FUMIGANT AND STRAWBERRY VARIETY EVALUATIONS IN MACROPHOMINA PHASEOLINA AND FUSARIUM OXYSPORUM INFESTED FIELDS

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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). Additionally, several strawberry varieties were significantly more tolerant to *F. oxysporum* than others but all tested varieties were susceptible to collapse caused by *M. phaseolina*.

In the 2009-2010 season we continued evaluations of fumigants and strawberry varieties in fields with confirmed infestations of *F. oxysporum* and *M. phaseolina*. At Oxnard, we compared six varieties in a *F. oxysporum* infested field that was fumigated with 200 lbs/acre of Inline (1, 3 D +chloropicrin). At Ventura, the same six varieties were tested in non-fumigated soil infested with both pathogens. Additional trial at the same location at Ventura compared low and high rates of drip-applied chloropicrin (200 and 300 lbs/acre), iodomethane (Midas, 300 lbs/acre), 1,3D+choloropicrin 37/56 (Pic 60, 300 lbs/acre), methyl bromide+chloropicrin (300 lbs/acre) and untreated check. On Oct 9, this fumigant evaluation trial was planted with Camarosa strawberry, known to be very susceptible to both pathogens (Koike et al. 2009). All trials were designed as randomized complete block experiments with four replications with treatments applied to individual 4 ft by 30 to 100ft bed sections designed for four row plantings. Black low density polyethylene mulch was used at Oxnard and black totally impermeable film (TIF) was used at Ventura. Trials were maintained with standard grower production practices. Number of dead and live plants was recorded during the season in all trials and causes of mortality were confirmed at the diagnostic labs. Additionally, we evaluated effects of row placement on mortality at the end of the season in all trials. In fumigation trial at Ventura, plant above ground dry biomass of surviving plants was evaluated on June 10, 2010 and fruit yields from 20 plants in each plot were recorded throughout the production season. In beds fumigated with Pic 60 we installed permeable bags with inoculum of *F. oxysporum* at 6 and 12 inch depth at bed centers, under drip lines and near bed sides. The inoculum was retrieved 7 days after fumigation and pathogen viability was determined. 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.

At Oxnard, fumigation prevented plant collapsed associated with *F. oxysporum* until June (Table 1) similar to previous studies. In June, a die-back started to take place in susceptible varieties, reaching 13% for Camarosa and about 5% for Albion, Ventana and Monterey by June 17.
At Ventura, some decline started to occur for Albion and Camarosa in May. Both *M. phaseolina* and *F. oxysporum* were isolated from dying plants. By June 3, Monterey, Palomar and Ventana lost 6-15% of plants, Camarosa and San Andreas 23 and 31%, respectively, and Albion 49% (Table 2). Even for varieties with least decline the surviving plants in June had marginal chlorosis on leaves and lacked normal vigor.

In fumigation trial no significant mortality was observed in any treatment (including untreated check) until May (data not shown). *M. phaseolina* was a primary pathogen isolated from the declining plants on May 22 with greatest mortality (11%) in chloropicrin treatment, significantly greater only when compared to iodomethane (5%), which was similar to all other treatments. This suggests lack of efficacy of pre-plant fumigants against late-season decline associated with *M. phaseolina.* However, plant biomass on Jun 7 was 18% less in untreated check compared to fumigated treatments (data not shown) and marketable yield was 28% less without fumigation (Figure 1). The trend for unmarketable yield was similar to marketable (data not shown). Yield decline in non-fumigated check (compared to fumigated treatments) started to occur in March (data not shown) but the pathogen-related mortality was not observed until May, suggesting that the negative effects of *M. phaseolina* and *F. oxysporum* on productivity may take place prior to plant collapse.

When mortality was compared among the two central and two side rows of strawberry plants, it appeared that 53% more Camarosa plants collapsed in side rows compared to central rows in Pic 60 treatment, while no difference were observed for untreated check (data not shown) at Ventura. At Oxnard, central rows had 91% less mortality in Camarosa and 68% less in Albion, compared to side rows in an Inline fumigated field. These observations suggested that fumigant distribution and, likely greater stress to the side rows accelerated pathogen-induced mortality in those zones compared to the bed interior. These observations were supported by results of differential *F. oxysporum* inoculum viability from various locations within the bed (Figure 2). No pathogen presence was observed under drip tape that supplied fumigant, however, bed sides (shoulders) had high levels of spore presence after fumigation, particularly at 12 inch depth.

