

ENCOURAGING SPIDER POPULATIONS USING MULCHES

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ABSTRACT

Are spiders practical bio-control agents? I compared spider and pest populations in mulched and unmulched potatoes.* There were three questions I hoped to address:

1. Does mulch create a habitat that encourages spiders (and perhaps other pest predators) to move in?
2. Do increased spider populations have any correlation with decreased pest populations or level of damage to vegetable crops?
3. Is mulching a practical alternative for market growers?

Test plots were established in fields where the crops were being grown for market. All crops were grown organically, using standards established by NOFA. We monitored pests using the same methods IPM scouts use, and tracked populations of Colorado Potato Beetles and leafhoppers each week throughout the growing season. Spider populations were sampled weekly as well. At the end of the season we compared yields from mulched and unmulched plots.

Overall, there were fewer insect pests on mulched plants than unmulched plants. Mulched plots supported higher spider populations than did unmulched plots. Surprisingly, there was no discernable difference in yields between potatoes that were mulched and those that were not.

INTRODUCTION

In past years I have noticed many spiders in my organic gardens. I had read about farmers in China using spiders as natural enemies of crop pests. The farmers place straw bundles in locations where there are high spider populations. After allowing time for the spiders to move into the straw, the farmers carry these bundles to new fields. By using spiders to help control agricultural pests, Chinese farmers decreased their use of chemicals by 50%. Farmers in Japan and the Philippines have

found spiders to be important natural enemies of aphids, mites, and lepidoptera larvae.

As early as 1921² spiders were recognized as potential enemies of pests such as leafhoppers. Recent studies³ in Tennessee help confirm the importance of spiders in biological pest control for some vegetable crops. Vegetables mulched between rows with grassy mulches suffered 60%- 70% less plant damage than the same vegetables grown in unmulched test plots. The mulched plots had higher populations of spiders than did unmulched plots. In fact, spider densities in mulched plots were 10 to 20 times higher than populations of other generalist predators. To test whether spider predation was an important factor in insect control, researchers removed spiders from mulched plots, and used barriers to exclude them from returning. With the spiders removed, plant damage in mulched plots was similar to that in unmulched plots .

In another study,⁴ researchers compared Colorado Potato Beetle populations in mulched and unmulched potatoes. While it took six applications of insecticide to control the beetle populations in unmulched plots, it took only two spray applications to bring the beetle populations below the economic threshold level in mulched potatoes. Clearly, spiders are at work eating insect pests in our fields and gardens.

In my study, I wanted to see if mulching might offer similar benefits to Northeastern farmers. There were three questions I hoped to address:

1. Does mulch create a habitat that encourages spiders (and perhaps other pest predators) to move in?
2. Do increased spider populations have any correlation with decreased pest populations or level of damage to vegetable crops?
3. Is mulching a practical alternative for market growers?

Update on farmers and cooperators involved in the project

Only two farms ended up carrying out the project for the entire summer (originally I had anticipated three). These were: Starflower Farm (Andy Leed and Liza White) growing approximately 1 acre of potatoes and 1 acre of mixed vegetables for market, and Harmony Farm (Sue Smith-Heavenrich and Lou Heavenrich) with a small 3-family CSA on under 1/2 acre. The Enrights were unable to participate due to a problem in getting mulch.

Kaiba White (Starflower Farm) played a major role in scouting for pests and spiders on their farm. She also assisted in other aspects of the project, such as harvest and weighing yields.

Tom Wall, our local extension agent, had discussed the idea of having a field day, but decided it would be more practical if we could tie more farms into such a trip. We will be pursuing the idea further.

Abby Seaman (western NY IPM extension) and Mike Hoffman (Cornell University), while not directly involved, did offer ideas and share information about IPM scouting and biological pest control. Abby was a co-leader for a workshop on potatoes at the NOFA-NY annual conference (March 4-5, 1995).

METHODS

The study was done in fields where the crops were being grown for market. All crops were grown organically, using standards established by NOFA. Potatoes were planted in rows 30" - 36" apart and spaced 9"-12" in the rows. In late June they were hilled and mulched with hay or straw. Mulched plots were eight rows wide, and about 35' long. Over five varieties of potatoes were represented in mulched and unmulched rows. One short bed of potatoes was hilled and mulched at time of planting (rows were spaced 18" apart).

