# NESARE Winter Pest Control in High Tunnels
# 2013-2014 Case Study Notes

Case studies were established on 7 grower-cooperator farms in 4 counties in the 2013-2014 winter greens season. Four farms were organic, two used integrated management, and one was biodynamic. Two farms chose to participate for a second year to continue developing new pest management skills. For ease of comparison to previous years' work, the farm lettering picks up where it left off last year.

Early pest detection and control using bio-rational means continued to be our emphasis. Regular scouting occurred at all farms beginning in summer crops and continuing through mid-January. The extreme cold this January and February made scouting impractical. There were few opportunities where the produce and tunnel temperature warmed enough (mid-30's) to safely scout the crop. Many locations suffered crop losses due to the extreme cold.

Aphid populations and pressure was measured by counting the number of aphids on 30 leaves per plot. In general, a proactive threshold of an average of 1.0 aphid/leaf was used to trigger control treatments.

Directly counting the number of caterpillars and slugs per plot is not alone a reliable way to measure changes in pest population. These pests are mobile and can be hidden in the growing environment. Feeding damage ratings measure the severity of pest feeding. Ratings directly measure the economic damage potential of a pest population and indirectly measure changes in population size and activity. For this project, feeding damage was rated on a 0-5 scale (see below) based on the amount of damage present relative to the size of the crop. Changes in damage ratings slightly lag changes in pest populations. While slug and caterpillar population counts were taken, control recommendations were more heavily influenced by damage rating trends.

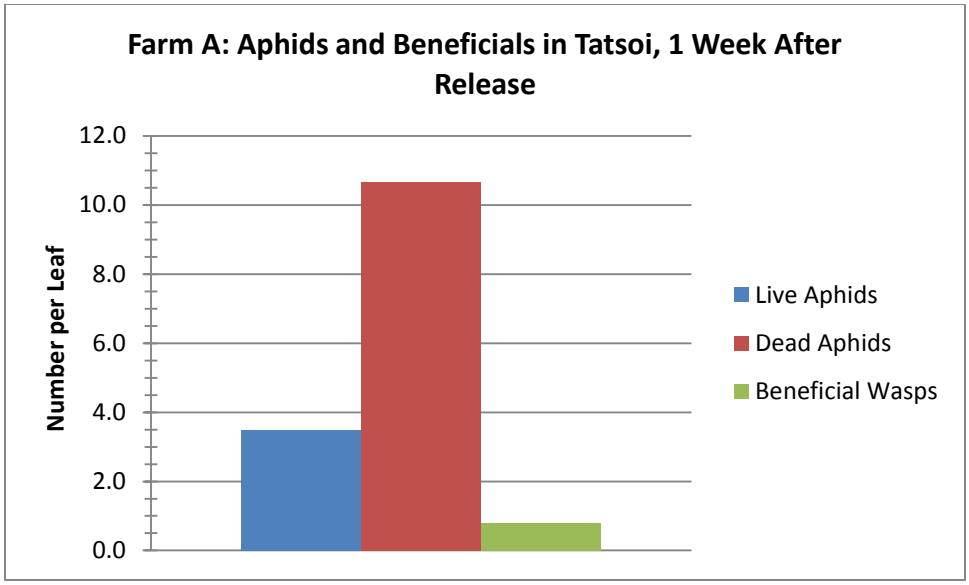
| **Feeding Damage Rating Scale** | | |
|---|---|---|
| 0 | Clean | No feeding damage |
| 1 | Very Light | Chewing present, no economic damage |
| 2 | Light | Lightly damaged, below level of consumer rejection. Chewing present on up to 1/4 of leaves. |
| 3 | Moderate | Most leaves still marketable (<10-25% loss). < 50% of leaves chewed. |
| 4 | Significant/ Substantial | Some plants unmarketable (20-50% loss). Many leaves chewed. |
| 5 | Heavy/ Severe | 50% + of plants unmarketable. Most of a given plant is chewed. |
| 6 | Dead | Or defoliated |

Intermediate steps are denoted by (n-.3) and (n+.3)

## Farm K: Phelps, NY

Crops: Spinach, arugula, tatsoi, leaf lettuce, hakurei turnips, alliums
Major pests: Aphids
Controls: Parasitoid wasps; Mycotrol- O
Minor pests: Flea beetles, leaf miner, caterpillars, slugs

