ORGANIC
FARMING
RESEARCH
FOUNDATION

P.O. Box 440
Santa Cruz, CA 95061

tel ~(831) 426-6606
fax ~ (831) 426-6670

email ~ research@ofrf.org
web ~ www.ofrf.org

Project report submitted to the Organic Farming Research Foundation:

Project Title:

Evaluation of mulching materials and limestone rates for management of fusarium wilt of sweet basil

FINAL PROJECT REPORT

Principal investigators:
Jeanine M. Davis
North Carolina State University
Mtn. Horticultural Crops Research & Extension Center
2016 Fanning Bridge Road
Fletcher, NC 27695

Co-investigator:
Una J. Harrison, Mtn. Horticultural Crops Research & Extension Center, NCSU

Research site:
"R" Farm, Weaverville, NC (certified organic)

Funding provided by OFRF: $5,525

Awarded: Fall 1997

Project period: 1998

Report submitted: January 1999

ABSTRACT

Basil fusarium wilt is a seed-borne disease that can severely reduce basil yields. The biggest concern, however, is that the pathogen can persist in the soil for ten or more years preventing the future use of the land for basil production. The objective of this study was to develop organic control methods that would allow production in infested soil. Several organic mulches, a biocontrol product (Rootshield), and lime applications were examined on soil intentionally infested with fusarium. Basil plants mulched with a composted pine bark had the lowest incidence of fusarium wilt. Used in a bareground situation, Rootshield had no effect on yields or disease incidence. Overall, lime applications also had no effect. This may have been due to late application and drought conditions.

Background:

The use of *basil (Ocimum basilicum L.),* a popular herb for culinary, cosmetic and medicinal purposes, is becoming more widespread in the U.S.. Fresh market production has increased rapidly over the past several years. In 1991, a devastating wilt disease caused by the fungus *Fitsarium oxysporum f* sp. *basiliciim* was first discovered in the U.S. It has since spread throughout the northeast, California, and the southern U.S.. Symptoms of the disease include wilting and stunting of plants, defoliation, stem necrosis, vascular discoloration, and death. The pathogen is being introduced into fields in the U.S. primarily through contaminated seed. The basil wilt pathogen is reported to cause disease only on basil, although it has been found to infect and colonize other mints, including rosemary and thyme (Keinath, 1994). Disease control measures available to organic growers are limited. Crop rotation is unfeasible because propagules that cause infection may persist in soil for 8-12 years. The first basil cultivar resistant to the basil wilt pathogen was made available for the 1999 growing season. Its level of resistance under field conditions and acceptability for commercial production is not yet known.

Previous studies with cyclamen and carnation have shown that organic mulches can suppress diseases caused by *Fusarium* sp.. Indeed, at the Mountain Horticultural Crops Research Station, NC in 1994, we found plant survival to be highest in the organic mulch treatments in a comparison of different mulches for fresh-market basil production. The basil wilt pathogen had been inadvertently introduced into this test via contaminated seed. Based on these observations, we submitted a proposal to OFRF to investigate the effect of different organic mulching materials on basil wilt. We also proposed to examine the effect of high and low limestone rates on basil wilt, for previous reports have shown that amending with lime to increase soil pH may help to reduce the harmful effects of fusarium wilt of other host plants, i.e., tomato, carnation and watermelon. The goal of our study was to provide useful disease management strategies for organic growers.

Deviations from our original proposal:

(1) In mid-April, our grower-cooperator withdrew from the study. We quickly found another certified organic grower-cooperator, John Rowland of "R" Farm, Weaverville, NC. John grows organic vegetables but has not grown basil commercially for several years. His farm was ideal for this study, because we did not wish to introduce the Fusarium wilt pathogen into an active basil production system.

(2) We initially proposed to use seed contaminated with the wilt pathogen in the test. We decided to change our approach after a phone conversation with Dr. Rob Wicke at the University of Massachusetts. Dr. Wicke encouraged us to infest the soil with *F. oxysporum f.* sp. *basilicum* rather than use contaminated seed, as it would more closely match the infested field conditions that we were attempting to simulate.

(3) As requested by the scientific board at OFRF, we included a biocontrol treatment in our test. The product we selected was "Rootshield", a biological fungicide (*Trichoderma harzianum* strain T-22, manufactured by Bioworks, Inc).. Rootshield protects tomato roots from Fusarium Crown and Root Rot.

(4) We proposed to monitor disease severity of 4 randomly chosen plants from each plot throughout the season. To increase accuracy and give greater confidence in our findings, the disease severity of every plant in the test was rated.

Methods

In early May, basil seeds (Johnny's Genovese variety, certified Fusarium free) were started in the greenhouse at the Research Station. The biocontrol treatment, Rootshield, was applied to a portion of the plants 10 days later. A wettable powder drench formulation was used according to the manufacturer's specifications. All basil transplants were thinned after emergence and trimmed one month after seeding to encourage branching.

