ORGANIC FARMING RESEARCH FOUNDATION

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The effect of weed management strategies on weed growth and fruit quality in a certified organic apple orchard

FINAL REPORT

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Project Summary

Currently, organic apple growers have insufficient information on which weed management strategies are most effective. Growers need information on the effectiveness of weed management strategies in order to maximize yield and fruit quality. The goal of this project was to determine if living mulch cover crops or shallow cultivation reduce weed competition and apple fruit size. Annual rye or rye mixed with clover did not reduce weed growth. A cover crop of clover alone reduced weed growth, and was more effective than shallow tilling once in a season with heavy weed growth, but was similar in effectiveness in a year with little weed growth. Shallow tilling once in late spring reduced weed growth in a season with little weed growth, but not in a season with heavy weed growth.

Introduction

Organic apple production is increasing in the northeast, but production is limited by a lack of effective weed control methods. Apple trees are poor competitors for water and nutrients. When weeds are not managed, reductions in yield and fruit size occur. Currently, organic apple producers have few alternatives for weed management and lack information on which alternatives are most effective. Current strategies include mulching, flaming, cultivation, living mulch cover crops and mowing. Each method has disadvantages that determine whether or not they will be adopted by growers.

Mulching has not been widely adopted by large orchards because of high cost, and flaming because of potential danger and inconsistency in weed control. Straw mulch controls weeds and favors tree growth compared to living mulch (Shribbs and Skroch,1986), but creates a favorable environment for voles (Merwin and Stiles, 1994). Increased tree loss to phytophthora root rot is another disadvantage of straw mulch (Merwin and Stiles, 1994).

Living mulch cover crops vary widely in their effectiveness, and little information exists on their performance in organic orchards. Living mulch cover crops vary in effectiveness at weed management and competition with apple trees. Low-growing broadleaves are less competitive with apple trees than tall broadleaves or grasses, but tree growth is less than with mulch or cultivation (Shribbs and Skroch, 1986). Legumes can increase tree nitrogen which may be useful in sites that are low in this nutrient (Marsh et al., 1996). However, not all legumes are appropriate as living mulch as demonstrated by crown vetch which reduced tree growth in a New York trial (Merwin and Stiles, 1994). When compared to an herbicide strip, white clover reduced tree vigor and yield (Neilsen and Hogue, 2000). However, white clover has not been tested for weed management in organic orchards where few alternatives to herbicides exist. Grasses compete effectively with weeds, but can also reduce yield and tree growth of apple (Miller and Glen, 1985; Schupp and McCue, 1996).

Cultivation in the tree row requires special equipment, but is effective at reducing weed competition. Shallow cultivation in the tree row requires special equipment, but is effective at reducing weed competition, and increasing yield and fruit size of apple (Schupp and McCue, 1996). Tillage generally increases yield compared to living mulches (Merwin and Stiles, 1994; Shribbs and Skroch, 1986). However, erosion, soil compaction and loss of organic matter are disadvantages of tillage, particularly with clean cultivation (Auchter and Knapp, 1929). In-row rotary tilling is shallow and done only under the tree row, so these disadvantages are likely to be less severe than with clean cultivation.

Weed management strategies with potential include cultivation, living mulch cover crops and mowing. Because of the potentially large investment involved in the establishment of weed management strategies, growers need information on the effectiveness of alternatives in order to maximize yield and profitability.

Objectives

In first year of the trial, five different weed management strategies were compared: 1) mowing (control), 2) white clover living mulch, 3) annual rye living mulch, 4) white clover and rye living mulch, and 5) shallow cultivation under trees. In the second year of the trial, three strategies were compared: 1) mowing (control), 2) white clover living mulch, and 3) shallow cultivation under trees.

Materials and Methods

Five weed management treatments were established June 14, 2001 in a certified organic orchard. >Bisbee Red Delicious=/MM.111 trees were planted in 1983 at a spacing of 5' X 16'. Trees were trained to a Y-trellis. Before establishing weed management treatments, mowing was the only weed control strategy. In the first season, the five treatments were mowing, a living mulch of annual rye (*Secale cereale*), a living mulch of Dutch white clover (*trifolium repens*), a mix of annual rye and white clover, and shallow tilling with a weed badger. Control plots were untilled but mowed as frequently as other plots. Data was collected on plots that received shallow tilling since this had to be done to establish a living mulch. This was done to account for the effect of shallow tilling separately from the effect of living mulch. In the second season, the treatments were mowing, a white clover living mulch, and tillage with a weed badger. Cover crop plots were also mowed periodically. To prepare the seed bed a weed badger was used to till a two-foot band on both sides of the tree row. Three passes were made on all plots. Seeds were sewn immediately following cultivation with the weed badger. Annual rye and white clover were each seeded at a rate of 156 lbs/acre in 2001. In 2002, clover was seeded at a rate of 270 lbs/acre. The rye was raked into the soil to a shallow depth. Each plot had four trees with a guard tree in between each plot. The treatments were replicated eight times in a randomized complete block design in 2001 and six times in 2002. Pests, diseases and tree nutrition were managed according to the Maine Organic Fruit Growers Association regulations.

Soil water potential was measured weekly with tensiometers at depth of 10 inches from mid July until mid October 2002. In mid to late July, one soil sample was collected from each plot. Samples were taken to a depth of eight inches. On the same day, one leaf sample of 50 midshoot leaves was collected from each plot. Leaves washed, rinsed in distilled water three times, and dried for one week at 70EC. Weed biomass was measured Aug. 29, 2002 on a area of 0.25 m^2. A ten-fruit sample was collected Sept. 30, 2002 to measure fruit size, fruit color, starch index (an indication of maturity) and insect damage.