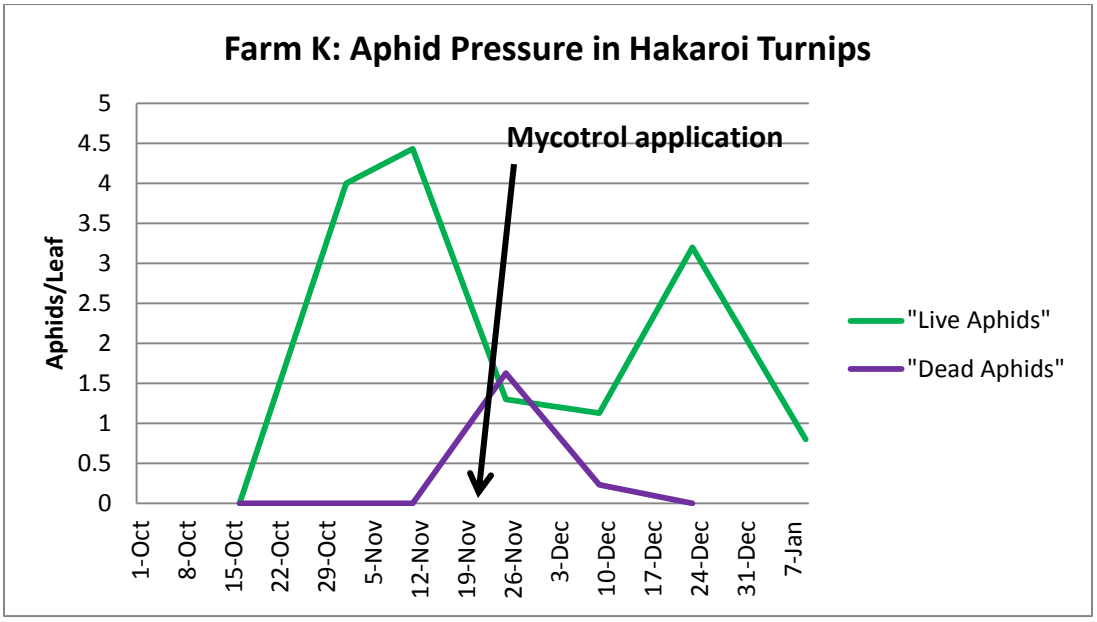
Scouting began September 4, 2013 in onions, spinach, arugula, tatsoi, and leaf lettuce. Flea beetles were causing minor damage to the spinach and did not warrant treatment. **Tatsoi grown under row cover had a large aphid infestation**. The row cover likely concentrated the aphid population in the tatsoi and delayed detection of the problem, since the row cover was left on continuously to protect against caterpillar pests. To control the aphid population, parasitoid wasps (ACE Mix from Syngenta, 500 count: *Aphidius colemani, Aphidius ervi, Aphelinus abdominalis*) were ordered and released under the floating row cover. **One week after release (WAT), the number of parasitized aphids was on average three times greater than the number of living aphids per plant**. Wasps were present at an average of 2.4 per plant. No aphids were detected in the tunnel on Oct. 1. The row cover was shaken out and left in the house to encourage wasps to migrate to other crops when the tatsoi was replaced with spinach. The aphid population remained below the action threshold (1 aphid/leaf) until Nov. 1 for all crops.




This release was highly successful, and acts as a proof-of-concept for the potential of parasitoid wasps. **It must be noted that this release took place under idealized conditions** of a very high release rate, co-confinement of pest and beneficial by the row cover, and appropriate temperature and moisture. Such rapid results should not be expected in most circumstances. Typically, a 500 count bottle would be released into an entire house to address a dispersed, emerging aphid population detected by routine scouting. In this normal scenario, **good aphid population reduction generally occurs within two weeks**.

Winter crops were alliums, spinach, head lettuce, and hakurei turnips. Very low, sporadic levels of aphids were present in lettuce season long, but never approached the action threshold. **On Nov. 1st, the hakurei turnips had 4 aphids per leaf and was at 4.43/leaf on Nov. 11th. Mycotrol-O (*Beauveria***

***bassiana* Strain GHA), a beneficial fungus, was recommended and applied** to the entire house at a rate of 1.5 tsp per gallon of spray volume (75% of maximum label recommendation) on Nov 20. Scouting on Nov. 25th showed a decreasing aphid population and a spike in the presence of dead aphids. Dead aphids were fuzzy, consistent with colonization by applied fungus. The single application maintained lettuce and spinach plots below threshold, but only **dropped the hakurei population to 1.13/leaf by Dec. 9.** This value was just above threshold, and the grower decided not to make a second application. By the end of the season, the aphid population was 3.2/leaf. The population fell in Jan. with extreme cold that also damaged the crop.




**The rebounding aphid population demonstrates that while a single spray was effective, a second application of Mycotrol-O was needed to provide season long control.** Project staff have repeatedly seen more complete control with Mycotrol-O and Botanigard (conventional formulation) when a follow-up application is made 5-10 days later. Additionally, these products work better when applied in humid, cloudy conditions, since the fungus requires moisture to germinate once it contacts the aphid. Unlike most pesticides, this product is better when applied before nightfall or on cool, cloudy days.

Other pests were present, but did not cause enough damage to require treatment. Light, spotty caterpillar and slug damage was observed in spinach in early October, close to harvest. Loss was minimal, and very light activity was observed for the rest of the season. Some leaf miner damage was observed in early November in spinach, but did not intensify to become economically threatening. Thrips were present at low, declining levels in the alliums, and were gone by mid-November. **Rot was a challenge in head lettuce, particularly the variety 'Panisse'**, due to the cold, wet conditions.

Extreme cold destroyed over 90% of the crop by Jan 22nd. **The grower noted that 50% less of his crop loss was caused by pests this year than it was in the winter of 2012-2013. He plans to use several advanced integrated and proactive pest management strategies next year.**

## Farm L: Ontario, NY

Crops: Salad mix, spinach
Major pests: Slugs
Controls: Cultural, iron phosphate bait
Minor pests: None

Scouting began in early September in tomatoes. A few aphids were present on weeds around the tunnel. Very little changed for the remainder of the summer season; aphids did not move into the crop. Winter greens were sown down in late October, with several serial plantings going in over a few weeks. Winter greens scouting began November 12. Two planting dates of salad mix and one planting date of leaf lettuce were monitored throughout the season.

This farm experienced no appreciable pest pressure in the 2013-2014 growing season. All losses were due to disease. **By applying several best management practices, focusing on preventative management, and making an effort to learn more about pest biology and control, this grower was able to reduce losses due to pests by 100%.**

There was a history of slug pressure and heavy losses**. In 2012-2013, the grower lost 500lb of produce to slugs.** He applied several techniques to mitigate damage in 2013-2014. Culturally, the grower used horizontal airflow fans (HAFs), good spacing, and excellent weed control to **improve airflow and make a drier, less favorable environment for slugs**.

