Cherry Orchard Floor Management
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Opportunities to improve profit and stewardship

Beginning in 1995, a group of scientists at Michigan State University set out to answer how orchard floor management could affect other horticultural practices, soil quality, and pest management in newly planted and established tart cherry orchards. Tart cherry growers and industry representatives provided consultation for the work through the Northwest Michigan Integrated Fruit Systems Think Tank.

Applying research results

Orchards are grown on many soil types and under different weather conditions. These factors, market demands, and a host of other considerations must be weighed when determining the best orchard floor and nutrient management options for a particular farm. Furthermore, many practices have both advantages and disadvantages; **there is no "best" system that can meet all objectives**. We hope that this research helps growers consider various management options and weigh some of the trade-offs associated with selected practices.

Mixed species ground cover.

Highlighted findings

Orchard floor management systems tested in this research are described on page 2 of this report.

Yield and profitability

- The highest yields and best tree growth occurred where hay mulch was thickly applied under trees, but this approach also had very high costs and produced the softest fruit in some years.
- The three most profitable systems were **Conventional plus ½ rate fertigation**, **Conventional**, and **Cover Crop + Fertigation**, which all offered high yields at low annual costs.
- Ground cover mixes with irrigation and no herbicide provided yields that were not significantly lower than conventional herbicide without irrigation, but were generally lower than conventional herbicide with irrigation.

Nitrate and simazine leaching

- The greatest nitrate leaching of all systems tested occurred where there was season-long weed control (herbicide strip) with spring, ground applied N at a full rate. Previous studies by Kesner, et al. indicated high leaching from fall applied N.
- Nitrate leaching was greatest in spring and fall. Vegetation growing under trees during these times greatly reduced nitrate leaching.
- Fertigation was an effective method to reduce N use and nitrate leaching.
- Simazine leaching was negligible in all of the systems tested.

Soil quality

- The addition of mulch, cover crops, and/or compost resulted in: 1) increased soil organic matter, 2) increased populations of beneficial soil microbes, 3) increased amounts of active soil carbon and nitrogen available to the trees.
- The highest population densities of soil microbes that make nutrients available to the tree are located on the soil surface in the litter layer.

Weed control

- Young cherry trees grow fastest where weeds are well controlled.
- Weed control in established cherry orchards is most important from early June through harvest.

Mite management

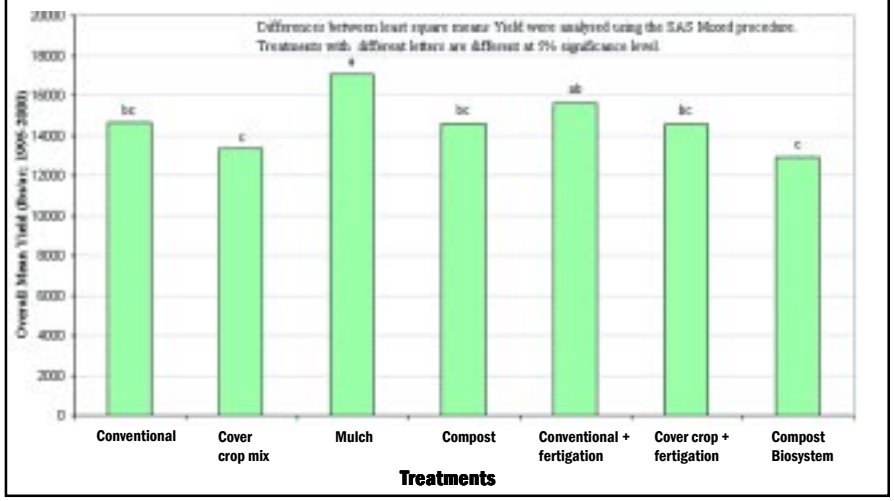
- Maintaining season-long, vegetation-free strips using either herbicide or mulch increased pest mite populations.
- Mixed species ground cover systems with no herbicide strip had the lowest pest mite populations.
- Beneficial mites were present all season in ground covers containing red clover.

Effects on yield

How did the different systems affect yield?

- The use of ground covers with no herbicides for weed control had surprisingly little effect on yield. There was some suppression of tree growth where cover crops were grown on the entire orchard floor with no herbicide strip, but over five years, yields were not significantly reduced. These studies give good evidence that weed control under the trees does not need to be overly aggressive.
- Hay or straw mulch, applied 6 to 8 inches deep, produced better tree growth and improved yield. There were three negatives to the heavy mulch system:
  1) Twospotted mite populations were higher than all treatments with broad-leafed plants growing under the trees. But even with more mites, the trees produced heavier yields.
  2) Cherries were softer in two of the seven years.
  3) The system can be expensive if mulch is not obtained free of charge. Even at $1 per small bale (a value equal to cost of standing hay free for the harvesting), costs exceeded all other systems.
- Systems that used a side-delivery mower to mow row middles and blow the trimmings under the trees were also among the top yielding systems in the trials.

