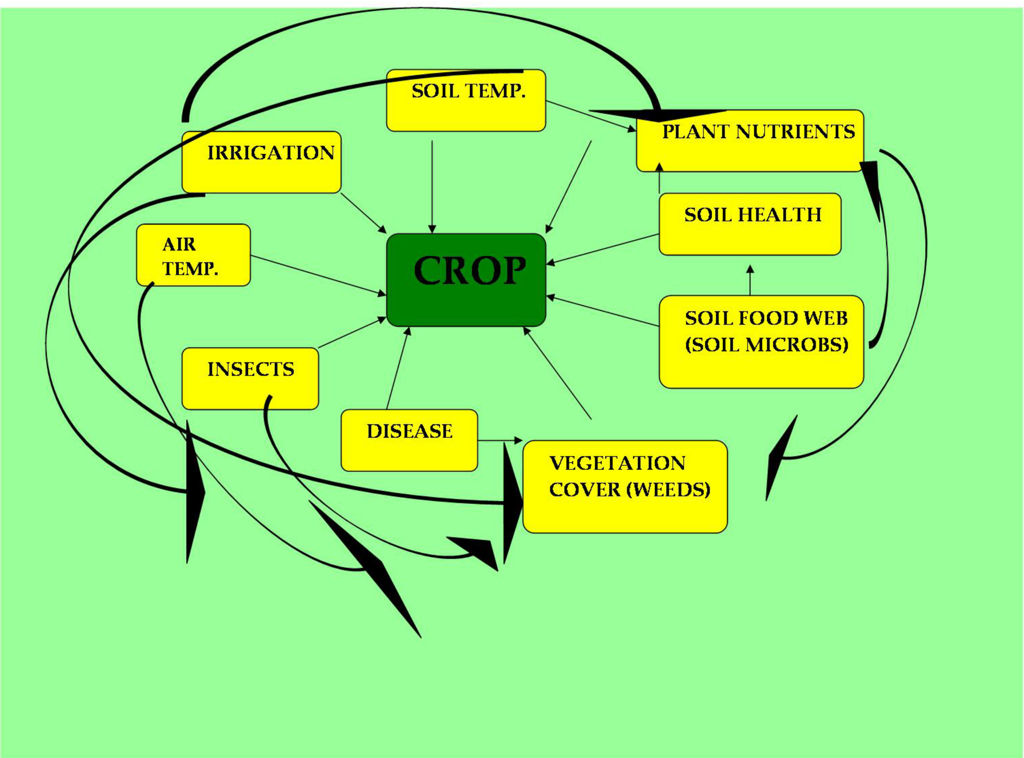
REDUCED TILLAGE/LIVING MULCH SYSTEM MANAGES INSECT PESTS

Western SARE Project # FW06-025

Helen Atthowe Biodesign Farm Stevensville, MT.
atthowe@missouladeduplace.org
Ethan Smith University of Montana Missoula, MT

How do you design and test a system for effective ecological function, sustainable yield, and reduced labor and inputs? We spent 11 years developing an agroecosytem approach to produce vegetables in the semiarid west, and then designed experiments to test and understand the system. We designed 3 studies: a long-term soil quality experiment, a short-term insect experiment, and a short-term weed experiment. **The goal is to see if our reduced tillage, enhanced vegetative diversity system can provide the plant nutrition, insect, and weed management for an adequate yield with less labor and fewer inputs.**



INSECT EXPERIMENT. Imported Cabbage Worm (ICW) is a pest of broccoli, cabbage, Brussels sprouts, and related plants in the Mustard family. Most vegetable producers use insecticides to manage this pest. In 2000 we stopped spraying for ICW. We have observed no economic injury from ICW since we stopped treating for this pest and began to rely entirely on biological control. In 2006, we designed an experiment to answer the following questions:

» Can ICW be managed without the use of pesticides?
» Can ICW be managed by increasing habitat for predators and parasites?

The experiment was a completely randomized design with three treatments and six replications for a total of eighteen 3'x 50' plots. There were 10' sections between each treatment replication. Analysis of variance (ANOVA) and separation of means by least significant differences (LSD) $P < 0.05$ were performed on the data.

There were three treatments:

1. **Unsprayed (CONTROL).** Only biological controls within the system would provide management of ICW in these plots.