**Inspecting transplants before planting revealed a slug infestation in the transplant house**, which was confirmed by project staff and determined to be substantial. His early scouting pre-transplant proved key to his success slug management. He was able to objectively make an informed evaluation of the risk and cost of treating the transplants and using them, starting with fresh transplants, or making other changes to his planting plans. He decided to treat the transplants and that greenhouse with iron phosphate bait, to discard highly infected plants in favor of new, clean stock, and to closely monitor transplants that seemed to be slug free. He then proactively applied iron phosphate bait at planting and continued to scout in all growing areas**. This grower was 100% successful in overcoming what could have become a very challenging growing situation because of his excellent pest management.**

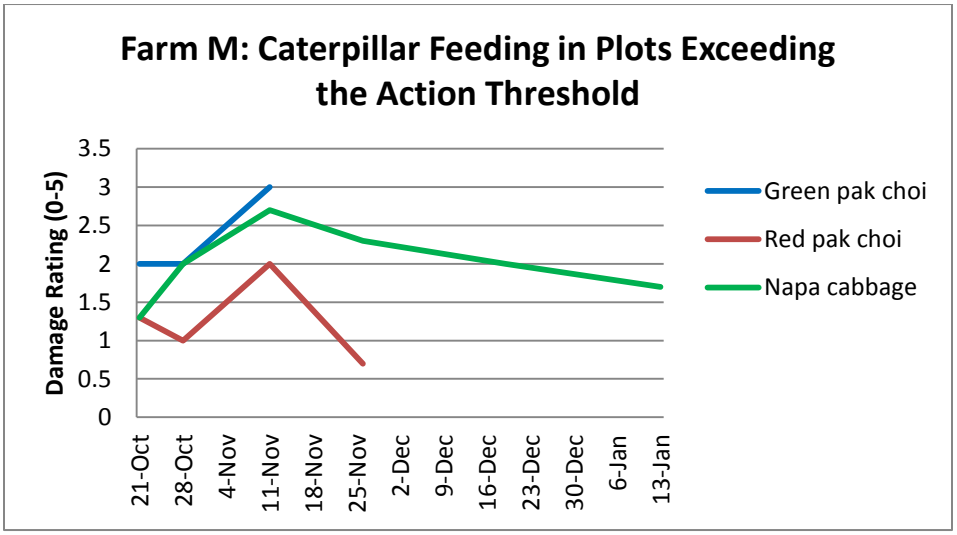
This grower used several cultural, preventative pest controls that reduced his susceptibility to caterpillar pests. He selected varieties that were vigorous and are less prone to pest problems. For example, he **chose salad mixes that contained no or few brassicas and were therefore unattractive to cabbage loopers, diamondback moths, and imported cabbage worms.** The grower has experienced that vigorous plants are able to more quickly outgrow minor feeding damage. Very light caterpillar feeding was observed in only 1 of 12 plots and only on one date.

This farm uses supplemental heat to prevent freezing. Supplemental heat protected the crop but caused snowmelt along the tunnel edges and led to excessive moisture on the periphery. Rot gained a foothold in the wet areas and benefited from the cool, cloudy weather. In the end, the grower lost 14% of his crop due to rot. **Losses would have been much high if he did not emphasize good airflow.**

**Farm M: Alden, NY**
Crops: Spinach, Swiss chard, hakurei turnips, kale, pak choi, mixed brassicas, arugula
Major pests: Caterpillars, slugs
Controls: Cultural
Minor pests: Slugs, spinach crown mite

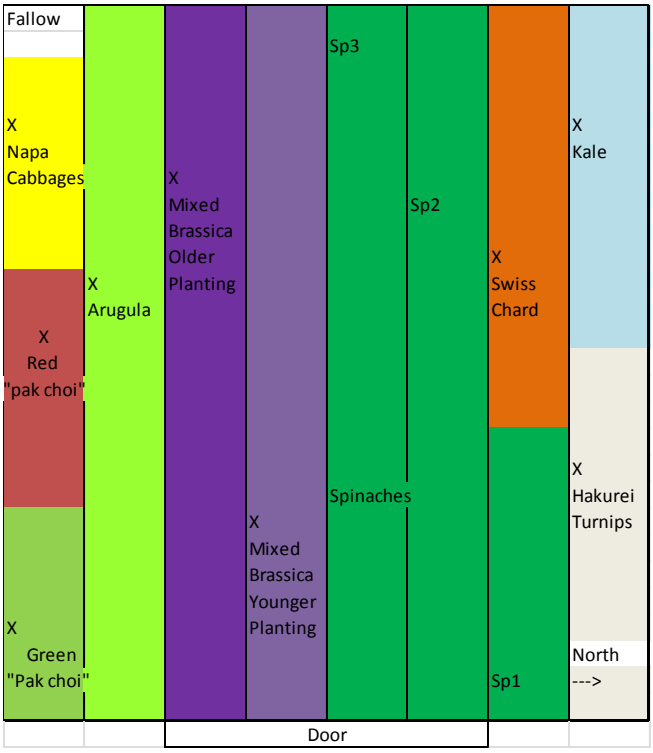
Work was conducted in a new tunnel. Fall crops were planted before the house had the plastic covering, which was put on in in early November. Scouting began Oct. 21, when young transplants had 1-7 true leaves and direct seeded plantings were cotyledonary. Kale, spinach, turnips, and pak choi transplants had very light, healed slug feeding. The feeding appeared old and well-healed. The grower relayed that the damage occurred in the transplant house. All continued to recover from the early, pre-planting damage. **The grower was very successful in transplanting the crop without also transplanting the pest.** Slug damage was infrequent and caused no economic damage for the rest of the season.

