 1,3-D; 20% Pic	0 b	14	9 ab
60% 1,3-D; 40% Pic	18 b	2	2 b
40% 1,3-D; 60% Pic	19 b	0	9 ab
20% 1,3-D; 80% Pic	17 b	3	8 ab
10% 1,3-D; 90% Pic	20 b	0	26 a
0% 1,3-D; 100% Pic	18 b	1	25 a
P-value	0.0053	0.1050	0.05

[1]Means within a column followed by a different letter are significantly different at $p<0.05$.

Table 3. The effects of chloropicrin (Pic) and 1,3-dichloropropene (1,3-D) ratios on broadleaf, grass and nutsedge shoot density in areas where the plastic was removed following crop transplant in a strawberry field at GCREC in 2020-2021.

Fumigant Ratio	Broadleaf weeds	Grass weeds	Nutsedge
	--------------------------#/m^2-------------------------		
Nontreated Control	17	2	36
100% 1,3-D; 0% Pic	10	1	72
90% 1,3-D; 10% Pic	14	2	6
80% 1,3-D; 20% Pic	14	0	24
60% 1,3-D; 40% Pic	9	0	39
40% 1,3-D; 60% Pic	10	1	16
20% 1,3-D; 80% Pic	8	4	46
10% 1,3-D; 90% Pic	7	1	17
0% 1,3-D; 100% Pic	10	3	9
P-value	0.5898	0.5072	0.6749

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