Solanaceous Crops (Potatoes, Tomatoes, Pepper, Eggplant)

Living Straw Mulch for Suppression of Colorado Potato Beetle (Leptinotarsa decemlineata)

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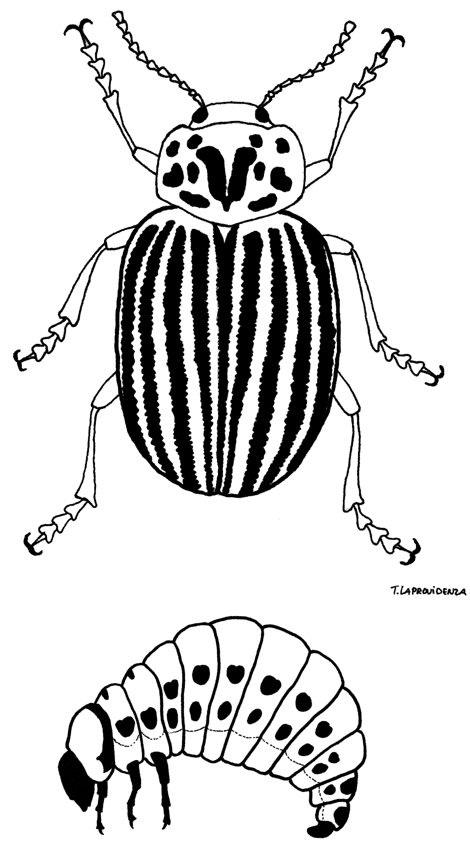
I manage a 42-acre certified organic vegetable farm along the Merrimack River Valley of southern New Hampshire. The Colorado potato beetle (CPB) is one of the region's more destructive insect pests. During the farm's transition to organic certification, I was unable to grow potatoes due to the severity of CPB damage. Even the timely use of M-One®, an early Bt biological insecticide, did not offer viable results.

A suggestion from Jim Bowman, an entomologist from the University of New Hampshire (UNH), to use straw to suppress early CPB activity, has led to years of experimentation, utilizing a living straw mulch system. Jim had noted that researchers and growers in the South had found that mulching potatoes with straw hindered early CPB activity, and they were able to reduce the number of weeks they sprayed CPB larvae and adults.

I was intrigued by the potential of growing straw *next to* my potatoes instead of bearing the costs of bringing it *into* my potato field. An experiment of "hiding" a row of potatoes in an overwintered field of hairy vetch and rye led to research trials designed by Jim Bowman at UNH. Utilizing Novodor® *(Bacillus thuringiensis tenebrionis),* a newer Bt product, as an additional component in the living straw mulch trials, we found that plants that were *covered* with mowed overwintered rye showed yields similar to potatoes treated with Novodor®. (We found Novodor® was a very effective CPB control.) There was very little CPB activity as long as the straw made contact with potato plant leaves. Later, as the straw was incorporated into the soil, CPB activity increased. Yields of the straw mulch potatoes were not significantly different from Bt-treated potatoes, however. Leaf damage had little effect on yields late in the growth stage of the potatoes.

Utilizing results from the 1993 UNH potato trials, I was able to develop a straw mulch system using the farm's implements in combination with a single seasonal Bt spray to control CPB. For the last two years, I have not had enough CPB activity in my potatoes to justify any Bt sprays.

Potatoes are planted where fields have been free of solanaceous crops for at least four years and into stands of well-established overwintered rye or rye/hairy vetch. During the first week in May, I till 5-foot-wide strips for my potatoes, leaving 5-foot swaths of rye between potato beds. Potatoes are planted in single rows in the center of the tilled strips. I plant potatoes later than most regional farmers, during the third week of May, allowing the rye to get waist high before the potatoes sprout. After sprouting, they are cultivated, and by the second week of June, they are hilled. As the rye begins to



Colorado potato beetle adult and larva

head, adult CPB begin to find the ends of the potato rows. The rye *must* be mowed before adult CPB move *into* the potato rows. I mow with a brush hog rotary mower, which blows the cut rye into the potato plants. After mowing, I walk the rows and kick rye straw onto the plants the mower has not covered. Straw coverage does not "bury" the plants but is more like a dusting; potato plant leaves should be able to bear the straw's weight. It's important that the potato rows are weed-free prior to mowing. Once the rye is cut, it is very difficult to manage weeds in the potato rows with implements. The rye aisles are easily managed by repeated mowing.