**Caterpillar damage was most prominent in red and green pak choi and napa cabbage plantings.** There were a variety of caterpillars present, including imported cabbage worms, cut worms, diamondback moths, and wooleybears. **The damage peaked on Nov. 11, when 11 caterpillars were present across these three plots.** Injury was not uniform across all plants; some were heavily damaged by cutworms while others had little damage or frass. Most plants had evidence of some caterpillar activity. Damage decreased as caterpillar activity decreased relative to plant growth moving into the colder weather. The green and red pak choi were harvested by Nov. 11 and 26, respectively, and had some bypass due to damage. The Napa cabbage was harvested later, also with some bypass. About half of the Napa cabbage heads observed on Dec. 19 had evidence of caterpillar activity.




**The damage was within the grower's comfort level for loss and marketability.** The farm decided not to treat at this pressure level. The bypassed heads were often those that had been fed on heavily by the large caterpillars. Many of those with cabbage complex and smaller caterpillar feeding were harvested and were market acceptable after thorough washing. There was minor, spotty feeding in the spinach,

hakurei turnip, second planting of brassica mix, and arugula. These plots stayed below 1.0 and did not need treatment.




The lack of caterpillars and damage in the majority of the house is somewhat surprising. The cabbage complex was expected to be present and causing similar damage in at least some of the other brassica plots. The plot map below shows the location of each planting. Each of the high damage plots were along the south wall of the house. There was a layer of wood chip mulch along most of the south baseboard. **It is possible that the mulch provided favorable habitat for caterpillars wandering into the tunnel, and the crop provided an adequate food source.** This may explain why a wide variety of caterpillars, especially the large cutworms and wooleybears, seemed to concentrate in the pak choi and Napa cabbage without infesting the rest of the house.

The spinach began to show some feeding damage on Nov. 11. Damage was spotty, impacting plants sporadically and remaining very light on a plot basis. While it was clear that something had fed on the plants, the damage pattern did not clearly point to either slugs or caterpillars as a source. Feeding was attributed to whichever most closely matched the damage in that plot. On Nov. 26 spinach crown mite was proposed as a potential cause. By Dec. 19, the damage pattern closely matched that caused by spinach crown mite feeding. Spotty, light damage continued until scouting concluded.

**Spinach crown mites feed at the growing point**, so it can take several weeks for damaged leaves to grow out, fully expand, and show the characteristic damage pattern. **Early signs of damage are small to medium sized round or oval shaped holes with healed edges.** The damage is difficult to distinguish from old, healed caterpillar or slug feeding. As the problem intensifies, leaves show crinkling or distortion. **New leaves begin to emerge with shot holes and deformed margins and may be puckered.** Severe infestations cause severe deformation and render the crop unmarketable for many weeks. Most crops will outgrow the damage and put on more normal leaves as the growth pace accelerates in spring.

**Downy mildew was present and struck the brassicas differently.** Arugula was being lost to downy mildew while green and red mizuna were fine. The kale in the brassica mix was defoliated, while the kale planted as a stand-alone crop showed no symptoms. Downy mildew has several races, or strains, of the pathogen. Varieties of many brassicas have been developed with tolerance or resistance to at least one strain of downy mildew. This case exemplifies that one variety may have resistance while another does not, based on which strain is present. One cannot predict which strain will be going around in a

given year. For these reasons**, it is a best management practice to select varieties that have at least some resistance, with preference for resistance to multiple strains.**

**Other fungal rots set in and limited the regrowth potential in several plots**. The unusually cold and cloudy weather, high humidity under the row cover, and harvesting wounds provided opportunistic pathogens an opportunity to establish in stressed, weakened plants. **Cultural decisions such as variety selection and ventilation impacted disease pressure on this farm.** Scouting concluded on Jan. 13, 2014, as many plots had been harvested and regrowth was suffering from disease pressure and extreme cold.