We intended to study other crops as well: cabbages, tomatoes, and peppers. The experimental plots were mulched at time of transplanting. Cabbages were raised under row cover early in the season to protect against flea beetles and maggots. The row covers were removed after they grew enough to withstand pest pressure. These vegetables were grown on raised beds or in wide rows.

Crops were cultivated for weeds and watered on an "as needed" basis. As it was a wet year, only new seedlings and transplants were watered. Pests were hand-picked or sprayed with Bt when their populations reached a level high enough to cause concern about economic loss.

Pest and spider populations were sampled weekly in both control and mulched plots. To sample pests we used IPM scouting methods, adapting them to the size of the plots. We stuck with the recommended "W" or "X" pattern of walking through the fields.

Potato beetles were sampled at five spots. At each location, five plants were sampled, across 5 rows (one/row). We counted the number of adults, larvae, and egg masses. Leafhoppers were sampled at 10 spots each time. To count adults, we made 10 sweeps using an insect net. Nymphs were counted by visual examination of the undersides of leaves on the lower third of the plants. At each location we sampled one leaf/plant for 5 plants, across five rows.

We used two methods to count spiders. Initially I had planned to toss a hula hoop randomly into a plot ten times and count the spiders inside the hoop. I abandoned this idea after corresponding with David Pimentel (Cornell University) and field tests that indicated it would disturb the spiders and possibly damage plants. Pimentel indicated that walking through a study plot and sampling every 3rd or 5th plant (depending on the size of the plot) would suffice.

For large areas of potatoes I adopted a path similar to the IPM scout, sampling two plants at each location for a total of 10 samples. We counted spiders on the plant, and on the ground immediately surrounding the plant (approximately a 3.5 sq ft area). For mulched areas, we dug into the mulch to check for spiders. We divided spiders into two groups: wanderers and web-spinners.

Information on crop yield was collected for potatoes only, as they were harvested over a concentrated time period. Rows to be measured and weighed were marked off, harvested separately according to treatments (mulched or not-mulched), and yields

weighed. Other crops were harvested throughout the season depending upon market demand, and it became too difficult for the growers to separately handle each treatment.

RESULTS

Overall, there were fewer insect pests on mulched plants than unmulched plants. To compare Colorado Potato Beetle populations, we sampled a total of 145 plants from each treatment (fig. 1). A chi square test was used to compare the total populations of adult, larvae, and egg masses. There was a significant difference between the numbers of beetles found on mulched plots and unmulched plots ($<.005$).

To compare Leafhopper populations, we sampled a total of 60 plants from each treatment (239 on mulched plants, 301 on unmulched). A chi square test was used to compare the total populations of adults and larvae. There was a significant difference between the numbers of leafhoppers found on mulched plots and unmulched plots ($<.01$). The lower population of pests on mulched plants did not seem to make much difference, though, due to the phytotoxic effect of leafhopper damage. Mulched plants did remain green longer, and look healthier longer than those in unmulched rows. For one variety (Superior) plants grown in rows died of hopper burn by 7/23. Those planted in the bed and mulched at time of planting were still alive and green as late as 8/10.

To see if there is a difference between leafhopper populations in potatoes that were mulched at time of planting (late May) and those that were mulched at time of hilling, I compared populations of adults and nymph from each treatment. Potatoes mulched at time of planting supported a lower pest population, 111 compared to 152 in rows mulched at time of hilling, about one month later. However, more samples need to be collected to see if this trend is significant (I had less than 40 samples for each treatment).

Mulched plots supported higher spider populations than did unmulched plots (fig. 2). The difference between spider populations in treatment and control potato plots is not significant due, I think, to the fact that the mulch was placed on the potatoes after hilling - almost a month later than mulch was placed on the other crops. Looking at other crops, the difference in spider numbers between mulched and unmulched plots is significant ($<.005$, using Chi-square). There were a total of 180 samples from mulched plots, and 180 samples from control (unmulched) plots.

It would have been ideal to be able to compare biomass for crops under different treatments, at the end of the season. Unfortunately, leafhoppers destroyed much of the potatoes, and what late varieties were left were hit by late blight and destroyed in the field prior to harvest. We did note that mulched plants looked healthier at the end of the season (this could be due to water retention and other factors).