After rye has been mowed, I will continue to scout potato rows for CPB activity. Where adults are found, I will also inspect adjacent leaves for CPB egg clusters. A total of two to three hours/acre of scouting and beetle picking suffices for the six-week period of late June through the end of July.

I'm not at all certain why this technique works. I suspect it is the combination of a number of elements. No broad-spectrum insecticides have been used at the farm for the past ten years. Numerous plantings of herbs, flowers, and cover crops have encouraged the proliferation of beneficial insects as well as other not-so-beneficial insects. In the straw-covered potatoes, I have observed lady beetles, spiders, ground beetles, stink bugs, tarnished plant bugs, leafhoppers, and many other unidentified insects. I have seen both lady beetles and stink bugs eating CPB larvae.

Rotation of potatoes distant from previous plantings forces adult CPB to search the farm to find the new season's crop. The lack of bare soil in the potato plots keeps the soil a little cooler, reducing potato plant stress and perhaps weakening the potato's "signal" to scouting CPB. The "architecture" of the cut straw probably frustrates the beetles as it impedes access from row to row and plant to plant. I imagine the scent of the drying and decomposing rye also masks the solanaceous potato scent further, confusing adult CPB. Jim Bowman suggested that soil bacteria hosted by the decomposing straw could possibly be affecting young CPB larvae and egg clusters.

What I have observed is that seasonally, fewer adult CPB find my potatoes; annually, potato yields and soil quality have improved with this technique.

Evaluation of Five Organic Techniques on Controlling Flea Beetles on 'Kennebec' Potatoes

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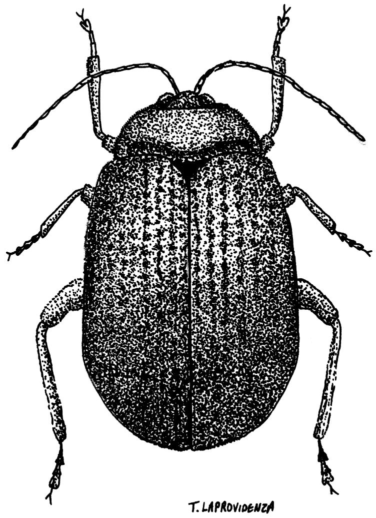
The objective of this research was to compare the effectiveness of five organic techniques (Reemay® cloth, hot pepper spray, lime dusting, Centrum® vitamins, and vitamin E) in controlling flea beetles on potato plants. Six new raised beds were prepared on new ground at La Paix Farm. Each bed was prepared and cultivated alike. Eight pounds of 'Kennebec' potatoes (Maine-certified) were planted in each 13-foot bed at the same time. Each bed was treated with one of five techniques weekly after the first flea beetles were seen on May 31.

Flea Beetle Control

Flea beetles never inundated the potato beds. The heaviest count of flea beetles on plants was on the control bed, which yielded the highest number of pounds of potatoes (32 pounds). The vitamin E bed had the next heaviest count of flea beetles (about half the control number) and yielded the third highest number of pounds of potatoes (25.5 pounds). The lowest counts of flea beetles were on the Reemay® bed and the lime bed, which yielded fewer potatoes than all the other beds and three other beds, respectively (15.5 pounds and 21.5 pounds). In fact, the Reemay® bed had less than one-half the potato poundage yield of the control bed (only 15.5 pounds compared to 32 pounds). Strangely enough, the Reemay® bed looked better than all of the other beds throughout much of the growing period. Because of these results, it could be theorized that in a minor influx of flea beetles on potato plants, there is no reason to use any control measures. So often, farmers get out to spray at the first sign of a bug. This research would challenge the need for a knee jerk reaction to a flea beetle sighting.

Quality

Although the vitamin E bed had only the third highest yield of potatoes, these potatoes were the larg-



Potato flea beetle

est and the most similar in size. The control and the hot pepper bed were second and third, respectively, in these criteria. The Reemay® bed had the highest number of tiny potatoes and very few large ones.

Efficacy of Techniques

The Reemay® and lime techniques controlled flea beetles better than the others, but for cost (3.5 cents/pound) and quantity/quality of yield, hot pepper spray would be the best bet. However, it bears repeating that if flea beetles are no worse than recorded here, no technique at all need be used, saving time and money.

All the techniques requiring solutions (Centrum®, vitamin E and hot pepper spray) are time-consuming if done by hand (about 15 minutes per 13 feet of row per week). If the problem with the Reemay® cover is heat buildup, perhaps cooling by watering more often would mitigate the heat problem, if indeed this is the reason for the poor yield. This would add, however, to the time and cost of the Reemay® technique, which was negligible.