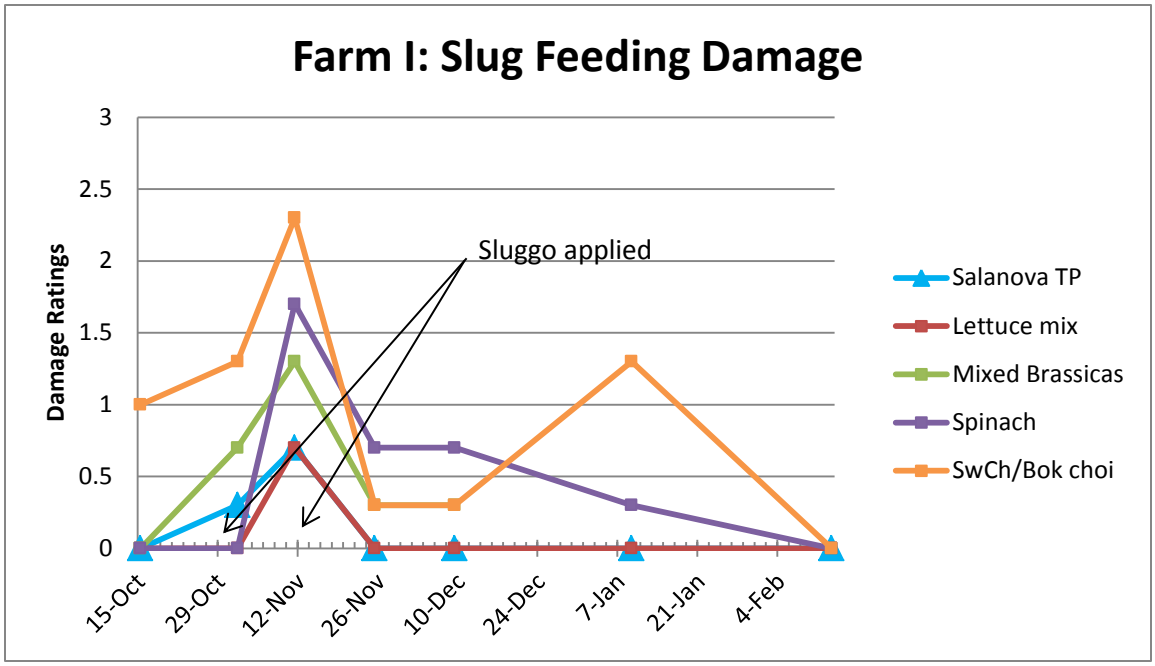
**Farm I: Canandaigua, NY**
Crops: Salanova, Lettuce, Spinach, Mixed Brassicas, Swiss Chard, Bok Choi
Pests**:** Slugs, Caterpillars
Controls: Sluggo

This was the second year of participation for this grower. Last year he struggled with a severe aphid infestation, a slug problem, and diseases. These troubles were exacerbated by a dense canopy. His season came to an early end due to fa hard freeze. **The grower learned a lot last year and has adopted many pest control BMPs, as outlined below.**

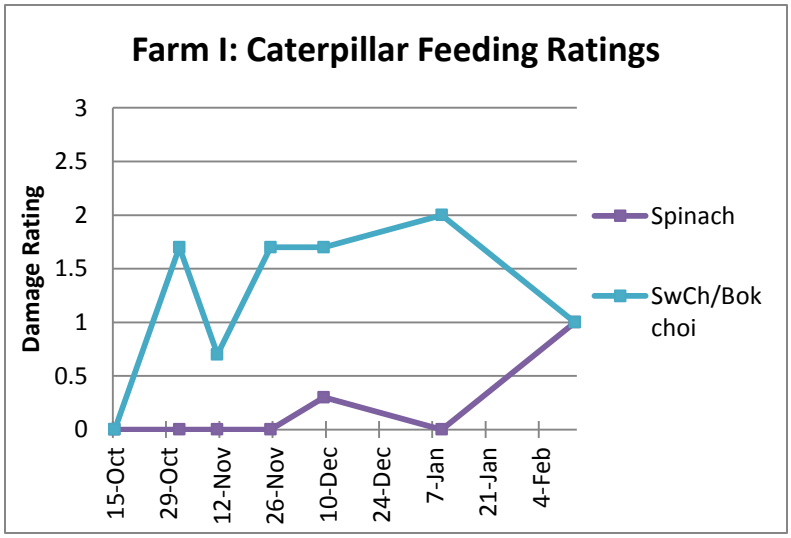
The summer tomato crop was kept free of pests. Aphids were noted on weedy sowthistles around the house prior to fall planting. Those aphids were not permitted to migrate into the house and did not become a problem. Good weed control during the summer likely played a role in this success. Winter crops of direct sown lettuce, spinach, and brassica mix and emerged and had true leaves by Oct 15. Chard, bok choi, and salanova transplants were established by early October. The grower used a wider spacing this year and had much less disease trouble.

Slugs were the primary pest. Very light damage was first noted Oct. 15 in the chard and bok choi. The grower applied 2 lbs of Sluggo (iron phosphate bait ) to the house on October 29. The grower was scouting regularly and acted very early based on knowledge gained last year. **He recognized the damage, correctly identified the pest, and used the correct rate of an appropriate control material at an appropriate timing.** All of this was self-directed; he had already treated before staff made the next scouting visit and realized the extent of the problem.

Slugs continued to be troublesome. **We have observed on several farms that the small black slugs are much more difficult to control than the large orange slugs**. The reason behind this difference is not known, but count data indicates that black slug populations tend to be larger than orange slugs. The grower made a self-directed follow-up application of iron phosphate bait after two weeks. This is in perfect accordance with recommendations. It has been observed on many farms that **slugs often need two rounds of iron phosphate bait treatment to be brought under control, due to bait degredation**. The population crashed after the two treatments and was maintained below the treatment threshold (damage rating of 1.5) for the remainder of the season.



