USING MUSTARD SEED MEAL TO BIOFUMIGATE STRAWBERRY SOIL

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Introduction. Most strawberry growers in the USA utilize the annual raised-bed plasticulture system. The system depends heavily on annual soil fumigation for pest control. The release of toxic secondary plant metabolites, such as allyl isothiocyanate (AITC) from damaged *Brassica* tissue can suppress populations of some soil-borne pathogens and pests.

The primary objective of this project was to determine if mustard seed meal would biofumigate strawberry soil and increase yields. The project evaluated rates of Oriental mustard (*Brassica juncea*) on strawberry yield and weed control.

Materials and Methods. A multi-year study was conducted on strawberries grown in an annual plasticulture system. From 2003 to 2005, trials with four replications and at least four treatments of mustard seed meal arranged in a randomized complete block design were established in September. Yields were collected each spring of the following year. Treatments were established in the same location each year on plots 4.3 m long and 1.5 m wide. Treatments included 1) non-treated soil; 2) 1120 kg/ha, 3) 2240 kg/ha, and 4) 4480 kg/ha of mustard seed meal) tilled into soil beds and covered immediately with plastic; and 5) 2240 kg/ha of seed meal tilled into beds and sealed with 1.3 cm sprinkler irrigation water. Beds not sealed with irrigation water were watered for 24 hr with dripline irrigation, starting immediately after covering with plastic.

Another multi-year study was started in fall 2006 on a different set of plots. Treatments in 2006 included 1) non-treated soil; 2) 560 kg/ha, 3) 1121 kg/ha, 4) 2242 kg/ha or 5) 4484 kg/ha of mustard seed meal; or 6) 336 kg/ha or 7) 673 kg/ha of Basamid were tilled into the soil in mid-September. The plots were immediately overhead irrigated with 1.3 cm of water to reduce AITC loss. The plots were retilled and plastic-covered beds formed three weeks after treatment and prior to planting strawberries. Weeds had emerged before bed formation and an area 0.3 m by 0.3 m was selected at random in each plot and photographed on October 2. The weeds in the photographs were later counted and classified as broadleaf or grassy weeds, garlic or nutsedge. Yields in the following spring (2007) were essentially eliminated by late spring frost.

Results and Discussion

Disease: In 2004, plants on beds treated with 2240 kg/ha meal and covered with plastic had less anthracnose ($P<0.05$) than control plants, indicating partial control

(Table 1). Plants on water-sealed beds tended to have more anthracnose symptoms than plants on plastic sealed beds.

Weeds. In the first year of the study, the meal had little effect on weed populations the following spring (Table 1). Broadleaf weeds were more numerous (mostly common chickweed and henbit) in the beds than grassy weeds (mostly tall fescue and ryegrasses) and both types grew mostly through holes where strawberries were transplanted. Beds sealed with 1.3 cm irrigation immediately after mustard seed meal incorporation tended to have more weeds than plots sealed with plastic. Weeds were removed by hand and not counted for the next two growing seasons.

In the fall planting of 2006, weeds had emerged before retillage. Most of the weeds were broadleaf or grass weeds with small numbers of wild garlic (*Allium vineale*) and nutsedge (*Cyperus spp.*). Broadleaf weeds in the plots were mostly common chickweed and henbit (*Lamium amplexicaule)* but prickly lettuce (*Lactuca serriola*), shepherd's-purse (*Capsella bursa-pastoris*) and curly dock (*Rumex crispus*) were also present. Grass weeds were mostly tall fescue (*Festuca arundinacea*) and ryegrasses (*Lolium* spp.). Increasing concentrations of mustard seed meal (from 560 kg/ha to 4484 kg/ha) provided better control of broadleaf weeds. Contrast comparisons indicated that mustard seed meal mustard meal (2242 kg/ha and 4484 kg/ha) provided similar broadleaf weed control as 336 kg/ha of Basamid (Table 2). Plots treated with 2242 kg/ha and 4484 kg/ha mustard meal had only 1.6 and 3.3 broadleaf weeds/0.09 m^2, respectively, compared 46.2/0.09 m^2 in control plots. Basamid (336 kg/ha) treated plots had very low broadleaf weed (0.4/0.09 m^2) and grass weed (0.4/0.09 m^2 populations. Mustard seed meal did not decrease grass nor nutsedge populations.