Surprisingly, there was no discernable difference in yields between potatoes that were mulched and those that were not. Six of the varieties grown in the study plots were sampled for yields: Red Norlands, Chieftain, Chippewa, Russet Norkotah, Katahdin, and Riddeau. Sections of row in treatment and control plots were harvested, and yields weighed. A total of 220 feet of row was harvested from each treatment, yielding 129.75 # for mulched rows and 138.10 # for unmulched. There is no significant difference in these yields. While the mulch did not seem to confer any benefit, it didn't harm the yields, as some had suspected might happen. Given a drier year, I think the mulched beds might have outproduced the unmulched controls.

One of the other questions I raised in my proposal was whether mulching might control weeds enough to make it worthwhile. The potatoes that were hilled and mulched at time of planting had no weeds throughout the growing season. Those that were mulched after hilling did have to be cultivated for weeds at least once. The thickness of the mulch layer will determine the amount of weed control, as well as timing of mulch application. The potatoes mulched at time of planting were covered by 18" of hay and grasses, whereas the rows were mulched with a 4" layer.

There were two unanticipated problems. The first had to do with using straw as mulch. Oat straw was donated for the project and mixed with the hay mulch at Starflower farm. Unfortunately, there were seeds in the straw, and they produced a great cover

crop of oats. But it was a weed problem in the potatoes. The oat cover crop was burned off using a propane flame weeder.

The other problem was presence of mulch at harvest. At Harmony Farm we did all our harvesting using hand implements, so it was no trouble to rake mulch off to the side before digging the potatoes. However, at Starflower Farm a mechanical potato digger was used. The hay and straw mulch clogged it up, requiring a second pass through the rows. Even then, some areas needed additional work with hand implements. If mulch is to be used as a cover on a crop that needs to be dug (like potatoes), we feel the mulch should be chopped. Also, there ought to be some way of raking any remaining mulch off the beds prior to mechanical harvest.

Specific site information

Starflower Farm suffered late potato blight, which necessitated destroying foliage on the late potatoes. Both farms suffered severe damage to leafhopper, destroying pretty much all but the late potatoes (which were hit by blight anyway...). Potato yields were low at both farms, though lower at Harmony Farm as this was our first year in production at this particular garden site. We harvested about half of what we expected.

New ideas/ Next step

I feel there is some value in exploring the role of spiders and other arthropods as natural enemies of crop pests. However, they cannot do the job alone. Growers need to constantly monitor

crops for pests, and if the levels get too high, then bring them under control to prevent economic loss. Because local farmers hill their potatoes, putting mulch on at the time of planting is not real feasible (unless they hill through the mulch). For this reason, I feel further study should focus on crops where mulches won't interfere with crop management or harvest. I think it might be worthwhile to look at a spider/mulch system on melons, tomatoes, squashes, cucumbers, cabbages, and onions.

Grassy hay mulch does seem to provide an attractive habitat for spiders, but it requires cutting and transport. And for growers who have small market gardens with no surrounding hayfields, it is yet another off-farm import. I would like to see if it's possible to grow a cover crop, such as vetch/rye, that could be mowed for mulch and crops planted (or transplanted) directly into it. I have submitted a SARE grower grant proposal for 1995 outlining my ideas.

For the last five years I have grown potatoes in raised beds and mulched deeply with hay. They seem to suffer less pest damage than potatoes grown in rows. They also require no weeding, and the yields are similar to regular rows. But it is labor intensive to plant and harvest them, and I can't think of any way it would be feasible to do on a commercial scale. Because of my observations of my raised beds, I believe that hay mulch does offer advantages to potatoes. The problem is finding ways to integrate mulching with mechanical crop management and harvesting.

To really be effective, the mulch needs to be applied at time of planting which, as we discovered last summer, is not practical if you want to hill the potatoes. One solution might be to plant and hill, and cover with mulch all at once. Another suggestion, offered by Susan Riechert, is to mulch at time of planting, and then go ahead and hill, mixing soil and mulch in the hills. Perhaps if the hay can be chopped such a system might work. I have doubts about getting through soil and mulch with my BCS walking tractor, though it's worth a try.

Will I use this practice?