2. **Sprayed bi-monthly with a pyrethrum/rotenone mix (CALENDAR**). The rotenone–pyrethrum was chosen to comply with organic certification, to have maximum negative affect on predators and parasites, and minimum affect on ICW. Pyrethrum and rotenone are plant-derived insecticides/acaricides. In combination they are very toxic to bees and other beneficial insects (Copping, 1998; Sandof and Raupp, 1999). These plots were sprayed ten times.

3. **Sprayed with Bt (Bacillus Thuringensis) when ICW larvae reached a threshold level (THRESHOLD).**
We used the ICW threshold level for Brussels sprouts reported in the 2006 Pacific Northwest Insect Control Handbook and the threshold level for cabbage reported in the University of Minnesota Extension Service Guidelines. Bt is a selective biological insecticide (bacterium) that specifically targets Lepidopteran larvae. It has short persistence due to u.v. light sensitivity. There is no reported effect on beneficial insects (Copping 1998). These plots were sprayed eight times.

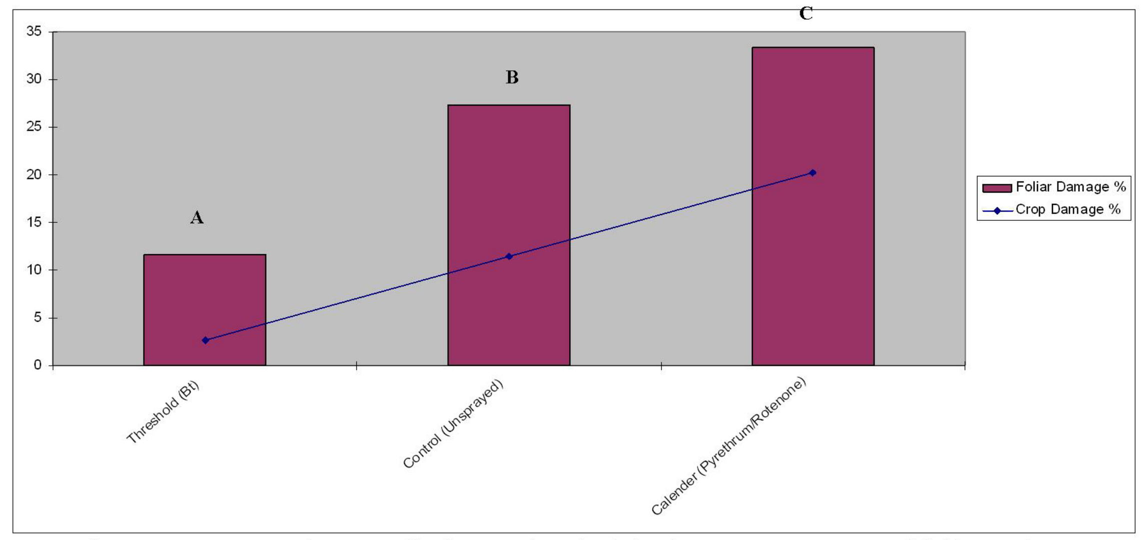


Figure 1. Bt sprayed (THRESHOLD) plots had the lowest percentages of foliar and Brussels sprouts damage (11.7% and 2.7%); Bt was sprayed 8 times throughout the season. Unsprayed (CONTROL) plots had higher foliar and crop damage (27.3% and 11.5%), but saleable crop levels were still adequate (88%); labor and material costs for insect control were zero. The highest level of foliar and crop ICW damage was observed in the rotenone-pyrethrum sprayed (CALENDAR) plots; Rotenone-pyrethrum was sprayed 10 times. Different letters indicate significant treatment differences ($P < 0.05$).