These results of these 2009-2010 studies confirmed previously identified differential susceptibility of strawberry varieties to *F. oxysporum* but not to *M. phaseolina* and the fact that fumigants provide protection from these pathogens early and mid-season but not during May-June. Greater attention should be given to fumigant delivery and distribution to all bed areas to delay plant collapse at the most susceptible zones such as bed sides.

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.

Table 1. Plant mortality due to *Fusarium oxysporum* at Oxnard, CA field fumigated with 200 lbs/acre of Inline (1, 3 D +chloropicrin).

Variety	**Nov 6**	**May 25**	**June 10**	**June 17**
Camarosa	76a	71a	68b	66 c
San Andreas	76a	75a	75a	75 a
Palomar	76a	75a	75a	75 a
Albion	76a	74a	73a	73 b
Ventana	76a	74a	73a	72 b
Monterey	76a	74a	73a	71 b

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

Table 2. Plant mortality due to *Macrophomina phaseolina* and *Fusarium oxysporum* in 2010 in non-fumigated field at Ventura, CA.

Variety	**Oct 21**	**Mar 5-**	**Apr 14**	**May10**	**May 25**	**Jun 3**
Camarosa	98a	95ab	95ab	89b	80b	76c
Ventana	98a	96a	96ab	95a	93a	85b
Monterey	99a	97a	97a	95a	95a	93a
San Andreas	98a	95ab	95ab	90ab	81b	68d
Palomar	97a	93b	93b	92ab	91a	88ab
Albion	97a	88c	88c	77c	64c	50e

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

Figure 1. Marketable fruit yield of Camarosa strawberry following drip applied fumigants and in untreated control. 'Pic' = chloropicrin; '+Fung' = intended application of Topsin M; 'MB /Pic = methyl bromide + chloropicrin; Pic 60= 1, 3D + chloropicrin 37/56; low=200lbs/acre, 'high' = 300lbs/acre. Treatments noted with the same letter are not significantly different at *P*=0.05.

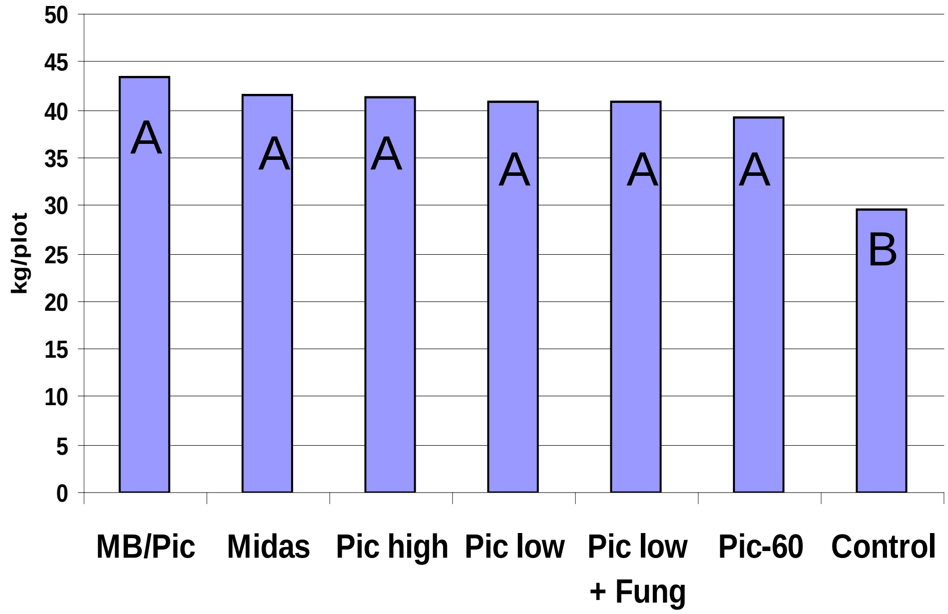

Figure 2. Number of spores of *Fusarium oxysporum* per gram of soil in different location in 64 inch –wide strawberry bed , seven days after fumigation with 1, 3D + chloropicrin 37/56.