NON-FUMIGANT COMBINATIONS FOR MANAGEMNT OF SAN ANDREAS STARWBERRY IN A BUFFER ZONE INFESTED WITH *FUSARIUM OXYSPORUM* AND *MACROPHOMINA PHASEOLINA*

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Macrophomina phaseolina and *Fusarium oxysporum* are increasingly troublesome pathogens in California strawberries causing plant collapse and yield reduction. Our previous work showed that soil fumigation was effective in suppressing the pathogens for most of the season (Koike et al. 2009); however, non-fumigant tools are needed to help minimize production losses due to these pathogens in areas where fumigation is not an option.

An experiment designed as a randomized complete block with four replications was conducted in a non-fumigated buffer zone at Ventura, CA in a field with documented history of *M. phaseolina* and *F. oxysporum*. Individual, 50 ft long plots received one of the following treatments: 1) mustard meal (2000lbs/acre incorporated with shanks) + solarization (60 days under clear mulch), 2) steam (applied with hoses to raise soil temperature at 12-inch depth to 140F) + mustard meal, 3) steam + solarization and 4) untreated check under black mulch.
San Andreas strawberry, known to be susceptible to *M. phaseolina* was planted in all plots on Oct 14, 2010. Soil was sampled at 6 and 12-inch depths in all plots 90 days following treatment applications. These soil samples were analyzed for presence of *M. phaseolina* and *F. oxysporum.*
Weeds germinated in treatments under clear mulch (Solarization+mustard and solarization +steam) were counted on 16 Nov and 6 Dec, removed and air-dried at convection oven for biomass determination. Two-dimensional strawberry plant measurements were taken on 29 Nov, 2010 to calculate canopy areas of a subset of 20 plants in the middles of each plot. Fruit from the same 20 plants was harvested throughout the production season to determine marketable and unmarketable yields. Plant mortality and survivorship (number of dead and live plants) was recorded in whole plots at 10 dates during the growing season and causes of mortality were confirmed at the diagnostic lab. All data were analyzed using SAS; model assumptions of equal variance and normal distribution were checked using the General Linear Model procedure. The overall error rate for multiple comparisons was controlled by Tukey-Kramer adjustment.

<u>Pathogen and weed survival.</u>
Soil day-night temperatures at 6 inch depth under clear mulch were 84-92F reaching 105 F for one week in Aug. Solarization+mustard was not as effective as solarization+steam in controlling weeds (predominantly common purslane, spurges and annual sowthistle), based on both density (Table 1) and biomass

(data not shown). Combination of steam with solarization also was most effective in suppressing the two pathogens in soil (Table 1). Increased soil temperatures by solarization near the surface and with steam at greater depths are likely responsible for beneficial effects of this combined treatment. No treatment provided complete control of either pathogens or weeds. However, we have also previously observed *F. oxysporum* survivorship and late-season decline in beds drip-fumigated with PicClor 60 (1, 3 D +chloropicrin).

Table 1. Effects of non-fumigant treatments on weeds and pathogens at Ventura, CA, 2010-2011

Treatment	Weed number (per plot?)		*M. phaseolina* (#colonies/5 g of soil)		*F. oxysporum (CFU/g soil)*	
	16 Nov	6 Dec	6-inch depth	12-inch depth	6-inch depth	12-inch depth
Solarization+mustard	60 a	23a	2.5 ab	3.6 a	223 ab	127 ab
Solarization +steam	21 b	4 b	1.7 b	0.1 b	95 b	74 b
Steam +mustard*			2.5 ab	0.7 b	299 ab	106 ab
Untreated*			3.5 a	3.1 a	361 a	255 a

Treatments noted with the same letter within each column are not significantly different at *P*=0.05.
* Weeds were not counted in Untreated and Steam+mustard plots since black mulch was used.

<u>Strawberry plant performance</u>
By the end of Nov. plants in treated plots were larger than in untreated check which, as expected, resulted in differences in early fruit production (Table 2),

Table 2. Plant area, early and total marketable fruit yield of San Andreas strawberry at Ventura, CA, 2010-2011.