There were no other insects on the vines which would cause holes, etc. (e.g., potato beetles, which had not been a problem at La Paix since 1984). However, helpful insects such as lady beetles, daddy long legs, spiders, and praying mantid were seen. One might conclude that the techniques used did not repel the good bugs along with the bad.

Wild Predators Feeding on Two-Spotted Spider Mite (TSM) in Eggplant

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I run a one-person vegetable IPM consulting business. Normally, I find two-spotted spider mite (TSM) only in strawberries and apples, but this year, because of the drought, TSM showed up in beans, tomatillos, and eggplant. Only in the eggplant on one farm was the infestation severe enough to affect yield.

The one vegetable grower with the mite problem had four fields at varying distances from the base of operations. Generally, the fields closest to the headquarters had the worst mite infestations.

Field #1 had the worst problem. It was located near where the equipment was kept. It was also right next to a vegetable field that I was scouting, and another vegetable field which I was not. Each of these adjacent fields had separate insecticide applications that demonstrate some mistakes growers can make if they are not precise about applications. In both instances, the grower did not accurately measure the amount of material needed for the target crop (this is separate and distinct from the issue of whether it was needed in the first place). Also, both materials are lethal to mite predators, one of the materials having been a Pyrethroid (the "organic" form of which is just as devastating on beneficials). Twice, excess material was applied to the eggplant field with disastrous consequences. All predators were wiped out in this field, and subsequent miticide applications were ineffective (pesticide resistance is common in TSM). Yield losses were severe.

The second field of eggplant was isolated but suffered as well from poor control of TSM. This illustrates how soil conditions can affect how predators do. The upper half of the field had good drainage; lush foliage provided good cover for the TSM predators. However, the other half was poorly drained and was stressed by a combination of factors. Pooling water from early heavy rain fostered an outbreak of *Phytophthora* that weakened or killed many of the lower plants. Drought followed and contributed to the scaling of the soil surface, restricting oxygen to the roots. TSM from the heavily infested part spread to the upper part of the field, reducing yield. Predators in the field did help some, but two applications of miticide were needed. The field had a history of *Phytophthora,* and the lower end should not have been planted; or, better yet, the whole field should have been rotated out of solanaceous and cucurbit crops.

The third and fourth fields of eggplant did much better, although money was wasted on an unneeded miticide application. These fields received a little more rain than the other fields, but they were also on relatively new land with good organic matter and low disease levels. This resulted in the soil having more resilience. There was a lot of soil life, and the soil surface did not get sealed after the drought ensued. The TSM appeared at the same time as on the other fields. The second week after the mites appeared, predators gained in numbers and variety. We found predatory mites, minute pirate bugs, *Stethorus* beetles, predatory midges, lacewings, lady beetles, and jumping spiders — all feasting on the TSM. They had plenty of cover during the drought and knocked the TSM down to almost nothing. Sadly, a farm employee who had just returned from a stint at another X-owned farm misread the recommendations for the other fields and applied an unneeded miticide over these fields. Even though the mite predators did their job, it was sad to see them killed off.

Biological Control of Tomato Fruitworm with Trichogramma *Wasps*

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Processing tomatoes are a major crop in California, with about 250,000 acres grown each year. In the northern production areas, where about 30% of the crop is grown, the tomato fruitworm, *Helicoverpa zea,* is the most important insect pest. Tomato fruitworm female moths deposit eggs on the plants near flowers. The developing larvae feed briefly on flowers and leaves but soon bore into green tomato fruit. The larvae feed within the fruit, damaging up to three during their development. The major problem resulting from infestations is that the quality of the harvested crop can be jeopardized if too much contamination is present. Contamination in the form of worms, worm parts, or fruit contaminated or decayed because of worm damage is unacceptable. If more than 1% (by weight) of a truckload is contaminated, the entire load can be rejected. Given these stringent requirements, growers are under pressure to make sure that contamination is at a minimum.

An integrated pest management (IPM) program was developed starting in the mid-1980s. This program includes a sampling plan for damaged fruit and tomato fruitworm eggs. Research had shown that fruit damaged by tomato fruitworm decays and falls off the plant. Consequently, early-season infestations, unless excessive, do not require insecticide treatments, because the damage will not be present at harvest. In addition, a certain percentage of the worm damage "disappears" during the mechanical harvest. Some damaged fruit may be sorted out by personnel on the harvesters, other damage may be crushed in the harvest and transport process. Other research determined that most tomato fruitworm eggs are deposited on the second leaf located under the highest flower cluster on the tomato plant. Thus, an egg sampling program was developed. Implementation of this program greatly improved the management of this pest and resulted in decreased insecticide usage.