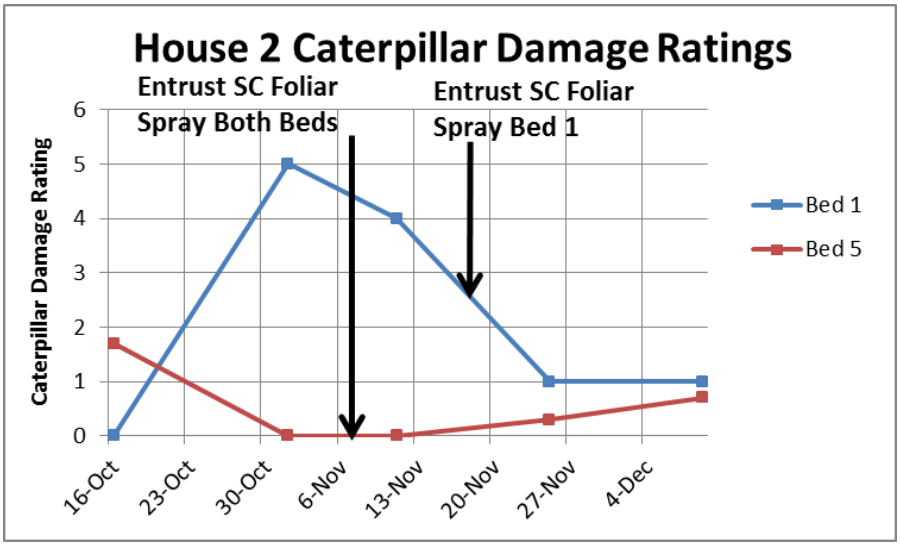

Caterpillars were troublesome in certain plantings. Wooleybear caterpillars were particularly voracious predators of the bok choi and swiss chard. They caused severe damage to plants they fed upon, but fed sporadically across the planting. This was the first year they were recognized as a major threat to greens production. **Wooleybears caused substantial damage to several crops on 3 different farms. The worst damage was always in the outside beds.** No Bt was applied at this farm to control the wooley bears. Instead, a volunteer that liked to pick caterpillars out of the house was the cause of the population decline. The grower reported some cutworm activity in the spinach, but it caused minimal losses and it would have been impossible to effectively treat at that time of year.



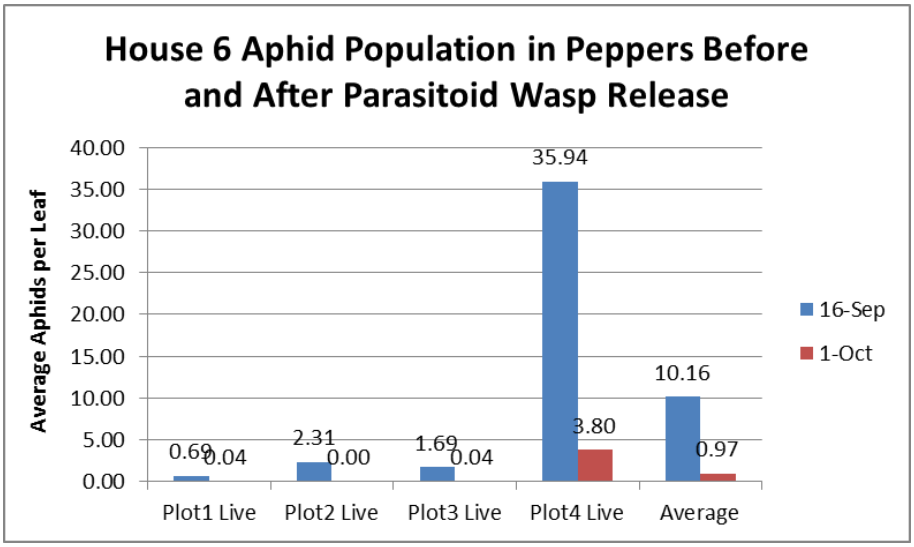

The crop was much better this year, and pest control far more effective than it was in 2012-2013. The grower repeatedly demonstrated increased pest management and skill in his cultural and reactive pest management practices. He lost fewer greens to pests and disease as a result of his knew knowledge.

**Farm N: Canandaigua, NY**
Crops: HOUSE 6- Green Kale, Red Russian Kale, Lettuce Mix, Spinach, Radishes
HOUSE 2- Carrots, Bok Choi, Radishes, Lettuce Mix
Pests: Caterpillars, Slugs, Aphids, Disease
Controls: ACE Mix Parasitoid Wasps (Syngenta), Entrust SC Foliar Spray, Disease resistant varieties

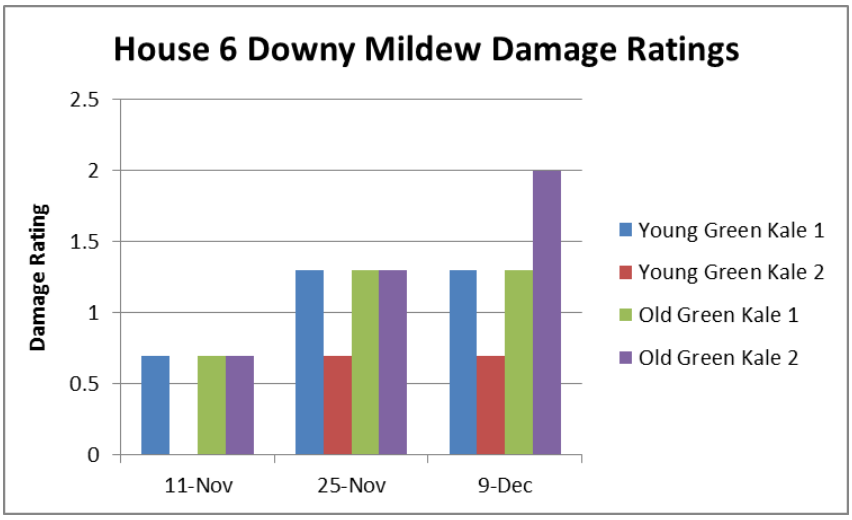
House 2 was initially planted with lettuce, kale, and radishes and was free of any pests when it was first scouted on September 4. Caterpillars and subsequent damage were recorded on October 16. The damage was particularly bad where a **large cutworms mowed down sections of plots and beds. Entrust SC (spinosad) was applied at a rate of 3g per 4 gallons of spray to help control the population on Nov 7.** A follow-up application was made to hot spots on Nov. 18. The amount of new caterpillar damage sustained by each plot went down. It is important to note that these damage ratings are based on cumulative caterpillar damage, so the fact that ratings dropped indicates that the plants grew out of their damage and put on new foliage. **In bed 1 the rating was dropped from 5 (heavy/severe) to 4 (significant/substantial) within a week of application and was down to 1 (very light, below threshold) by November 25.** Aside from caterpillars, House 2 has seen no significant damage from any other pest. There was one area of severe rot in the lettuce mix noticed on December 9.