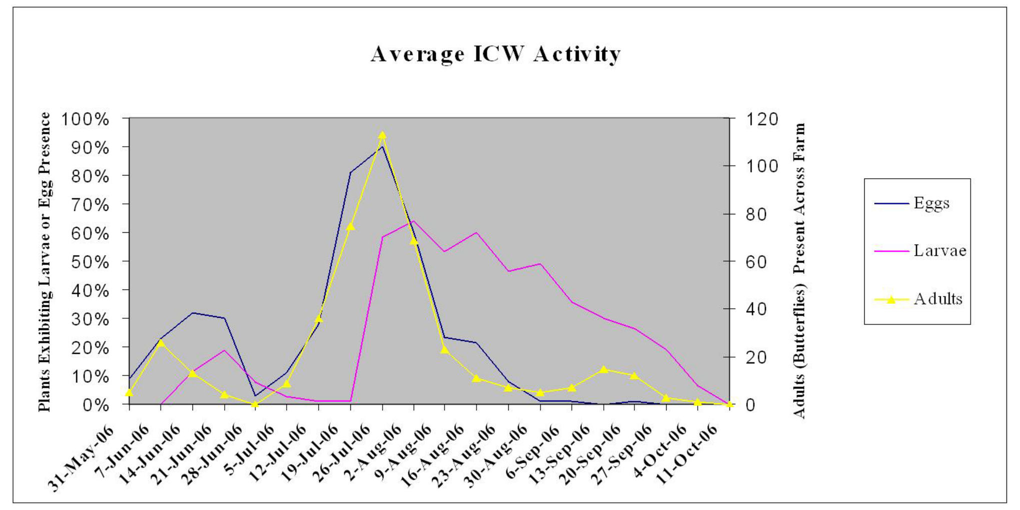
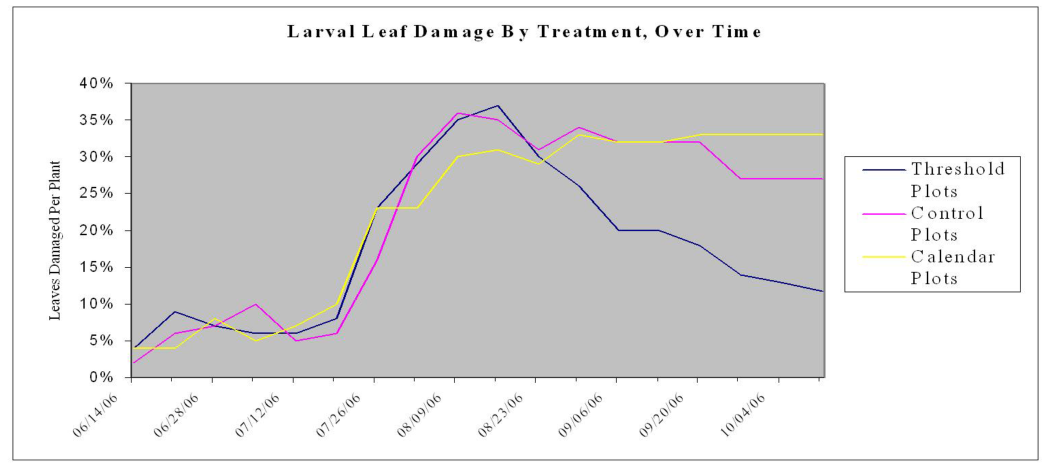


Figure 2. ICW activity in 2006 was high. Egg and Larvae activity correspond with the left Y-axis, and are expressed by the percentage of plants sampled that had 1+ larvae or eggs. Adult activity corresponds with the right-hand Y-axis, and is measured by the number of ICW butterflies counted along the farm transect.

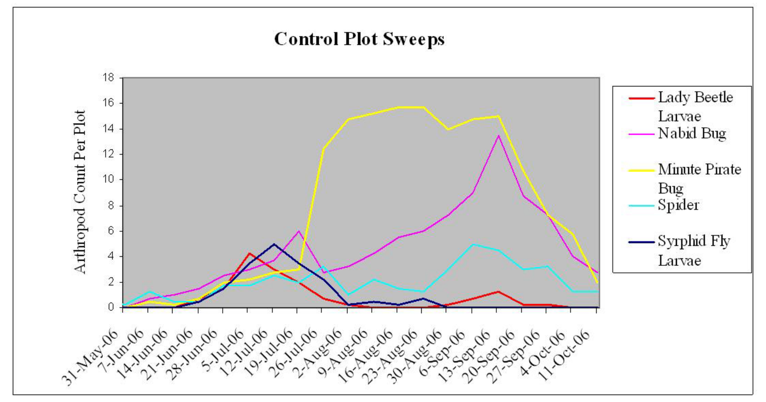


PREDATOR/PARASITE POPULATIONS:

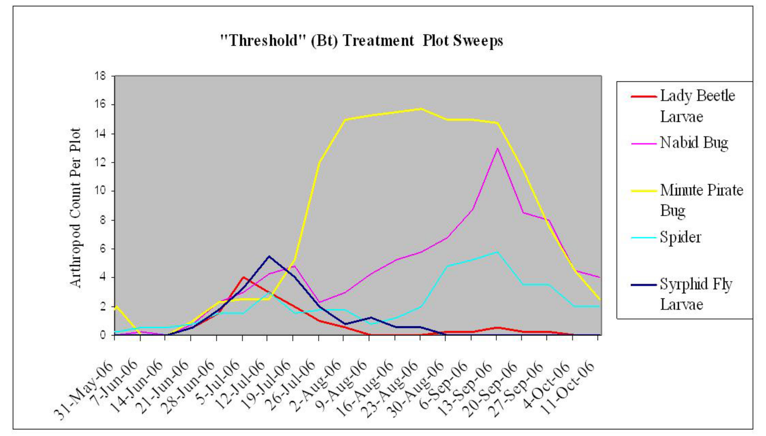
We had expected to find a high level of ICW parasitism by parasitic wasps in our study. Much of the biological control of ICW reported in the literature has been attributed to parasitic wasps. However, we collected and raised larvae from both ICW generations and found no parasitism of the 78 total larva collected. Generalist predators were present in great numbers in our weekly sweeps and pitfall traps

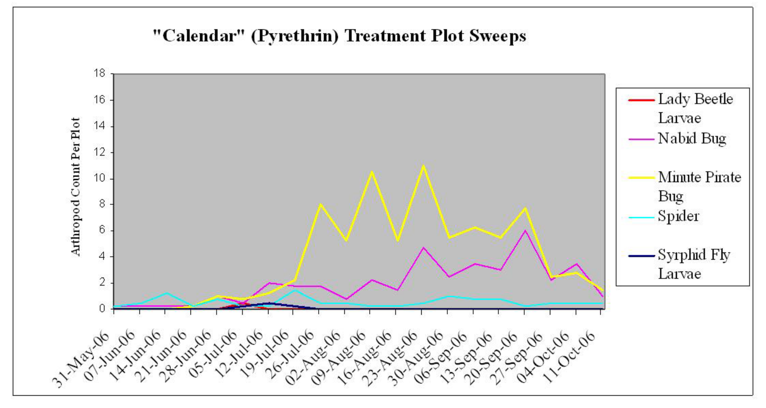
	Carabids			Spiders		
	Threshold	Control	Calendar	Threshold	Control	Calendar
7/5/06	2.75	3	0.25	7.75	8.25	2.5
8/2/06	2.5	2.5	0.25	7.5	9.5	2.5
8/30/06	2.5	2.25	0.25	8.25	9.75	2.5
9/27/06	3	2.75	0.25	9	9.5	1.25

Results of pitfall trap installations. Columns indicate the average number of spiders or carabid beetles captured during the 7-day trap installations. There were significantly fewer spiders and Carabid beetles captured in calendar plots where rotenone-pyrethrum was sprayed bi-monthly ($P > 0.05$). Spider populations were particularly disrupted by rotenone-pyrethrum sprays.



Predators caught in weekly sweeps May - October Population and species number were highest in control and Bt plots





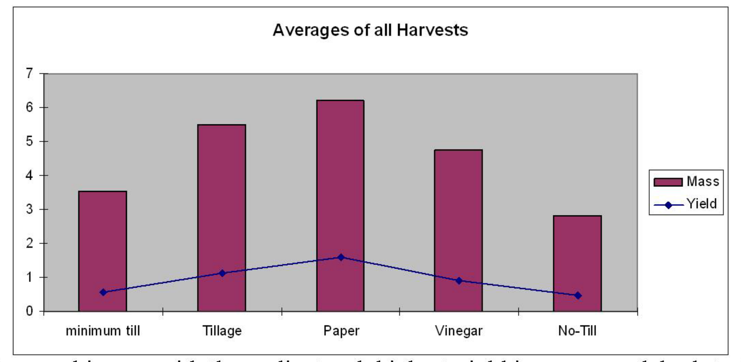
Predator populations were significantly lower in rotenone-pyrethrum sprayed plots, esp. populations of lady beetles, syrphid flies, and spiders.