Treatment	Plant area, cm^2	Early marketable fruit (Jan – Feb 2011) yield, g/20 plants	Total marketable fruit yield (Jan-May 2011), g/20 plants
Solarization+mustard	316 a	1221 a	4660 ab
Solarization +steam	371 a	1368 a	5973 a
Steam +mustard	332 a	1274 a	4805 a
Untreated	220 b	745 b	3200 b

Treatments noted with the same letter within each column are not significantly different at *P*=0.05.

Significant yield loss in untreated check compared to treated plots started to occur early and resulted in 42% less fruit by Feb. (Table 2) even though no plant mortality was observed in any treatments until mid-April (Figure). The same pattern of yield decline and mortality was observed in previous season when untreated check was compared with fumigation treatments. Declining plants were primarily diagnosed with *M. phaseolina*, which typically causes late-season die-back regardless of pre-plant treatments. In this study the die-back occurred earlier and was greater in treatments with solarization with clear mulch. It is likely that higher soil temperatures under clear mulch accelerated plant growth and physiological development. The increased soil temperatures in spring under clear mulch also promoted infection with *M. phaseolina*, which is known to cause rapid decline of plants stressed with heavy fruit loads under high temperatures.

Non-fumigant treatments, particularly the combination of steam and solarization provided some control of the soil borne pathogens and weeds but did not eliminate them from soil. However, plant growth and early and total fruit production were significantly improved in these treatments compared to untreated check. Since soil fumigation is not available for buffer zones and does not provide complete pathogen control either, the non-fumigants treatment should be considered as management options, provided their economic feasibility can be established.

RERERENCES

Koike S. T. Gordon, H. Ajwa, Daugovish O., M. Mochizuki and M. Bolda. 2009. Fumigant and strawberry variety evaluations in *Macrophomina* and *Fusarium* infested fields. MBAO proceedings, 13:1-4. San Diego, CA.

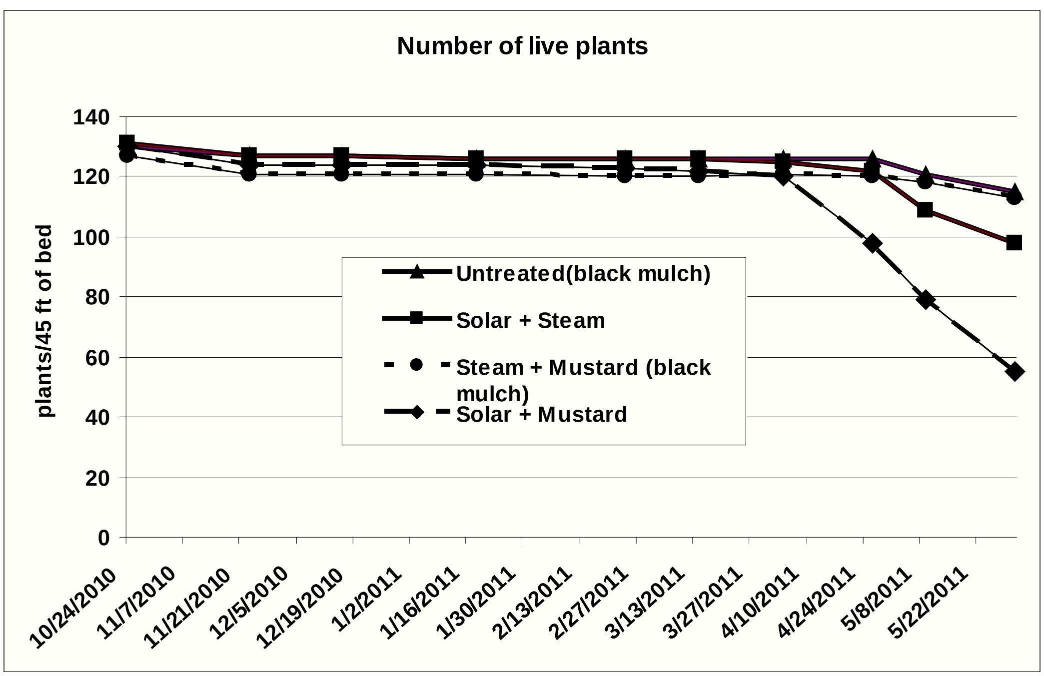

Figure. Number of live San Andreas strawberry plants at Ventura, CA, 2010-2011. *M. phaseolina* primarily was isolated from declining and dead plants.