Yield: In 2004, plots treated with 2240 kg/ha seed meal and covered immediately with plastic had 27% and 29% more yield than water sealed plots or untreated plots, respectively. Plots treated with MM (1120 kg/ha to 4480 kg/ha) averaged 12% more yield and 7% larger fruit than control plots. Irrigating with 1.3 cm of water to reduce AITC volization was apparently less effective than immediately covering with plastic, perhaps due to timing of irrigation. In 2005 plants grown on beds treated with meal averaged 20% more yield than on control plots. Plants on beds treated with 4480 kg/ha meal and immediately sealed with plastic yielded 25% more than plants on untreated beds. Yields in 2006 and 2007 severely limited by spring frosts.

Conclusion

Soil incorporation of 2240 kg/ha to 4480 kg/ha mustard seed meal can increase yields of plasticulture grown strawberries by 20% to 29% compared to control plots. The reasons for the boost in yields are unclear from these trials. The trial in 2006 showed that the seed meal can greatly decrease competition from broadleaf weeds in autumn established strawberry plants, similar to the control provided by Basamid. Higher concentrations of mustard seed meal are being evaluated for AITC production and for weed and pathogen control.

Table 1. Effect of mustard meal and soil surface sealing on anthracnose severity and weed populations of 'Chandler' strawberry grown in plasticulture.

Treatment			Weeds (no./plot)[Z]		
Mustard (kg/ha)	Surface Seal	Anthracnose[Y]	Broadleaf	Grass	Total
0	Plastic	2.9	55.2	2.6	58.6
1120	Plastic	2.5	48.4	4.0	52.8
2240	Plastic	2.0	39.6	13.2	53.8
4480	Plastic	2.9	49.2	32.0	81.3
2240	Water	2.9	61.6	3.4	65.6
LSD @ 0.05		0.8	20.2	17.8	27.5

[Z]Number of weeds per plot, 26 March 2004.
[Y]Rating scale: 1= no disease, 2= very slight infection, 3= moderate infection, 4= heavy infection.

Table 2. Effect of mustard seed meal and Basamid on weed populations.

	Treatment[Z]		Weeds (no./ 0.09 m^2)[Y]		
	Chemical	Rate ($kg \cdot ha^{-1}$)	Broadleaf [X]	Grass[W]	Garlic
1	None	---	46.2 a[V]	6.8	0.6
2	Mustard meal	560	31.6 ab	16.6	0.2
3	Mustard meal	1121	16.0 bc	11.6	0.2
4	Mustard meal	2242	1.6 ce	6.6	0.0
5	Mustard meal	4484	3.3 c	23.5	0.3
6	Basamid	336	0.4 c	0.4	0.0
7	Basamid	673	1.0 c	0.2	0.0
	Significance		**	NS	NS
	Contrasts				
	Mustard (4,5) vs. Control		**	NS	*
	Mustard (4,5) vs. Basamid (6)		NS	NS	NS

[Z] Treatments soil incorporated September 18, 2006.
[Y] Weed counts made October 2, 2006
[V] Means separation within column by Duncan's multiple range test, $P \leq 0.05$.
[NS,*, **] Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

Table 3. Effect of mustard seed meal and soil surface sealing on strawberry fruit size and yield.

Treatments		Fruit size (g/berry)			Yield (g/plant)		
Mustard ($kg \cdot ha^{-1}$)	Surface seal	2004[Z]	2005[Y]	2006[Y]	2004[Z]	2005[Y]	2006[Y]
0	Plastic	10.4	14.1	19.6	242	182	75
1120	Plastic	10.9	13.1	20.2	261	200	69
2240	Plastic	11.5	13.5	20.4	313	189	76
4480	Plastic	11.7	14.3	19.0	281	241	82
2240	Water	10.4	13.6	20.0	245	219	95
LSD @0.05		0.4	1.5	1.5	70	70	23

[Z] 'Chandler' strawberries.
[Y] 'Sweet Charlie' strawberries.