I will continue to mulch because it doesn't hurt, and in a dry year I feel mulching will help. Also, mulching along with hill culture, was used by local precolumbian farmers for many hundreds of years. Such a practice would not have endured had it not offered some benefit.

For me, grassy mulches help retain water in my plantings, and add organic matter to my soil. As I pull weeds, I toss them on top of the mulch layer too.

What will I tell other farmers?

I think encouraging natural predators is a good idea if it can be incorporated into the cropping system. But it will only work if pesticides and herbicides are not used. For farmers who do not already grow using organic methods, giving up chemical sprays to encourage spider populations is one hell of a leap of faith. I tell people that encouraging natural predators is part

of the solution. They have to use a variety of weed and pest management methods. I think this kind of pest management is ideal for small growers who want to get off the pesticide treadmill, and for home gardeners (who probably shouldn't be using pesticides anyway).

Mulches are often used for weed control, and to retain soil moisture. I do not think the use of plastic mulches is sustainable, as plastics are not biodegradable and represent an off-farm import. If organic mulches can be shown to encourage natural predators and control weeds, it may help in our search for sustainable farming practices.

I mention the increased spider populations in mulched plots, and the lower pest numbers. But I also tell them about the problems we had with the mechanical harvesting.

Outreach

I wrote a general information article about spiders as natural enemies and their potential use in gardens. I included a brief explanation about my project. This was submitted to a gardening magazine and is currently under review. Although the editors were enthusiastic about my proposed article, I do not know if it will actually be published.

I will be sending another article (more like this report) to *Maine Organic Farmer & Gardener* for inclusion in a future issue. I also plan to send a brief report to Ken Allen for his *Vegetable Garden Research*.

March 4th I presented a workshop on the nightshades with Abby Seaman (western NY IPM), and talking about my project. I will be giving a report to Abby, as well, to share with other growers as she sees fit.

If you desire photocopies of articles for your SARE files, please let me know. I can send them on to you at a later time.

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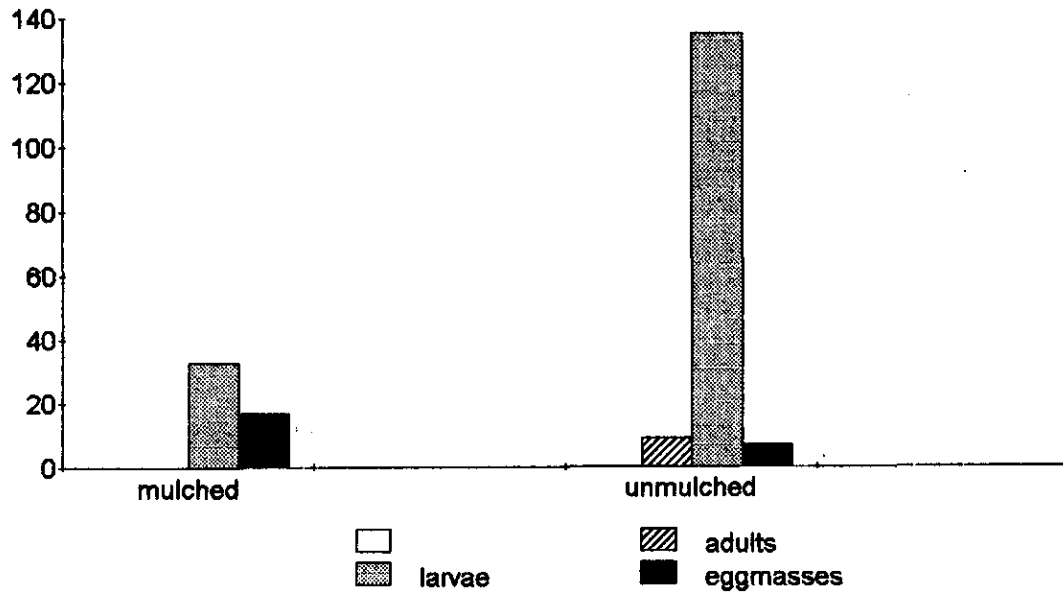
² Dudley, J. E. Jr.

³ Riechert, Susan E.