To produce the basil wilt inoculum for infesting the test area, we used a culture of *F. oxysporum f.* sp. *basilicum* that had been previously isolated from diseased basil. The culture was grown on potato dextrose agar plates, and then mixed with autoclaved fescue seed. The infested seed was allowed to incubate for 3 weeks and was shaken daily to evenly distribute the fungus. The inoculum was then air dried in paper bags, ground in a coffee grinder, and stored in the refrigerator until used for the test.

The experiment was a split plot with a randomized complete block design. Each of 4 blocks consisted of two lime rates as main plots with mulch and the biological control treatment as subplots within each main plot. We were anxious to spread lime as quickly as possible, but because of the change in test location, it was the first week of May before we were able to prepare the soil. Lime treatments were calculated as the amount of ground limestone needed to raise the existing soil pH (5.9) to low (6.5) and high (7.5) levels. One week before transplanting, a 4-5-4 composted poultry waste product ("Replenish", Rose Acre Farms, Seymour, IN) was spread and incorporated into the soil at the rate of 100 lb N/A. The plants were also side dressed once late in the season at the rate of 20 lb N/A.

The test area was infested with the basil wilt pathogen by incorporating the dried, ground inoculum into the soil to a depth of 8-10". Basil transplants were set 8" apart in rows 1.5' apart. Ten basil plants were planted in each subplot and mulched with one of the following mulch treatments: wheat straw, composted hardwood bark, or composted pine bark (Nature's Helper, Smith Industries, Cummings, GA); control subplots were left unmulched. Rootshield-treated basil transplants were not mulched.

Our weather in the summer of 1998 was extremely hot and dry. Once the basil was transplanted, frequent visits were made to keep the plots watered. Forecasts continued to promise rain, but every storm passed us by. Plants were hand watered until August, when an irrigation system was set in place.

Four times during the season, the disease severity was determined of every plant in the test. Petioles were collected from diseased plants located randomly throughout each block, and were plated onto Komada's selective medium for isolation into pure culture. The identity of the cultures was confirmed to be F. *oxysporum f.* sp. *basilicum*, as inoculation of basil seedlings with the isolates in the greenhouse produced typical basil wilt symptoms.

Basil was harvested four times throughout the season (3,7,11 and 15 weeks after transplanting) by trimming plants to the first pair of new leaves on the lower stems. The data recorded consisted of the combined fresh weight of leaves, stems and petioles from all plants in each subplot. Data were analysed by the GLM procedure of SAS (Statistical Analysis System, Cary, NC) and significant differences were determined by Duncan's Multiple Range test.

Results

High Lime is. Low Lime Rates:

Soil samples were collected from the unmulched (control) subplots before transplanting to determine how the pH levels had been affected by the two lime rates. The average soil pH of the high rate plots was 6.5, and of the low rate plots was 6.0. This was well below the intended pH levels of 7.5 and 6.5, yet was not surprising due to the late date of limestone application. Soil pH readings from samples collected in late August indicated that the pH had not changed from our previous readings.

Over all, the weight of basil harvested and the severity of basil wilt were not affected by lime rate. The average weight of basil per subplot (10 plants) at the low rate was 566 g and at the high rate was 574 g. The mean disease severity rating in the low rate treatment was 2.5, while in the high rate treatment it was 2.6. The absence of any effect by lime rate is probably due to the small difference (.5) in actual soil pH between plots treated with the two lime treatments. The late lime application and drought conditions delayed the soil reactions necessary for soil pH to be increased by the lime.

Mulch Material Comparison:

At the first harvest, the subplots mulched with wheat straw and hardwood bark had greater yields than the other treatments (Fig. 1). By the second harvest, however, yields from the wheat straw and hardwood bark treatments were significantly lower. In fact, the lowest overall mean yield for the season came from the wheat straw mulched plots, with the hardwood bark mulched plots yielding slightly better (Table 1). Of the three mulches tested, the pine bark mulch treatment had the highest total yield for the season, but it was not significantly different from the unmulched control treatment.

Basil plants in the pine bark mulched plots were the least affected by the basil wilt pathogen. Disease incidence and severity ratings during the season were lower for this treatment than for other treatments (Figs 2&3). Overall, there were fewer diseased plants and disease was less severe in the pine bark mulched plots than any other treatments. These results are encouraging, for they suggest that use of pine bark mulch in an infested field may allow production of substantial basil yields, while also reducing the potential for F. *oxysporum f. sp. basilicum* to produce inoculum for subsequent growing seasons.