House 6 had a heavy aphid infestation in summer peppers at on Sept. 4. They were present in the tomatoes and there was a high risk that they would move over into newly transplanted and sown winter greens crops. Parasitoid wasps were released in the house on September 10th. **On September 16 the average number of aphids per leaf was 10.16, and on Oct. 1 that number was .97 per leaf.** It should be noted that ladybeetles and larvae were present on the peppers on September 16 and that they likely played a role in the reduction of aphid numbers in this tunnel. No aphids were counted in the winter green crop for the duration of the season. **This was a remarkably successful use of biologicals. An extremely high pest population in a summer crop was brought under threshold in two weeks, and then eradicated with the removal of the pepper host.**

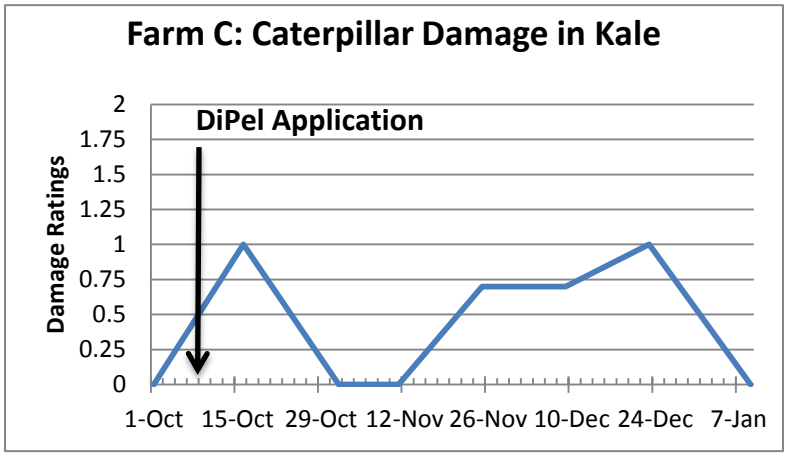



**All greens were established by Nov. 1 and had no further pest troubles in the winter season. However, this house suffered badly from disease.** The environment was frequently moist and cool, which slowed plant growth and favored root rots and damping off pathogens. Brassica downy mildew became particularly destructive. **Compounding the disease risk was the selection of susceptible varieties of brassicas.** Leafy crops were all marketed as baby greens, so it amounted to a complete crop loss when the kale was defoliated by the downy mildew. The radishes did not defoliate, but the pathogen attacked the exposed portion of the roots and caused them to rot. Pathogen pressure continued to build up in the house and forced the grower to abandon several beds. The farm switched to more disease tolerant kale varieties for later sowings and had better success.



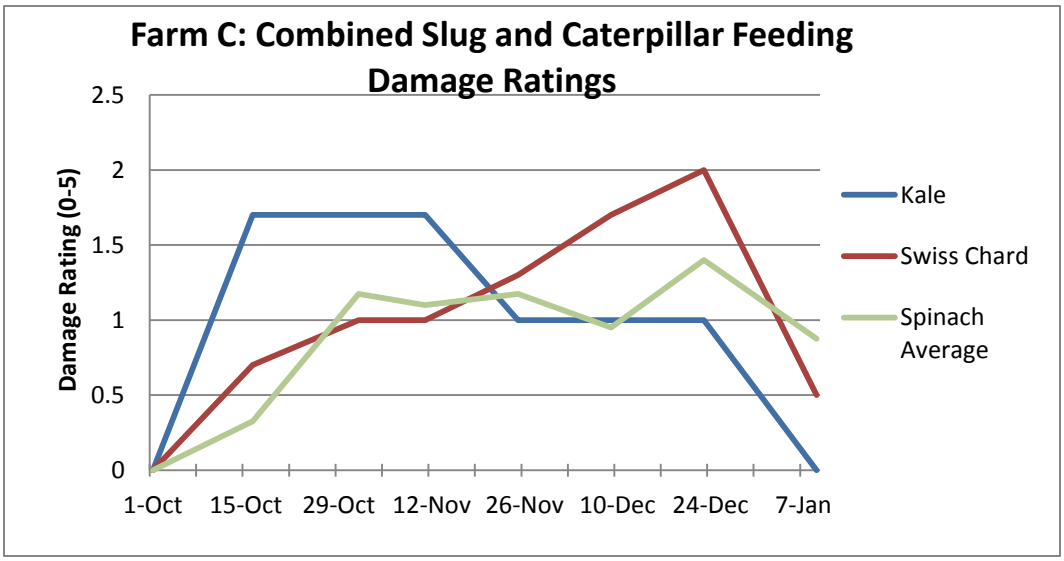
**Farm C: Clyde, NY**
Crops: Spinach, Kale, Leaf Lettuce, Swiss Chard, Beets
Pests: Caterpillars, Slugs, Weeds
Controls: DiPel

Scouting at this farm began on September 16. The summer crop had been removed and the fall crop was getting established. Aphids were detected on kale and lettuce mix and appeared a month sooner on the kale. However, pressure remained below threshold throughout the season.