⁴ Zehnder & Goldstein

figure 1. Colorado Potato Beetles on Mulched and Unmulched Plots

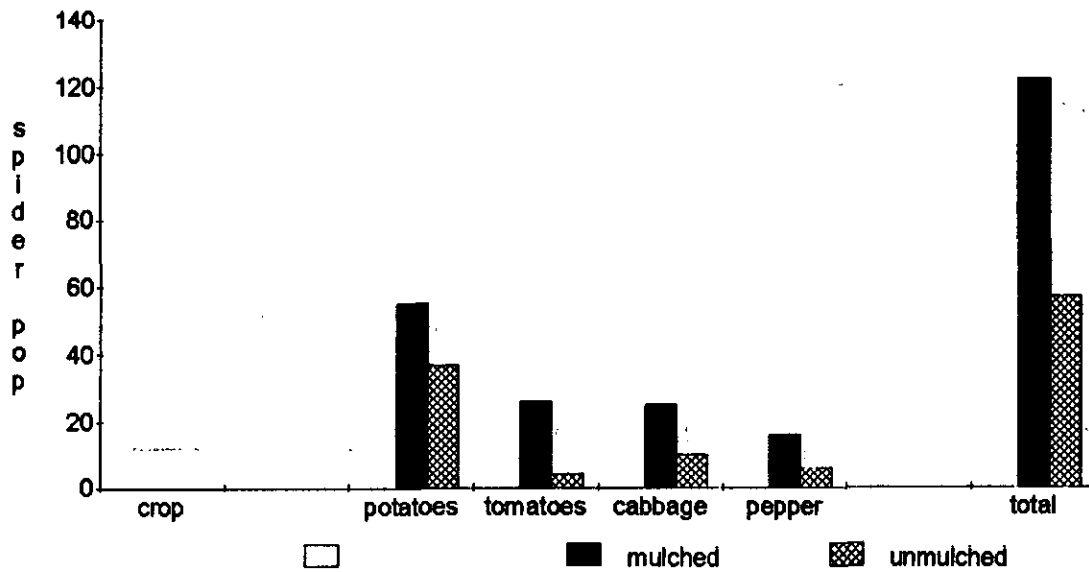
	mulched	unmulched
adults	0	9
larvae	33	135
eggmasses	17	7
total	50	151



145 plants sampled for each treatment. $\chi^2 = 50.75$, significant at .005.

figure 2. SPIDERS IN MULCHED AND UNMULCHED CROPS

crop	mulched	unmulched
potatoes	55	37
tomatoes	26	4
cabbage	25	10
pepper	16	6
total	122	57



180 samples taken in each treatment (mulched and unmulched). $X^2 = 23.60$, sig. at .005 level.

A bibliography of relevant literature

Bishop, Leslie and Susan E. Riechert. 1990. Spider colonization of Agroecosystems: mode and source. *Environmental Entomology* 19 (6): 1738- 1745.

Dudley, J.E. Jr. 1921. The potato leafhopper and its control. *Farmers Bulletin #1225, USDA* (August 1921).

Hoffman, Michael P. and Anne C. Frodsham. 1994. Natural Enemies of Vegetable Insect Pests, Cornell Cooperative Extension.

Mansour, Fadel et. al. 1983. Spider management in ecosystems: habitat manipulation. *Environ. Management* 7 (1): 43-49.

Olkowski, Helga (translator). The usefulness of spiders. excerpted from the Chinese textbook, Agricultural Entomology (1982). in: Least Toxic Pest Management in China, p. 51. 1991, BIRC, Berkeley, CA.

Pimentel, David. 1994. personal communication (6/16/94)

Riechert, Susan E. 1990. Habitat manipulations augment spider control of insect pests. *Acta Zool. Fennica* 190: 321-325.

_____ 1995. personal communication (1/4/95)

_____ and Tim Lockley. 1984. Spiders as biological control agents. *Ann. Rev. Entom.* 29 : 299-320.

_____ and Leslie Bishop. 1990. Prey control by an assemblage of generalist predators in a garden test system. *Ecology* 71 (4): 726-736.

Zehnder, G.W. and J. Hough-Goldstein. 1990. Colorado potato beetle (Coleoptera: Chrysomelidae) population development and effect on yield of potatoes with and without straw mulch. *J. Econ. Entomol.* 83 (5): 1982-1987.