Mechanical killing of cover crops with a roller/crimper in an Organic No-Till Corn Cropping System: Evaluation of the effectiveness of an on-farm constructed mechanical roller/crimper to roll down & kill cover crops and prepare the rolled plant material as a weed suppressing soil cover for an organic no-till corn system.

Roller /Crimper Design:

John Brubaker received a Northeast SARE Farmer/Grower Grant to design and construct a front tractor mounted, tubular (roller/crop crimper). This roller is designed to mount to the front of a tractor by utilizing a three point hitch connection.
The Roller is 10 ft 6inches wide. The roller rotates freely on flange bearings that are held in place by a wide 4"x4" tube stock mounting frame yoke which is mounted to the 3 point hitch. The roller tube was constructed from a 16" diameter x ½" thick steel pipe. Flat stock steel 4" wide x 5/16" thick is bolted to angle irons that are welded to the surface of the tube. The angle irons are at an approx 60° angle to the surface of the tube roller, and are attached 7½ to 9 inches apart horizontally across the roller surface in a wide v shaped (chevron pattern). The flat stock does the crimping of the cover crop. The flat stalk is bolted to these angle irons and the angle irons hold the flat stock at that same 60° angle to the surface (back toward the tractor) which keeps the flat stock at a correct angle of impact. At this angle of impact the crimpers hit the soil and plant surface without digging into the soil surface excessively and they don't throw soil back, this creates a minimal of soil disturbance. In addition the wide v shaped chevron pattern design of the crimpers is patterned so that two adjacently positioned crimpers are hitting the soil 7" apart at the same time, the chevron pattern also eliminates the cyclical "bumping effect" that would occur if the crimpers where positioned horizontally straight across.

Placement & Utilization of the Roller/Crimper & Corn Planter:

The Roller was mounted to the front mounted three point hitch on a John Deere 2950 Tractor, (85 Horsepower). On the back of the tractor a 2 row corn planter was utilized. This planter was specifically put together to cut into and no-till plant the corn into a heavy cover crop plant residue that was rolled. The planter is a combination of a Monosem vacuum air seed pickup unit attached to a Kinze planter. The Kinze planter unit utilizes from front to back, a residue manager /coulter combination consisting of a pair of 12" fingered residue managers that are angled to open and separate the cover crop, positioned inside the pair of fingered residue managers is a 15" fluted disk blade to cut through the cover crop. This is followed by a 15" double disk opener, followed by a pair of 12" rubber closing wheels. A plastic Keeton seed firmer is also utilized to firm the seed, after placed in the seed furrow.
The design of mounting the Roller/Crimper to the front of the tractor, allows for Rolling/Crimping the cover crop and Planting the seed all in a one pass operation. This not only is time efficient but also eliminates the problem of cover crop "re-growth". From past experience (using a pull behind stock chopper to kill the cover crop) the cover crop would re-grow in the area where the rear tractor tire first depressed the cover crop before it was stalk chopped, which resulted in a poor kill ratio, with re-growth, in the tire area.

Corn cover crop field strip design layout:

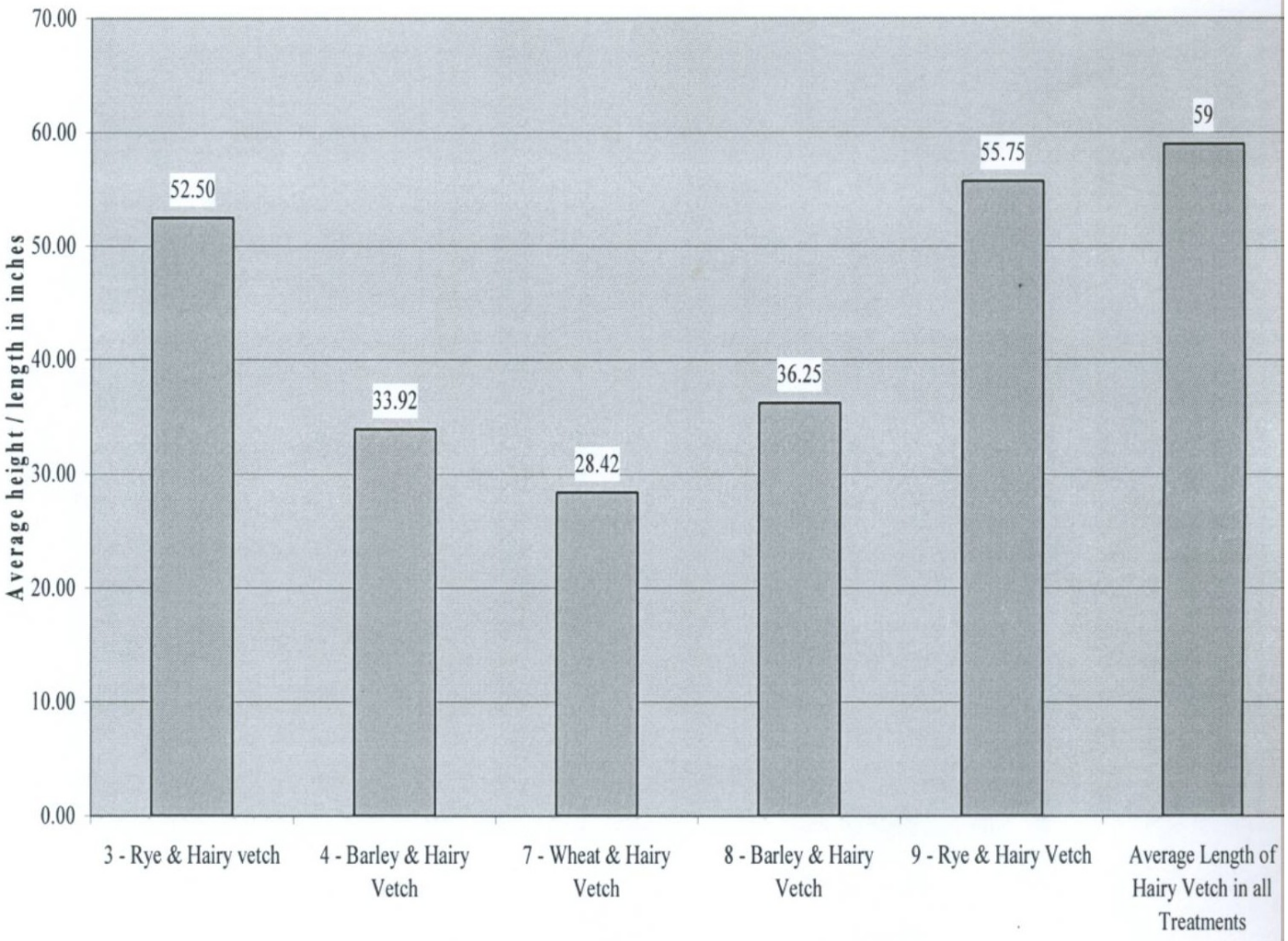
In a 3.8 acre field, (Rodale Research Farm Field #71-72) 12 adjacent long strips (20ft. wide x 690 ft long) were laid out to evaluate the effectiveness of the roller/crimper that John constructed. The strips were flagged and sub dived into 3 treatments lengthwise for data collection and evaluation. Every strip was planted with hairy vetch; the differentiation of the treatments from strip to strip was determined by the cover crop that was planted with the hairy vetch. The strips were planted **{9/9/02}** each with separate cover crops. These consisted of small grain cover crops (winter cereal rye, winter wheat, spring oats, black oats) buckwheat and sorghum-sudan grass all planted at the rate of 1.5 Bu/Ac. On **{9/10/02}** the hairy vetch (AU Early Cover variety) was planted at a rate of 25 lbs/Ac in all the strips. All cover crops were planted with a John Deere 450 Grain Drill, 17 rows, with 7.5" wide rows. The two strips (planted to rye and hairy vetch) were used as a moldboard plow and chisel plow treatment to compare both a cultivated and minimum-till cultivation to the No-till treatments.

