

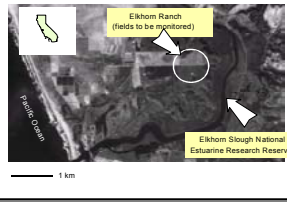
# MAINTAINING AGROECOSYSTEM HEALTH IN AN ORGANIC STRAWBERRY/VEGETABLE ROTATION SYSTEM (PART 4): THE FIRST FOUR YEARS

J MURAMOTO<sup>1</sup>, SR GLIESSMAN<sup>1</sup>, ST KOIKE<sup>2</sup>, C SHENNAN<sup>1</sup>, D SCHMIDA<sup>3</sup>, R STEPHENS<sup>4</sup>, AND S SWEZEY<sup>1</sup>  
 UC SANTA CRUZ<sup>1</sup>, UC COOPERATIVE EXTENSION<sup>2</sup>, SANDPIPER FARMS<sup>3</sup>, ELKHORN RANCH<sup>4</sup>

## ABSTRACT

Continued growth of organic strawberry and vegetable production in California faces two challenges: soil-borne disease management without use of synthetic chemical fumigants, and fertility management to optimize fertility input use while ensuring protection of vulnerable habitats. The goal of this project is to demonstrate effects of diverse organic strawberry/vegetable rotations and integrated ecological practices on agroecosystem health. In 2001, we initiated a replicated on-farm trial at Moss Landing, California with number of years between strawberry crops as main plot (5 levels) and strawberry cultivar as sub-plot (2 levels). Ecological practices such as biofumigation with broccoli residues and mustard incorporation, compost application, use of vegetables that do not host *Verticillium dahliae* (spinach and broccoli) as rotational crops, and choosing strawberry cultivars that are less sensitive to disease are used in integrated manner. While the main treatment effects will be tested after the fifth year, soil health indicators (*Verticillium dahliae* propagule number, soil inorganic N, and other physicochemical indicators) and agroecosystem health indicators (yield, disease incidence, and nutrient budgets) will be monitored during all five years. In the first four years, strawberries, vegetables and cover crops had moderate yields and no major disease problems. No significant differences were found between any treatments in yields of any crops during the period. The N monitoring in organic strawberries suggested: 1) the maximum N loss during the rainy season reached 214 kg ha<sup>-1</sup>, and 2) pre-plant plastic mulch application and adjusting basal/supplemental N rates can significantly reduce N loss during the rainy season while maintaining fruit yield. Broccoli residue incorporations frequently reduced *Verticillium dahliae* propagule number in soils, whereas mustard incorporations did not. Further, a major weed (*Capsella bursa-pastoris*) of the plot hosts *Verticillium dahliae* suggesting weed management is integrated with soil-borne disease management.

## ELKHORN RANCH (MOSS LANDING, CA)



## INTRODUCTION

Continued growth of organic strawberry and vegetable production on the central coast of California faces two challenges: soil-borne disease management without use of chemical fumigants, and fertility management to optimize fertility input use while ensuring protection of adjacent vulnerable habitats from water pollution.

*Verticillium wilt* is a soil borne disease caused by *Verticillium dahliae*. Today it poses the greatest threat for organic strawberry production in California. While a number of ecological techniques can reduce pathogen populations to a degree, none provided adequate control when used alone.

Compost and cover crop applications increase soil organic matter and improve soil quality, but are often inadequate to fulfill the late nitrogen demand of strawberries and vegetables. Consequently, many organic strawberry and vegetable growers have intensified their use of various commercial organic fertilizers that are relatively soluble. This practice has received criticism since it may not convey many of the environmental benefits commonly associated with organic production (ATTRA 2003). Impact of current N-management practices in organic strawberries on the environment is unknown in California. There is a critical need of research-based information on N fertility management in organic strawberry systems.

In 1999, an organic strawberry grower and the land owner requested our assistance in establishing an organic strawberry/vegetable rotation system at Elkhorn Ranch at Moss Landing, CA. A team of multidisciplinary researchers conducted soil characterization and began monitoring soil health indicators in Oct. 1999. Upon completion of the three-year transitional period in 2001, an organic rotation experiment that integrated multiple ecological practices was initiated.

In this poster, we report results from the first four years on crop yields, N loss during the rainy seasons, and *Verticillium dahliae* populations in soils.