Figure 1. Average yields from seven tart cherry orchard floor systems, 1995-2000.



Descriptions of orchard floor treatments discussed in this report

Conventional. Spring-applied simazine; post-emergent herbicide as needed; full-rate of ground-applied nitrogen, spring-applied; not irrigated.

Conventional + fertigation. Fertigation standard; pre-emergent simazine; post-emergent herbicide as needed; four fertilizer applications during the season, a total of ½ full ground rate; with irrigation.

Cover crop mix. Mixed species to provide diversity, durability, and legumes (crimson clover, annual ryegrass, berseem clover -- annual ryegrass was replaced by hard fescue spring 1996); no herbicides; height control under trees by mowing; ground-applied nitrogen as needed; with irrigation.

Newly planted mixed species ground cover.

Cover crop + fertigation. Ground cover fertigation; ground cover species same as in "cover crop mix treatment;" no herbicides; height controlled under trees by mowing; fertigation begin at standard rate, adjust based on growth, tissue and nitrogen data; with irrigation.

Compost Biosystem. Compost; no herbicides; mulch deposited under the trees using a side-delivery mower when mowing row middles; maintain nutrition using alternative nutrient sources based on supplemental soil tests; with irrigation.

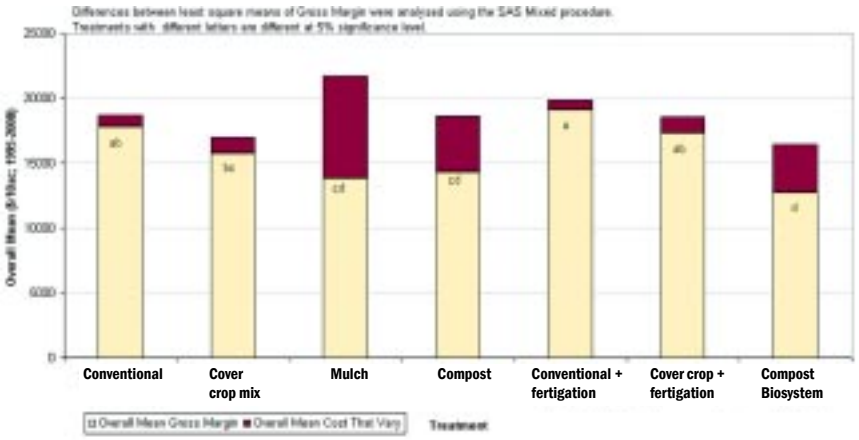
Mulch. Supplemental organic mulch (e.g. hay mulch); no herbicides; additional mulch deposited under the trees using a side-delivery mower when mowing row middles; ground-applied nitrogen, as needed; not irrigated.

Compost. Mixed organic materials and cow manure compost; no simazine; mow under trees or post-emergent herbicides, as needed; mulch deposited under trees using a side-delivery mower when mowing row middles; not irrigated.

Measuring profitability

We measured profitability using the "gross margin" of revenues minus the costs that vary among treatments. Costs were estimated based on custom rates for labor and equipment, plus variable inputs used. To avoid complicating the experimental outcomes with tart cherry price variability, we assumed a constant grower price of 12.75 cents/lb. (the 1995-98 average). After calculating a gross margin for each experimental plot, we conducted an analysis of variance to see if there were statistically significant differences in average gross margins. Capital costs of trickle irrigation systems were not included.

Figure 2. Total revenues, costs that varied across systems and remaining gross margin profitability, 1995-2000



What was most profitable?

The three most profitable systems included two fertigation treatments, plus the Conventional treatment.