	dirt road	dirt road		
	Hairy Vetch Buffer	Hairy Vetch Buffer	Hairy Vetch Buffer	
	Rep 1	**Rep 2**	**Rep 3**	
	Buffer - Black Oats / Hairy Vetch	Buffer - Black Oats / Hairy Vetch	Buffer - Black Oats / Hairy Vetch	
C H R I S T M A N R O A D	Treatment 11 - Rep 1 Oats / Hairy Vetch	Treatment 11 - Rep 2 Oats / Hairy Vetch	Treatment 11 - Rep 3 Oats / Hairy Vetch	**11**
	Treatment 10 - Rep 1 Sudax / Hairy Vetch	Treatment 10 - Rep 2 Sudax / Hairy Vetch	Treatment 10 - Rep 3 Sudax / Hairy Vetch	**10**
	Treatment 9 - Rep 1 Rye / Hairy Vetch	Treatment 9 - Rep 2 Rye / Hairy Vetch	Treatment 9 - Rep 3 Rye / Hairy Vetch	**9**
	Treatment 8 - Rep 1 Barley / Hairy Vetch	Treatment 8 - Rep 2 Barley / Hairy Vetch	Treatment 8 - Rep 3 Barley / Hairy Vetch	**8**
	Treatment 7 - Rep 1 Wheat / Hairy Vetch	Treatment 7 - Rep 2 Wheat / Hairy Vetch	Treatment 7 - Rep 3 Wheat / Hairy Vetch	**7**
	Treatment 6 - Rep 1 Buckwheat / Hairy Vetch	Treatment 6 - Rep 2 Buckwheat / Hairy Vetch	Treatment 6 - Rep 3 Buckwheat / Hairy Vetch	**6**
	Treatment 5 - Rep 1 Oats / Hairy Vetch	Treatment 5 - Rep 2 Oats / Hairy Vetch	Treatment 5 - Rep 3 Oats / Hairy Vetch	**5**
	Treatment 4 - Rep 1 Barley / Hairy Vetch	Treatment 4 - Rep 2 Barley / Hairy Vetch	Treatment 4 - Rep 3 Barley / Hairy Vetch	**4**
	Treatment 3 - Rep 1 Rye / Hairy Vetch	Treatment 3 - Rep 2 Rye / Hairy Vetch	Treatment 3 - Rep 3 Rye / Hairy Vetch	**3**
	Treatment 2 - Rep 1 Oats / Hairy Vetch - Chisel Plow	Treatment 2 - Rep 2 Oats / Hairy Vetch - Chisel Plow	Treatment 2 - Rep 3 Oats / Hairy Vetch - Chisel Plow	**2**
	Treatment 1 - Rep 1 Oats / Hairy Vetch - Moldboard Plow	Treatment 1 - Rep 2 Oats / Hairy Vetch - Moldboard Plow	Treatment 1 - Rep 3 Oats / Hairy Vetch - Moldboard Plow	**1** 20 ft
	<----- 200 ft ------>	<----- 200 ft ------>	<----- 200 ft ------>	90 ft. to end of field >

Attached Graphs of (Height & Length) and Biomass of Cover Crops:

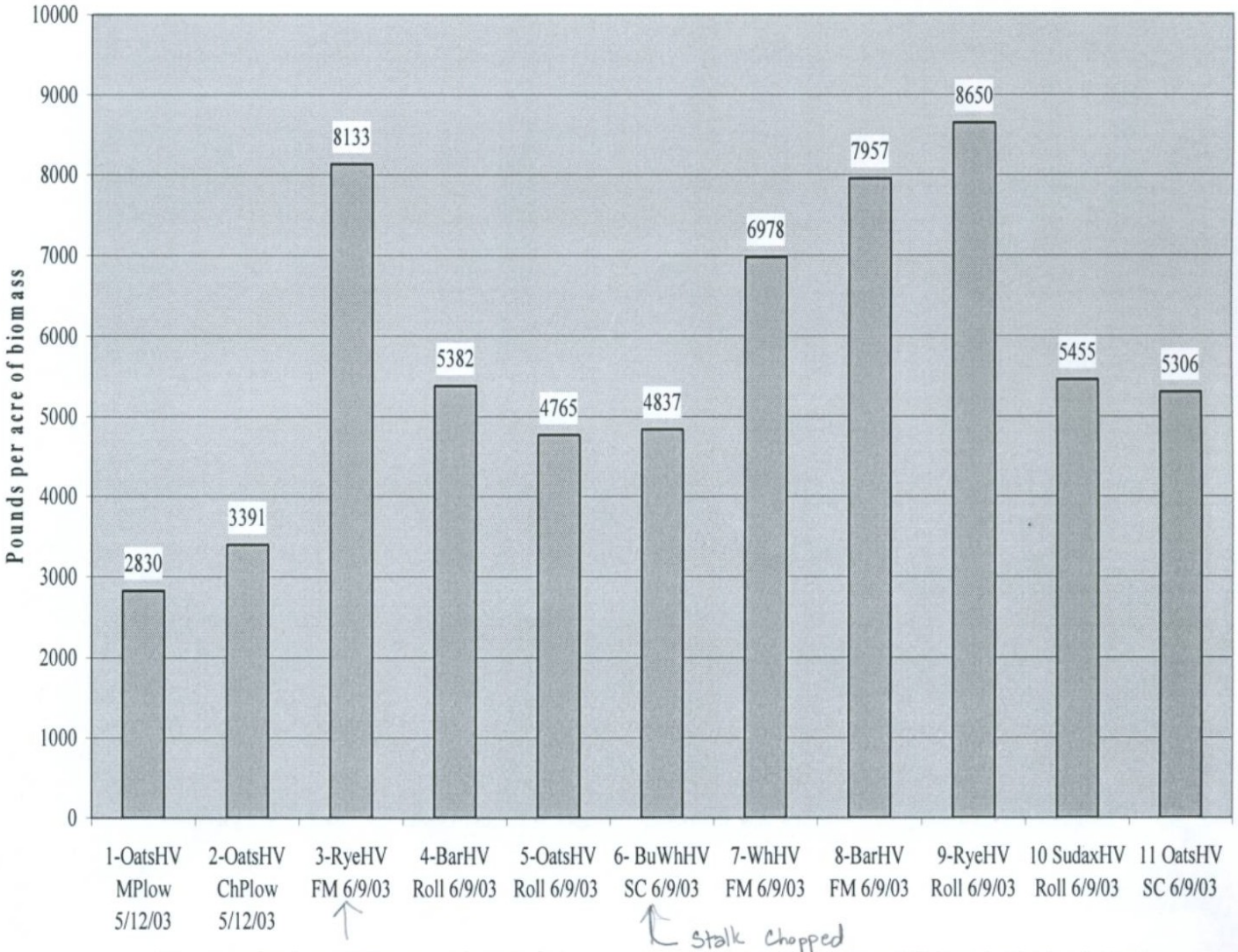
Prior to rolling the cover crops biomass, biomass cuts were taken to weigh & the small grains were measured for height, hairy vetch was measured for length. With this information we can quantify the amount of cover crop material that the roller was effectively able to handle as a cover crop management consideration.

2003 Corn cover crop experiment, Height of small grain cover crops & Length of Hairy Vetch on 5/28/2003



Treatment # and Name, Note Treatments 1 & 2 were Moldboard & Chisel plowed, Treatments 5,6,10, &11 had only Hairy Vetch left growing, the fall cover crops had winter killed.