An interesting observation in the pine bark treatment was that the transplants were stunted and yellow early in the season, yet recovery and subsequent growth occurred to the extent that at the final harvest, yields were greater than other treatments included the test (Fig. 1). It is possible that the early stunting was due to immobilization of nitrogen, or to the small sized mulch particles which appeared to limit the percolation of water into the soil early in the growing season. (The pine bark product used in our test, "Nature's Helper" is a composted organic soil conditioner with a particle size of ½ " screen.) The 1998 growing season was one of the driest on record in western North Carolina, and much of the water applied to the pine bark treatment rolled off the mulch instead of percolating through.

Even though the plants were stunted at the start of the season, it appeared that the basil mulched with pine bark was able to "catch up" with the other treatments with respect to the amount of basil produced. Our results indicate that development of basil wilt was suppressed in this treatment. We do not know what role the amount of soil moisture under the pine bark mulch played in this test. We can only speculate that the drier conditions created by the fine mulch particles would have made a less optimal situation for pathogen development. However, the fact that disease was significantly lower in the pine bark mulched plots than in the unmulched, and thus drier, control plots indicates that other factors, such as suppressiveness of pine bark to Fusarium disease, may be involved. These results support other reports that have determined composted pine bark media to be suppressive to Fusarium disease (Hoitink et al, 1986, 1993).

Rootshield:

Basil harvest weights, disease incidence, and disease severity ratings from Rootshield treatment did not differ from the control subplots (Fig. 1, Table 1). We do not know whether this product is ineffective against the basil wilt pathogen, or whether survival of the biocontrol organism, *T harzianum,* was adversely affected by the hot and dry conditions it was exposed to through much of the season. Studies involving tomato disease caused by F. *oxysporum* suggest that *T harzianum* may proliferate in the soil when added along with a suitable food base such as a wheat bran/peat preparation (Sivan, 1987). Perhaps use of the Rootshield product with a mulch would be effective against basil wilt.

Interactions:

Although there was no effect of lime rate alone on basil yields or wilt severity in this test, significant interactions occurred between lime rate and two other treatments. In the hardwood bark mulch treatment, there was less damage due to basil wilt and total basil yields were higher when amended with the high rate of lime, indicating that a higher soil lime concentration had a suppressive effect on disease development. In the Rootshield treated subplots, the opposite effect occurred, where basil yields were significantly higher and basil wilt was less severe when amended with the low lime rate than with the high lime rate. We do not know why these interactions occurred, although it is interesting to consider their outcome in light of the fact that the soil pH did not vary considerably over the growing season.

Conclusions:

We are encouraged by the results from this year's test, for we feel that mulching basil with composted pine bark could be a useful disease control strategy for organic production of basil in an infested field. Some questions still remain about its use however. Would a larger particle size of pine bark allow more water to percolate, thus giving transplants a better start early in the season (particularly in dry years), and yet still be as effective in disease suppression? Or would the product be more suppressive to disease if incorporated into the soil? This strategy would more closely mimic the pine bark media that is currently used to successfully suppress Fusarium disease in commercial nursery operations.

The Rootshield investigation in our test was inconclusive, yet we feel that a more fair comparison of this product might be to incorporate it with a food base to allow the biocontrol agent to proliferate as has been suggested in the literature. Perhaps treatment of basil transplants with Rootshield followed by mulching with pine bark mulch, or planting into soil incorporated with pine bark mulch, could be a successful wilt control strategy for organic basil growers.

Based on the results from this study, we cannot make recommendations about lime rate as a management tool for basil wilt. In such a dry year, lime amendments should have been made several

months before planting in order to make a comparison of soil pH effects. The hardwood bark mulch treatment was more suppressive at the high lime rate, yet when yields and disease severity ratings were compared with other mulch treatments, use of hardwood bark was inferior.