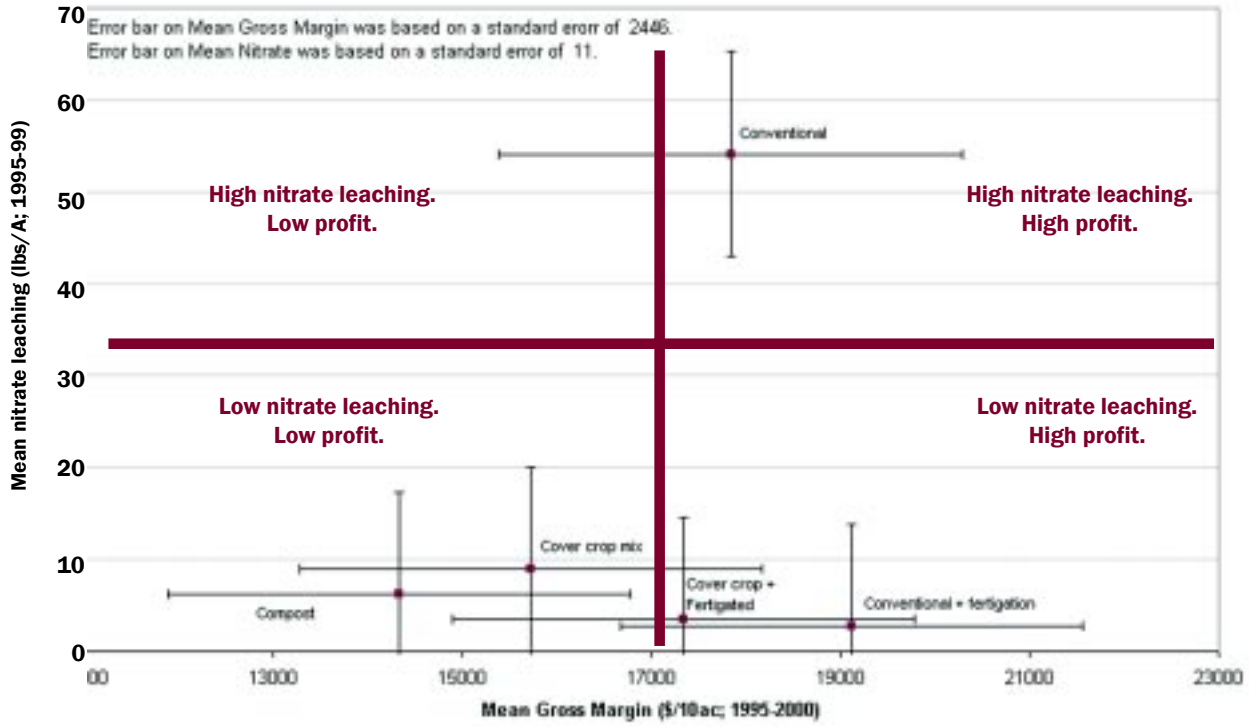
- **Conventional plus ½ rate fertigation** gave high yields at low cost ($760/10 ac/yr)
- **Conventional** gave slightly lower yields, also at low cost ($850/10 ac/yr)
- **Cover Crop + Fertigation** gave comparable yields to Conventional, but at slightly higher cost ($1190/ 10 ac/yr)

Above, Figure 2 shows how high costs (dark color) knocked the high-yielding mulch and compost systems off the profitability pedestal in favor of the lower cost systems.

While growth and yield may present the most compelling reasons for adopting new management strategies, profitability also takes into account the cost of inputs necessary to implement each orchard floor management system.

- Profitability sometimes involves trade-offs with other objectives, such as reduced nitrate leaching. Below, Figure 3 shows that while conventional ground-applied N in spring is a profitable system, it also resulted in five times more nitrate leaching than the next highest treatment measured.

Figure 3. Nitrate leaching / profitability trade-off:
Although Conventional was as profitable as the other two top profit treatments, it caused far more nitrate leaching.



- **Conventional + fertigation** at 1/2 N rate gave high profitability and minimal nitrate leaching. As shown in Figure 3, it looked best in both dimensions among the five treatments where leaching was measured.

Ground cover management influences nitrate leaching

Under Northwest Michigan conditions, most total N leaching occured from October through April. Low soil moisture during the summer minimized leaching potential. The conventional and cover crop treatments in Figure 4 received identical nitrogen rates and timing. The only difference was the amount of vegetation under the trees.

- Vegetation growing under the trees reduced N leaching:
  1) Vegetation provides carbon and soil organic matter to support increased populations of microorganisms that utilize N, reducing the amount of N in a leachable nitrate form.
  2) Plants take up N, reducing the leachable nitrate N in the soil.
- Spring and fall are the critical times to have vegetation growing under the trees to minimize nitrate leaching.

Fertigation helps to reduce leaching

- Nitrate leaching is significantly reduced when nitrogen is applied via fertigation:
  1) Less total N is applied
  2) N is used at much lower rates per application
- Yields and growth that are comparable to fall and/or spring broadcast application can be obtained by fertigating at 50 percent of the total N rate split in four applications.