Biomass of Cover Crops {Pounds per acre}, 2003 Corn Cover crop trial



Cover crop treatment & biomass cutting date, All cover crops were planted at 1.5 Bu/Ac on 9/9/02, Hairy Vetch at 25 Lbs/Ac on 9/10/03

FM = Flail mowed

02

Do to the higher than average amount of rainfall, the cover crops grew rapidly in the spring of 2003. Prior to rolling the cereal rye, cover crops were measured up to 4ft. 8 in. tall, and the vetch was measured up to 5ft. long. Combined (Hairy vetch & small grain) dry biomass weights of 8,650 lbs (4.3 Ton/Ac) were measured from the samples taken. This biomass & length would provide a very thick mat of plant material.

5-22-03, The roller/crimper was tried in the test strip to determine how it would handle the cover crop. At this point the vetch was not far enough along in its flowering stage but we wanted to do a test application of the roller/crimper. With the heavy biomass layer we were concerned that the Roller/Crimper was not aggressive enough.

5-23-03, First evaluation made, it seemed as if the crimper roller was not aggressive enough. It seemed to be crimping some of the plants of the upper most layer of vetch only, not the lower level of plants in the thick "mat" of hairy vetch. The thickness of the rolled material buffered some of the lower material which did not seem to be adequately crimped to kill it. We didn't know if effective kill would be achieved due to the early flowering stage of growth, or because of ineffective mechanical kill of the new roller design. We did observe that the vetch laying in the tire tracks of the tractor seemed to be flattened and may kill due to the extra weight of the tractor passing over it.

5-27-03, Re-evaluation of the Hairy Vetch that was rolled - The vetch that was rolled grew back up as if the roller had no effect on it. It had rained over the weekend and it seems the vetch recovered quite well except for that vetch in the area of the tractor tires. We decided to fill the roller with water, it was designed with an opening and fitting to seal for that purpose. The roller will hold approximately 80 Gallons of water, which would add approximately 720 lbs. to the weight of the roller.

5-28-03, The cereal rye was pollinating. The hairy vetch was progressed in the % of crop in flowering stage. It was at about 25 to 30% flowering stage. Much flowering along the edges of the plot, but the % decreased as you move inward. Treatment 3 Rye/Hairy Vetch had about 60% to 75% of the rye knocked down. Treatment 4 Barley/Hairy Vetch had about 90% of the barley knocked down. Treatment 7 Wheat/Hairy Vetch had about 5% of the wheat knocked down with 95% climbed on with vetch. Treatment 8 Barley/Hairy Vetch had about 50% of the barley knocked down, with the barley next to Treatment 9 the taller rye (South side) still standing.

6-11-03, There was 40 to 50% flowering of the hairy vetch, we began rolling and planting the corn, initially we planted a pass in the Southern buffer strip area which consisted of hairy vetch alone. The roller worked fine. The front set of finger rollers or "residue managers" which "opens the plant material to the sides" worked fine, after that, the fluted coulter cut through any remaining vetch and cuts a slit in the soil. The double disk openers were much more effective in opening a seed slit for planting compared to the "shoe opener" that was used on the buffalo no-till planter in the past. This year's combination of plant residue handlers - fluted coulter - double disk opener -was the right combination for effective seed placement in an organic no-till scenario. The rear set of fingered residue managers that were designed to gather the vetch back over the planted seed row were not effective. The problem was that the viny hairy vetch would get wrapped around them and gathered to form a wrapped clump; after the clump accumulated it began to act as a drag and catch the hairy vetch and pull it along exposing the soil surface. We solved this problem by removing the rear fingered trash managers and then the clumping and dragging did not occur.
The Roller on the front of the tractor is wide enough to roll a 10 foot width of material down, this is the width of 4 rows of 30" Corn, because we only planted with the a 2 row planter, the roller coming back "against the grain of the cover crop which was previously rolled the other way on the pass before began to bind and jam up. This was due to the 2 directions of rolling over half of the pass, only the side which was previously rolled the other direction would jam and bind. The side that had been rolled only in one direction had no problem with binding and jamming. This also only occurred in the heavy biomass of rye and hairy vetch, but not in the other small grain cover crop combinations due to the fact that these other small grains (barley, wheat) were not as tall as the rye.