SUMMARY

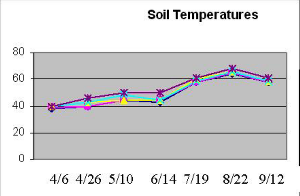
Though it is difficult to quantify all the interactions in the high plant diversity, reduced tillage vegetable production system we studied, we found acceptable biological control of ICW in unsprayed broccoli, cabbage, and Brussels sprouts. We saw an increase in crop damage and a decrease in generalist predators where we sprayed rotenone-pyrethrum to disturb the predators and parasites in our system. Yields were very good in minimum-till plots, but were reduced in no-till plots, probably due to cooler soil temperatures, slowly available nitrate-nitrogen, and general plant competition. More work is needed to understand the complex interactions in production systems that increase plant diversity and reduce tillage. This study indicates great potential for pest management using a systems approach.

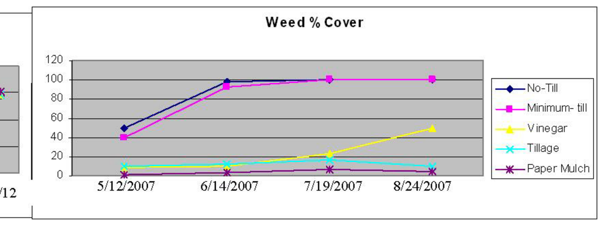
WEED EXPERIMENT – How Much Can We Reduce Tillage?

We had further questions about the effect of reduced tillage on crop yield and quality. In 2007 we looked in more detail at nutrient cycling and weed, or vegetation, competition in plots with different in-row soil/weed management treatments. We maintained the between-row untilled, permanent clover that helped to provide habitat for the predator complex in our 2006 insect study. The in-row treatments were: no-till, minimum-till, conventional tillage, sprayed with vinegar, and mulched with paper (Ecocover). None of the treatments received any fertilizer other than the tilled-in clover in April. The no-till plots were flamed 3 times. Minimum-till plots received only one initial light tillage. Tillage plots were tilled two times and hoed three times (every 5 to 6weeks). Vinegar and paper mulch plots were tilled once and then sprayed 3 times with vinegar (every 5 to 6 weeks), or covered with paper mulch.

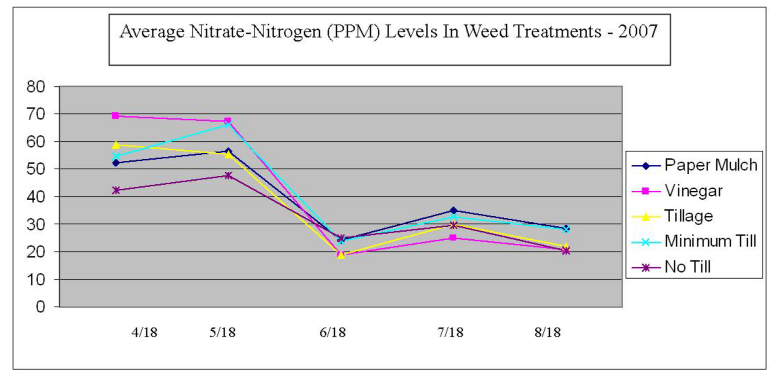


Plants were bigger , with the earliest and highest yield in paper mulch plots, followed by tilled and vinegar plots. The lowest yield and smallest plants were in the no-till plots. Different letters indicate significant treatment differences ($P < 0.05$).





Paper mulch and tillage plots had slightly higher soil temperatures from April through the end of August. They also had the lowest vegetation cover (clover and weeds). Vinegar plots had cooler soil temperatures and more vegetation cover, 50% by August. Soil temperatures were lowest and vegetation cover highest in the no-till and minimum-till plots.



Nitrogen levels were highest early in the season in vinegar and tilled plots and lowest in the no-till plots. Minimum-till plots had higher nitrogen levels than paper mulch plots through August. We assumed nitrogen levels would be highest were soil temperatures were higher (paper-mulch plots). But, by July the highest nitrogen levels were found in the both paper mulch and minimum-till plots, the *highest and next to lowest yielding* plots. In 2007, unlike in 2006, there is not a clear relationship between total nitrogen levels and yield. Except in the no-till plots, where nitrate-nitrogen levels were lowest all season