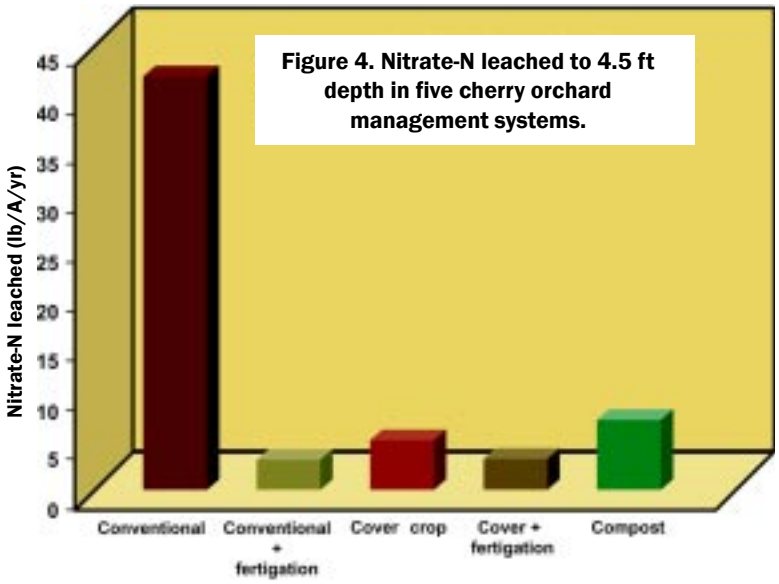


Figure 4. Nitrate-N leached to 4.5 ft depth in five cherry orchard management systems.

From *Fruit Crop Ecology and Management*. Landis, J.N. et al.

Is simazine leaching a problem?

Simazine leaching was very low in all treatments. The highest level, found in the conventional treatment, was less than 0.0002 lbs/A. Simazine levels were so low that there was no significant difference between treatments with and without simazine applied, due to residuals from prior years.

Soil quality – Improving habitat for beneficial microbes

Soil quality can be defined as the ability of a soil to resist degradation and respond to management. All orchard sites should be assessed regularly. Soil organic matter is one of many indicators of soil quality (see list on this page). Through the process of mineralization, soil microbes decompose organic matter releasing nutrients to the tree. Adding carbon under the trees is one way to boost soil organic matter. Our work clearly indicated:

- The highest population densities of the microbes involved in making nutrients available were located in the orchard surface litter layer (Figure 5).
- Active soil carbon and nitrogen were significantly lower under a conventional fertilizer and weed management system than in the other systems.
- There were fewer beneficial nematodes, more plant parasitic nematodes (Figure 6), and more nitrate leaching (Figure 4) associated with the lower quality conventional soils.
- In-row soil population densities of beneficial nematodes, mycor-

Indicators of soil quality

1) Topsoil and rooting zone depth.
2) Organic matter levels.
3) Size of active carbon and nitrogen pools.
4) pH and electrical conductivity.
5) Biotic diversity of soil microbes.
6) Water-holding capacity, infiltration and bulk density.

Use of ground covers was associated with increased biotic diversity.

Figure 5. Vertical distribution and population density of organisms associated with eight cherry orchards in northern Michigan in January 2002.