## GOAL

To demonstrate indicators of soil health and agroecosystem health and strategies for soil-borne disease and fertility management in an organic strawberry / vegetable rotation system.

## APPROACH

### 1. On-Farm Rotation Experiment

An organic five-year rotation experiment was initiated on a local farm in 2001. To manage soil-borne disease, we integrated multiple ecological practices including biofumigation with broccoli residues (Subbarao et al., 1999), mixed cover crops including mustards, compost application, strawberry variety selections, and choosing vegetables that do not host *Verticillium dahliae*. Experimental design was a split plot arrangement of treatments in a randomized complete block with a break period between strawberries as the main plot (four 65 cm rows, 18.6 m long), and strawberry cultivar as a sub-plot with four replications. Total area of one acre was loaned for the experiment by the landowner.

ROTATION TREATMENTS	Year 1	Year 2	Year 3	Year 4	Year 5		
Treatment	2000	2001	2002	2003	2004	2005	2006
A (0 yr. + 4 br.res.)	cv	br	cv	br	cv	br	cv
B (1 yr.)	cv	br	cv	br	cv	br	cv
C (2 yrs.)	cv	br	cv	br	cv	br	cv
D (3 yrs.)	cv	br	cv	br	cv	br	cv
E (Control)	cv	br	cv	br	cv	br	cv

\*Period between strawberry plantings.  
 br.res. applying broccoli residues before planting strawberries, cv cover crops, st. strawberries (2 different cultivars), sp. spinach, vg. vegetables other than broccoli and spinach (i.e. lettuce).

### 2. Monitoring Soil Health and Agroecosystem Health Indicators

Throughout the experiment, we are monitoring soil health indicators (*Verticillium dahliae* propagule number, available nutrient levels and other physicochemical indicators) and agroecosystem health indicators (yield, disease incidence, N loss during the rainy season, and production costs).

## RESULTS AND DISCUSSION

### 1. Crop Yield

Strawberries grew well without any major pest and disease problems and had relatively high yields for an organic system. Average marketable fruit yield of cv. Aronias was 36-44 tons ha<sup>-1</sup> during the first four years. Cover crops and vegetables had fair to moderate yields (data not shown). In year 2, we lost broccoli by the damage by ground squirrels. No significant differences were found in the yields between any rotation treatments for any crops during the four-year.

### 2. N-Loss During the Rainy Seasons (Strawberry Plots)

We estimated N-Loss from the root zone during the rainy season (between 0 and 20 weeks after planting, which is approximately from mid November to early April) using the following formula:

$$N\text{-Loss}_{20\text{wks}} (\text{kg ha}^{-1}) = (\text{Soil inorg. N}_0 - \text{Soil inorg. N}_{20\text{wks}}) - (\text{Plant uptake N}_{20\text{wks}} - \text{Plant input N}_0)$$

where, Soil inorg. N<sub>0</sub>: Inorganic N (= NO<sub>3</sub>-N + NH<sub>4</sub>-N kg ha<sup>-1</sup>) in 0-30 cm deep soil on the planting day, Soil inorg. N<sub>20wks</sub>: Inorganic N in 0-30 cm deep soil at 20 weeks after planting, Plant uptake N<sub>20wks</sub>: Plant uptake N (kg ha<sup>-1</sup>) at 20 weeks after planting, and Plant input N<sub>0</sub> N input (kg ha<sup>-1</sup>) from transplants.