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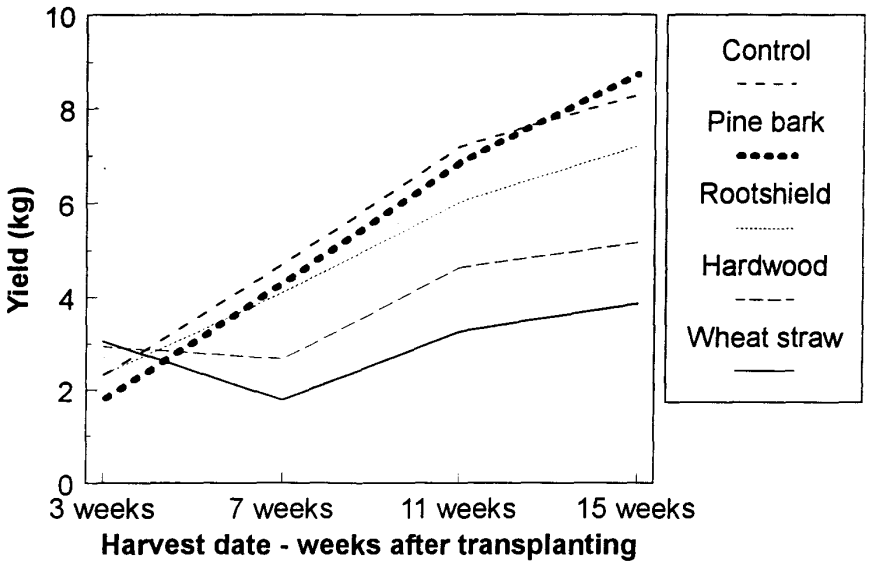
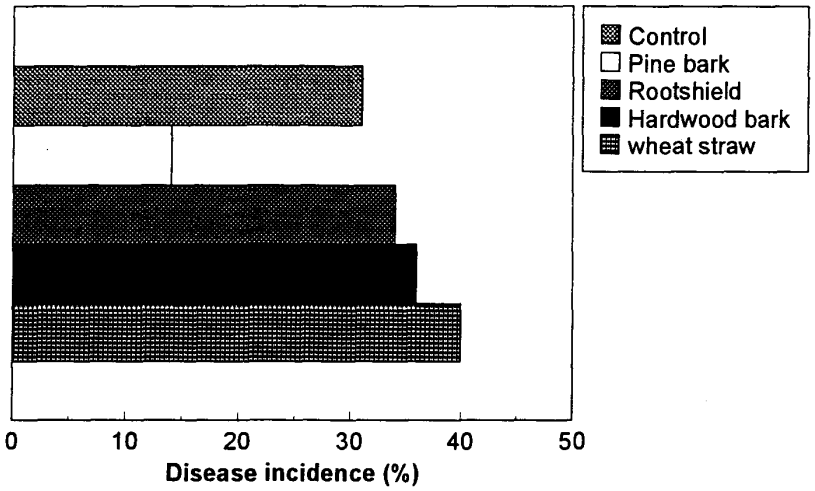
Fig. 1. Effect of mulching material vs Rootshield on yield of fresh basil in a field infested with *Fusarium oxysporum* f. sp. *basilicum*



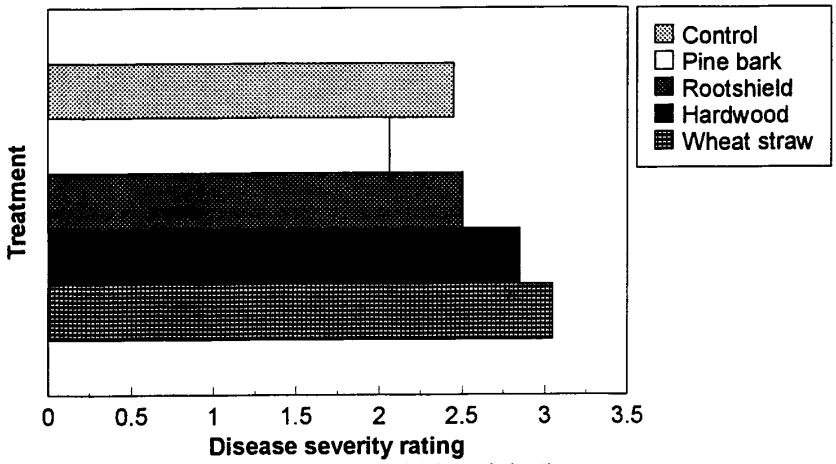
Yield = harvest weight (kg) from 8 subplots containing 10 plants each

Fig. 2. Effect of mulching material vs. Rootshield on incidence of basil wilt caused by *Fusarium oxysporum* f. sp. *basilicum*



Disease incidence determined 3 weeks after transplanting as the percentage of plants per treatment exhibiting infection by the pathogen.

Fig. 3. Effect of mulching material vs. Rootshield on severity of basil wilt caused by *Fusarium oxysporum* f. sp. *basilicum*



Mean of 10 plants in 8 subplots/treatment rated 4 times during the season

1=no visible symptoms; 2=upper leaves small and curled; 3=plant stunted with small curled leaves; 4=plant stunted with dark streaks on stem, or wilting commenced; 5=plant severely wilted or dead

Table 1. Effect of mulching material vs. Rootshield on mean harrvest weight of sweet basil from a field infested with *Fusarium oxysporum* f. sp. *basilicum*

TREATMENT	MEAN HARVEST WT/SUBPLOT (g)
Control (no mulch)	703 A
Pine bark	677 A
Rootshield	615 A
Hardwood	482 B
Wheat straw	374 C

Mean g weight of 8 subplots, 10 plants/subplot harvested 4 times over the season. Means followed by the same letter are not significantly different at P=0.05 using Duncan's Multiple Range Test.