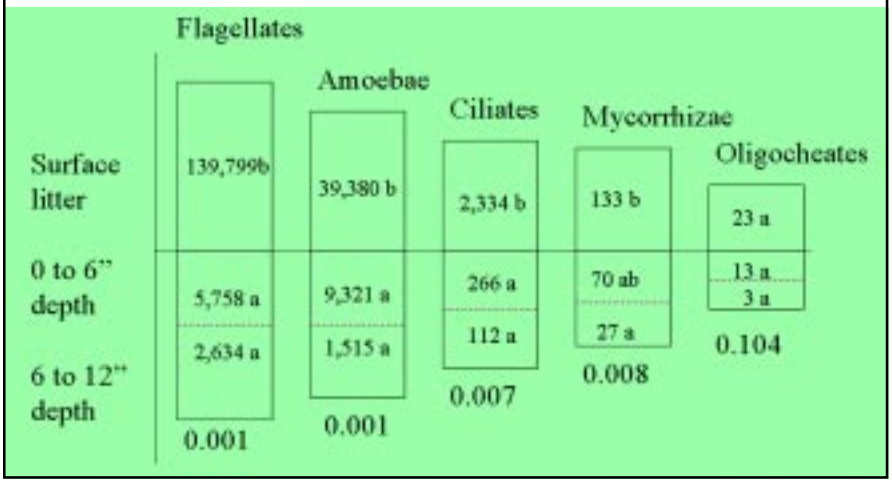
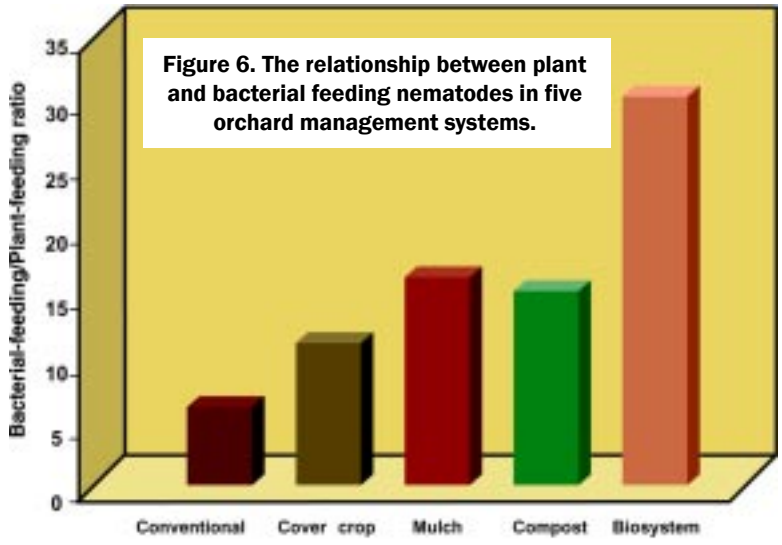


Figure 6. The relationship between plant and bacterial feeding nematodes in five orchard management systems.



From *Fruit Crop Ecology and Management*. Landis, J.N. et al.

rhizae and oligocheates (microearthworms) were greater under an organic production system.

Ground cover management in young orchards

Managing ground cover in young orchards is very different from managing bearing orchards. Young trees will benefit from adding mulch or compost, but remember:

- Trees in young orchards can be severely stunted by competition with ground cover plants for moisture and nutrients.
- Seasonal weed control with herbicides decreased both microbial activity and soil organic matter.
- Mulching around young trees will add nutrients, carbon, and organic matter into the system, and will reduce moisture loss.

Weed control in established orchards

Two of the concerns with growing ground cover plants in the tree row are: 1) plant competition with trees for moisture during midsummer, 2) difficulty seeing tree trunks during harvest. These concerns can be addressed by promoting a good population of plants under the trees in fall and spring and by providing good weed control from early June through harvest (in Northwest Michigan) with the use of a contact herbicide (such as glyphosate or paraquat) or by use of a mulching system. A third concern is that vegetation provides habitat for voles.

Mite management

High mite populations were consistently associated with vegetation-free (herbicide) strips in conventional systems and systems using thick mulch. High mite populations in the mulch system were not detrimental to yield. Combining mixed species ground cover plants and no herbicides supported low pest mite populations.

- Season-long populations of beneficial mites were associated with red clover.
- Beneficial mite populations were higher on red clover than on white clover.
- Compost biosystems consistently had the lowest mite populations.

Using legumes in ground cover

In using legumes in a ground cover, consider:

- Legumes provide nitrogen to the orchard ecosystem.
- Deep-rooted legumes (alfalfa) help break up hard pans and aerate soil to a greater depth.
- Legumes did not harbor high plant parasitic nematode populations in these studies.
- Legumes generally do well when potassium is relatively high. Consider periodic applications of potassium with a broadcast spreader that fertilizes the row middles.
- To optimize soil nitrogen, do not mow legumes until near flowering.
- Red clover, white clover and alfalfa were relatively easy to establish.
- Over time, legumes in bearing cherries tend to be replaced by grass:
  1) Shade hastens the decline of legumes such as alfalfa.
  2) Frequent mowing will favor the short plants such as Dutch white clover but is hard on the larger legumes.
  3) Legumes require periodic reseeding to rejuvenate ground cover plantings.

Putting it together

Over the past seven years we have learned that significant environmental and ecological benefits can be gained by adopting alternative ground cover and nitrogen management systems without significantly increasing economic risks. The challenge for growers is to use this information to design strategies that are effective and cost efficient for their farms.

Suggested reading

Fruit Crop Ecology and Management. Landis, J.N., J.E. Sanchez, G.W. Bird, C.E. Edson, R. Isaacs, R.H. Lehnert, A.M.C. Schilder and S.M. Swinton (eds). 2002. Extension Bulletin E-2759. Price $16. To order, call MSU Extension county offices or MSU Extension Bulletin office at 517-355-0240.

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