This IPM program was further refined with the discovery that natural populations of *Trichogramma* wasps were killing a large percentage of tomato fruitworm eggs. These minute wasps, about the size of a period on this page, were discovered to parasitize up to 100% of the eggs at times during the season. Four different species were recorded. The female wasp locates eggs using chemical odors associated with the egg. Once she locates an egg, she inserts one or more of her eggs into the tomato fruitworm egg. The wasp eggs hatch into larvae and develop inside the fruitworm eggs. After about four days, parasitized fruitworm eggs turn black. After about ten days, the wasp larvae have matured into adults and one to three will emerge from each tomato fruitworm egg. These fly away, seeking additional fruitworm eggs to start the process over again. If not parasitized, fruitworm eggs remain creamy-white in color, and a larva emerges after about five days.

Because tomato fruitworm eggs were already being sampled as part of the IPM program, it was relatively easy to incorporate egg parasitism into the sampling plan. When fields are sampled, thirty leaves are picked and examined for the presence of fruitworm eggs. In the past, if four or more white eggs were found, the field was sprayed. Now, both white and black eggs are recorded, and the ratio of black to white eggs is used to determine if a spray is needed or not. Depending on the number of black eggs present in the leaf sample, the threshold increases up to 12 white eggs, a four-fold increase over the old threshold that did not consider egg parasitism.

A recent survey showed that 36% of the pest control advisors in one county in northern California now use the black egg sampling technique. If this results in a very conservative 10% reduction in insecticide use, it translates into enormous savings, given the large scale of this crop.

This example of applied research and its implementation demonstrates the importance of indigenous natural enemies. Prior to this research it was assumed that biological control was insignificant in this system. This example also points out that we need to devote far more effort to determining the role of natural enemies in agricultural systems.

Discussion: Solanaceous Crops

Several people noted Myra Bonhage-Hale's finding that plants with a low level of insect damage had higher yield. Mike Hoffmann noted that the same is true with striped cucumber beetles (although this benefit drops off rapidly as the damage increases), and others noted that this effect has been reported for other insects.

Eero discussed how he manages his rye cover crop, tills strips into it, and plants potatoes. He tills the rye at the end of April, then seeds the third week of May, giving the rye a little less than a month to break down. He mows the cover crop, then uses a rotary tiller (unless the crop is low, then he uses the tiller directly). He is hoping to buy a spader to reduce the labor involved in tilling a cover crop and to reduce the oxidation of organic matter. A combination of a spader and field harrow would make incorporating cover crops easier and still allow him to make good seed beds for small-seeded crops.

Jude Boucher suggested that leaving a cover crop until mid-June in the year after growing potatoes would interfere with the movement of Colorado potato beetles out of the field and into neighboring fields. The adult beetles have difficulty walking through and flying out of fields of grains.

Audience: There always seems to be a part of the field under stress — where the irrigation doesn't hit, for example — and the pests are often higher in those areas. Would an area like that be a good area to grow beneficials, such as predatory mites, to get them off to a good start and to reduce the population of pests in that hot spot?

David Stanley: I have more experience with mites in strawberries than in vegetables, and if you have a weak place in your strawberries that's being hammered by mites, it's because there isn't enough cover there for the beneficials, both predatory insects and predatory mites. Especially in the height of summer, the predators like cover. So, I would say that you should just get rid of the problem. I would tend toward sanitation.

Audience: Is tomato fruitworm a problem for organic growers?

Mike Hoffmann: Stink bugs are more of a problem this far north. Tomato fruitworm (which is the same organism as corn earworm) migrates in too late to be a problem on tomato in most of the Northeast.

Audience: I have a problem with stink bugs on tomato — the damage creates messy white stuff under the tomato skin.

Mike Hoffmann: What is the habitat like? Do you have raspberry nearby? Typically tomatoes and raspberry don't mix — raspberry provides an overwintering habitat for stink bugs.

David Stanley: I know that there are some solitary wasps that specialize on stink bugs. I don't know if you can count on them in a large commercial setting, but they are nest-site limited. Find out what wasps are in your area and what nest situation they require. If you have a small market garden, you may be able to benefit if you set up a suitable site (for example, sandy soil at a certain pitch facing south, depending on the species of wasp).