Project Results

In 2001, the season was dry (no rain) from June until after harvest, so establishment of clover and rye was sporadic. Orchards in Maine are typically not irrigated. In 2002, clover was well established. The season of 2002 began with sufficient rainfall, but between July and September, there was little or no rain.

Shallow tilling once reduced weed biomass compared to the Control in 2001, but not significantly in 2002 (Table 1). Weed growth was much greater in 2002, so tilling once was not sufficient to control weeds in this season. By harvest, weeds soon grew back and were as numerous and as tall as in control plots by harvest. Shallow tilling should be done three times in the growing season to have maximum benefit for tree growth and fruiting (Schupp and McCue, 1996). Shallow cultivation was done once, but the grower was not able to repeat this since it required labor and the use of a tractor that was also needed for other jobs. This may be a limitation of the use of shallow tillage. Clover reduced weed biomass in both seasons and was more effective than tilling once in 2002, the season with heavy weed growth. Rye grass and rye grass mix with clover did not significantly reduce weed biomass and were not tested again in 2002.

Soil water, measured gravimetrically in August 2001, was not affected by ground cover, but the season was very dry. Soil water, measured with irrometers in August and September of 2002, was highly variable between the different plots and unaffected by ground cover management.

Fruit size, measured as individual fruit weight, was not affected by any of the weed management strategies (Table 2). A heavy crop occurred in 2001 and was followed by a light crop in 2002. Size in this orchard was smaller than normal for this variety in both years indicating that something besides crop load or weed control was affecting size. Trees had poor shoot growth and were somewhat spurbound, a condition is which there is an excess of spurs. This may have limited fruit size more than weed management. Fruit color, maturity, and level of insect damage were not affected by any treatment. Clover can add nitrogen to the soil and increase nitrogen in fruit which inhibits red color development. This did not occur in either year of the trial.

In 2001, soil pH was near optimum (Table 3). Cover crops and tilling did not affect soil fertility or leaf nutrients. Most leaf nutrients, N, Ca, K, P, B, Cu, and Zn, were within the optimum range. Two nutrients, Mg and Mn, were in the low range. In 2002, soil pH was reduced by tilling once and was slightly reduced by clover (Table 4). Soil organic matter, calcium and magnesium were unaffected by weed management, but soil potassium was reduced by shallow tilling and by clover. Leaf nutrients in 2002 were unaffected by weed management except for potassium which was slightly lower in trees with clover.

Conclusions and Discussion

A living mulch cover crop of clover reduced weed growth. Clover consistently reduced weed growth in both years. To establish the clover required as much input from the grower as shallow tilling. However, it has not yet been determined if the clover will sustain itself in following years or will require reseeding. A living mulch of annual rye or rye mixed with clover was ineffective in reducing weed growth.

Shallow tilling once in late spring was also beneficial in a season with little weed growth, but not in a season with heavy weed growth. Shallow tilling may be more consistent in weed control if done more frequently, particularly in years with heavy weed growth, but also requires investment in special equipment.

Outreach

A presentation on the results of this project will be presented at local fruit grower meetings in 2003.

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Table 1. Weed management effects on above ground weed biomass and soil water in 2001 and soil water tension in 2002.

Treatment	Weed biomass (grams / 0.25 m^2)		Soil water (%)	Soil water tension** (-centibars)	
	2001	2002	Aug. 24, >01	Aug. 25, >02	Sept. 5, >02
Control	47	127	8.9	72	66
Tilled once	25*	98	9.1	68	45
Clover	25*	63*	8.0	82	80
Rye	36	--	8.3	--	--
Mix	36	--	9.0	--	--

* Indicates that the treatment had a significant effect compared to the Control.
**Soil water in 2001 was measured gravimetrically on approximately 300 g of soil.
In 2002, soil water tension was measured at a depth of 10 inches with irrometers. A higher number indicates drier soil.

Table 2. Weed management effects on average fruit weight in 2001 and 2002.

Treatment	Average fruit weight (grams per fruit)	
	2001	2002
Control	111	129
Tilled once	102	117
Clover	115	118
Rye	101	--
Mix	114	--

Table 3. Weed management effects on soil pH and organic matter (OM), and on leaf nutrients in 2001.

	Soil		Leaf (%)		
Treatment	pH	OM (%)	N	K	Ca
Control	6.4	6.5	2.2	1.4	1.3
Tilled once	6.5	6.2	2.3	1.3	1.2
Clover	6.5	6.4	2.3	1.4	1.2
Rye	6.3	6.6	2.3	1.4	1.3
Clover and rye	6.3	6.3	2.4	1.4	1.2

Abbreviations: OM is organic matter, K is potassium, N in nitrogen and Ca is calcium.

Table 4. Weed management effects on soil pH and organic matter (OM), and on leaf nutrients in 2002.

	Soil			Leaf (%)		
Treatment	pH	OM (%)	K (ppm)	N	K	Ca
Control	6.7	6.9	141	2.3	1.6	1.6
Tilled once	6.4*	6.5	122*	2.3	1.6	1.5
Clover	6.6*	6.8	101*	2.3	1.5*	1.5

Abbreviations: OM is organic matter, K is potassium, N in nitrogen and Ca is calcium.