Lepidopteran pests were first observed Oct. 1 on kale. A high count of 9 cabbage complex pests coupled with no appreciable injury showed that the infestation was just beginning, but would cause marketability losses. **Proactive scouting detected an emerging pest threat at the perfect moment. The grower made one very well timed application of Bt in early Oct. to the entire house.** While caterpillar feeding was observed for the rest of the feeding, the population was held at a very manageable level. Damage ranged from scarcely present to very light and caused no economic losses. The small surviving population of brassica favoring caterpillars present in kale did eventually become active enough to cause increasing injury in mid-Nov. Feeding activity fell off with extreme cold, as this grower suffered a freeze that damaged a portion of his crop.

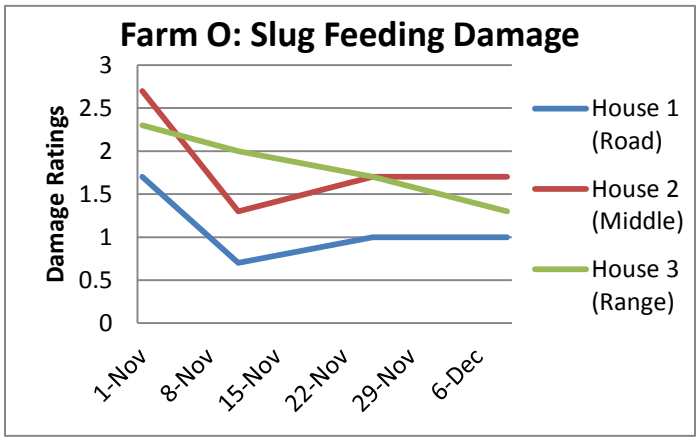
Slugs caused greater damage. **Slug damage was heaviest where there was the thickest mat of chickweed.** Chickweed provides optimal habitat for slugs and prevents bait from being effective. Therefore, control focused on removal of the favorable habitat. Unfortunately, the chickweed problem was so severe that the grower could not keep up. It smothered the low growing crops. He tried a novel approach of marketing the chickweed to a restaurant that had expressed interest in it as an edible green, but even that did not effectively reduce the population. In the end, this grower ended up putting his crop under due to a severe weed problem.

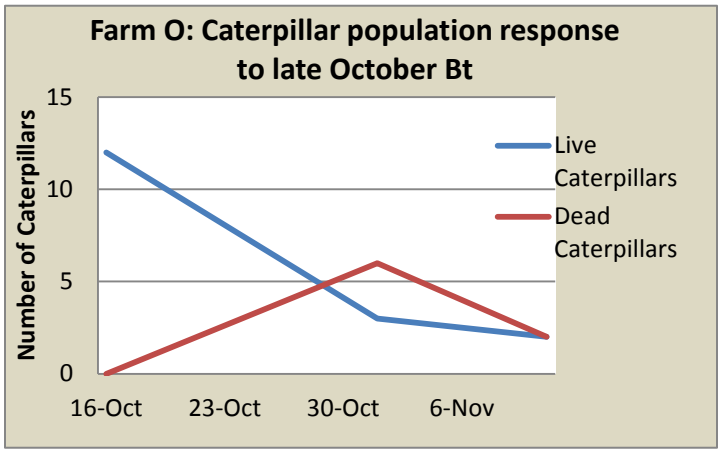


**Farm O: Bellona, NY**
Crop: Kale
Pests: Caterpillars, Slugs
Controls: DiPel (Bt), Deadline Bullets (metaldyhyde bait)

Three small high tunnels ('Road', 'Middle', and 'Range') filled with the same variety of kale were scouted from Oct. 16, 2013 to Jan 9, 2014. Each tunnel was treated as a replicate plot. Caterpillars and slugs were present in all three tunnels. Cabbage complex caterpillars (imported cabbage worm, diamondback moth, cabbage looper) were the worst in the 'Road' tunnel, with many caterpillars found on plants in mid-October. The grower treated with Bt in late October, and the caterpillar population decreased. However, pupating caterpillars were present on Nov. 1, and caterpillars were still found on Dec 23, indicating that lepidopterans can continue to complete their life cycles in cool fall conditions. In this project, staff has documented multiple cases where caterpillars have pupated over winter and led to moth flights in the tunnel.

**Cabbage complex caterpillars will remain active throughout the cool season if left untreated**. They may become harder to find and feed less during the coldest months, but they will become more active as the weather warms. In this project, staff has documented multiple cases where caterpillars have pupated over winter and led to moth flights in the tunnel. For this reason, **it is a best management practice to treat increasing populations of cabbage complex caterpillars early, to gain control before the colder months.** Sprays are difficult to apply in the dead of winter, and **some popular products, like Bt, work better when temperatures are well above freezing**.




Slugs were the major problem in the other two houses, though they were present in all three. The grower applied metaldyhyde bait (Deadline Bullets) to address slug feeding in early November. Deadline was chosen over Sluggo at this IPM farm because it degrades less quickly. Slugs concentrated underneath the weedmat, which provided ideal habitat**. Slug management continued to be difficult because of the weedmat refuge. In the future, slug bait may need to be applied beneath the mat just prior to planting to gain adequate control.**

The grower was able to hold pest damage a consistent or slightly declining level, but was unable to get complete control of the populations. **Three factors led to the incomplete control: extraordinary pest pressure from very high populations, late control applications combined with cold weather, and extremely favorable pest habitat**. The grower reported that he would have been able to market the majority of his crop, had he not lost it to freezing and weather related bolting.