Figure 1 shows N-Loss<sub>20wks</sub> in strawberry plots during the four years. For a comparison, a strawberry plot that had a similar marketable fruit yield (~40 tons ha<sup>-1</sup>) was chosen from each year. In year 1, pre-plant soil inorganic N analysis revealed 150 kg N ha<sup>-1</sup> of residual inorganic N. By adding 222 kg N ha<sup>-1</sup> of total basal N, inorganic N content at the time of planting rose to 260 kg N ha<sup>-1</sup>. After receiving 280 mm of precipitation, the grower applied plastic mulch in January 2002. In the meantime, it was estimated that 214 kg ha<sup>-1</sup> of inorganic N was lost from the root zone within 20 weeks from planting (fig. 1. Year 1. Trt. A). Based on the results, the grower modified his N fertility management for year 2. He adopted: 1) pre-plant plastic mulch application to reduce N-loss during the rainy season, and 2) adjusted the rates of basal/supplemental organic fertilizer applications to better meet the N demand of strawberries. He decreased the rate of pre-plant pelletized organic fertilizers to a half of the previous year and increased the rate of liquid fertilizers through fertigation in the late growth stage. As a result, N-Loss<sub>20wks</sub> was reduced to a 13 kg N ha<sup>-1</sup> without sacrificing fruit yield and N uptake of strawberries (fig. 1. Year 2. Trt. C). In the third year, we tried pre-plant plastic mulch under higher application rates of compost and broccoli residues, which raised the inorganic N level at planting to 200 kg ha<sup>-1</sup>, and N-Loss<sub>20wks</sub> to 180 kg ha<sup>-1</sup>, a similar level with the year 1 (fig. 1. Year 3. Trt. A). In the fourth year, we reduced total basal N application rate to 136 kg ha<sup>-1</sup>, the lowest rate in the experiment. Regardless of the higher precipitation during the season, the fruit yield of strawberries in treatment A was comparable with the year 3 and N-Loss<sub>20wks</sub> was as low as 14 kg ha<sup>-1</sup> (fig. 1. Year 4. Trt. A).

Above results from four-year N monitoring demonstrated that: 1) organic strawberry production could have a considerable N-loss and a significant impact on the environment during the rainy season, 2) to minimize N loss during the rainy season, keeping a low inorganic N level at the planting is the most important and a pre-plant plastic mulch application has a limited effect, and 3) combination of compost and broccoli residue application increased the amount of soil inorganic N at planting and subsequent N loss during the rainy season, thus basal fertilizer rate needs to be adjusted accordingly.

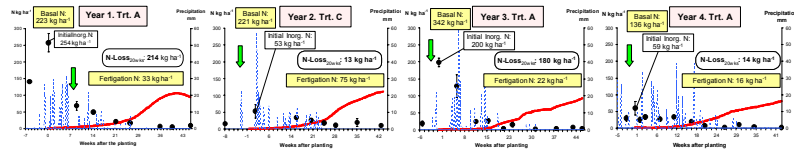


Fig. 1 N dynamics in strawberry plots during the first four years.

### 3. *Verticillium dahliae* Population in Soil

The *Verticillium* test brought about generally low counts (less than 5 microsclerotia per gram of soil) in the first four years (fig. 2). Interestingly numbers of *Verticillium dahliae* microsclerotia in soils decreased frequently after incorporating broccoli residues regardless of treatments, whereas no such reduction was observed after mustard incorporation (fig. 2). In treatment B and E, *Verticillium dahliae* microsclerotia in soils increased during the summer of year 2 when broccoli was lost due to ground squirrel damage. Later we learned that the major weed of the field, Shepherd's purse (*Capsella bursa-pastoris*) also hosts *Verticillium dahliae*. Therefore, weed management should be integrated with the soil-borne disease management.

We planted strawberries on all plots in Nov. 2005. By comparing the effect of the different rotation systems on strawberry fruit yields, disease incidence of the plants, *Verticillium dahliae* propagule population in the soils, and soil microbial communities measured by PLFA method, we will examine how much we can practically shorten the time before strawberries can be replanted on the same field to less than five years without having a negative effect on soil microbial diversity.

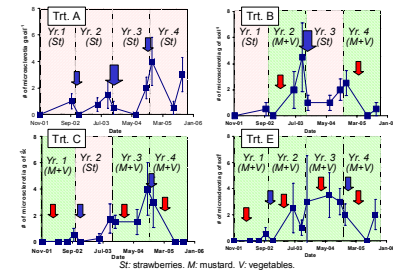


Fig. 2. Changes in Numbers of *Verticillium dahliae* Microsclerotia in Soils in Different Treatments. The mean  $\pm$  SEM.  $\blacktriangle$  Broccoli residues or  $\blacktriangledown$  mustard

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## FOR MORE INFORMATION

Joji Muramoto  
 Center for Agroecology & Sustainable Food Systems  
 University of California, Santa Cruz  
 Santa Cruz, CA 95064

on the web @:  
[joji@ucsc.edu](mailto:joji@ucsc.edu) <http://www.agroecology.org/joji.htm>