Audience: Have there been experiments with mites using essential oils — thyme, spearmint, black walnut oils, for example?

David Stanley: I haven't worked with those oils, but other soap and oil sprays — Safer® soap and summer oils — affect predator mites as well as pest mites, whether they affect the mite cuticle or interfere with respiration. When apple growers use dormant oil, they spray at a point when the mite predators are in the ground cover and have not emerged from hibernation, so that the oil doesn't affect predators of the red mite. I recommend that you scout to see if there are any predators in the field before you take action against pests, because what you use against pests may kill off the predators as well.

Audience: Eero, did you have many wireworms in your rye-vetch cover?

Eero Ruuttila: In carrots, but not in potato.

Mike Hoffmann: It would take more than one year in a cover crop to get a wireworm problem. They have a long life cycle — two or three years — so they take a while to build up.

Audience: Has anyone here had a problem with European corn borer on peppers?

David Stanley: Sometimes people don't recognize a problem with corn borer on peppers because it is mistaken for rot and thrown away without looking inside to see the caterpillar. Does anyone have a handle on what percentage of pepper fruit they harvest of the total fruit that set? If you are losing half of your peppers, and your soil pH is good so that you aren't getting blossom end rot, then you could be losing them to pepper maggot or European corn borer. You can tell the difference because the corn borer has a dark head capsule, while the pepper maggot is all light in color.

Audience: Is there a particular strain of European corn borer that gets into the pepper or beans? Do both strains get on sweet corn?

There are still questions to be answered about the biological and ecological significance of European corn borer strains. "Strain" is an interesting term. There are different ways of dividing the corn borer species into "strains." There are univoltine (one generation per year) versus bivoltine (two generations per year) strains. There are strains attracted to the "E" or the "Z" pheromone. Some are attracted to broadleaf plants versus monocot plants.

Audience: I grow chili peppers and haven't seen corn borers there. Years ago, I did grow sweet pepper, and I had some corn borers.

(Note: See the section on corn, page 27, for more discussion of European corn borer in peppers.)

Aaron Gabriel: Does anyone have questions about aphids on peppers or tomato?

Audience: Lady beetles and other predators take care of them, if they're there.

Audience: Sometimes growers have aphids on plants in the greenhouse and they put the plants out before the natural enemies come in. Then the aphids seem to build up later. Could you establish natural enemies on the transplants in the greenhouse and then move them out to the field to help synchronize the natural enemies to the pests?

David Stanley: Lady beetles don't do too well in greenhouses, but if you get the aphid parasitoids going in the greenhouse, it might help the situation. You can buy them on the market, and there are a number of wild ones. We see them every year out in the field. One problem with transplants is that they may be overfertilized, and that tends to promote aphid growth. You need to manage nitrogen in the greenhouse to prevent or at least slow down the aphid buildup.

Also, don't put peppers or tomatoes out too early. Cold shock slows down their growth and makes them more susceptible. If you wait until June, the predators and parasites will be active by then. With cabbage transplants, you may get the plants out before the predators and run into a problem early in the season.

Elizabeth Henderson: I noticed one year, when the buckwheat got away from us early in the season, that the buckwheat attracted a lot of aphids and then the aphids attracted a lot of lady beetles. Then, when we set out our peppers, tomatoes, and eggplants, the lady beetles were right there in huge numbers. It was a nice bridge for the lady beetles after they move off the dandelions.

I also have a comment about the straw mulch — I don't think we know yet whether it's the turning under of the cover crop or the mulch itself or the combination. It could be that you have well-nourished plants.

Eero Ruuttila: There are a lot of things going on. It could be just that the soil is cooler from the shading of the straw. The straw could also be a barrier.

Audience: It may be that the potato beetles have a hard time finding the plants. They may have trouble walking through the turf, and when they are flying, they may not be able to see the potato rows — when the rye is still standing, probably all they can see is rye. It is also possible that the rye gives off odors that disrupt their ability to find the odor of potato plants. There is the possibility of disruption on several different levels.

Elizabeth Henderson: I had the same effect when I turned under strips of my clover sod one year. There wasn't any mulch at all.

Eero Ruuttila: I am equally motivated to use this system by the buildup of organic matter from the rye. I need that carbon.

Elizabeth Henderson: Last year, we tried a new hairy potato, an experimental variety from Cornell. We didn't have many Colorado potato beetles on any of our potatoes, but we didn't have any on those at all. The grower who sold me the potatoes called them 'NY101.' It was an ordinary, white, decent potato.