Evaluation: As the cover crops were being rolled an evaluation of the effectiveness of the rolling and planting operation was made. The roller/crimper that John built operated with excellent results of rolling and killing the cover crops. The rate of travel across the field was 3.5 MPH. The roller had been filled with water for additional weight. As stated earlier this roller/crimper effectively rolled small grain /hairy vetch legume cover crops grown together, which had small grain plants that were measured up to 4' 8" high, and hairy vetch of up to 5 feet in length. Collectively these crops yielded up to 4.3 Ton/Ac of dry biomass. With this height and biomass the roller/crimper effectively rolled down, crimped and prepared the cover crop "mat" adequately so the no-till planter could plant into the biomass. After initial adjustments and removal of the rear finger disk residue managers because of clumping, the resulting planted no-till seed bed was a success. The planted corn seed was dug after planting to check for placement and depth which was correct. This system can be rated highly for utilization in an organic no-till system.

The strips were planted with NC+ Variety 48F37 Organic Corn, (RM102 day) a shorter day corn was chosen to due to the later planting date constraint because of the timing of the flowering stage of the hairy vetch for effective kill. This timing delays the planting date of corn in an organic no-till corn system and is an important consideration to manage to obtain sufficient corn maturity for the reduced growing degree days due to the delayed planting date.

VE - vegetative emergence of corn 6/17/03 (6 days from planting), the corn was being eaten by something, round holes about 3/8 inch to 5/8 inch in diameter. We were not sure what was causing this. At first we thought it may be "voles" digging up and eating the seed, or perhaps birds. The corn was dug or pecked out of the ground and consumed. The amount of loss due to damage was sporadic. Later we observed the black birds eating the corn, by 6/18/03 there was 50% loss do to bird damage. Many remains of the V1 – (first leaf stage) leafs that were pecked off and left lying on top of the soil, at other locations we found the holes in the soil were the birds pecked down to get at what remained of the germ of the germinating seedling. Some seedlings had about 2 inch to 2 1/2 inch radicle root development. In some cases we could see the plumule pulled out of the ground and left sitting on top of the soil, in other cases it was eaten or pecked off with a hole in the ground with the remains of the germinated seed and seminal roots that had developed still intact in the hole. Yet in most cases the entire seedling was missing with only a hole left in the soil surface. By 6/19/03 there was an 85%-90% loss of the corn, eaten by black birds. This corn was the smallest corn at this time in the area, most available for the birds at this date. As a result there will be no yield data available for this trial.

Despite the loss due to the birds, the observation and experience gained from the trial was very beneficial. We know this system works. The rolled down matt of biomass which did all kill was monitored and weed control was maintained by the suppressive soil cover until June 25 (14 days) That was without any crop growing into it. At that time the weed pressure from in the slits of cover crops where the corn was planted began becoming more pronounced. Considering the corn was not growing in the field which would have begun to form its own canopy and competition, this early weed suppression of the rolled cover crop would have been critical during the early stages of crop growth for the corn.

Soybean Cover Crop Trial

A cover cropping trial utilizing strips of different cover crops was designed and set up to evaluate the effectiveness of the roller/crimper that John built for a No-till Organic Soybean system.

Soybean cover crop field strip design layout:

A 3.3 acre field, (Rodale Research Farm Field #7-8) was used to set up 8 adjacent long strips (20ft. wide x 900 ft long). These strips were laid out to evaluate the effectiveness of the roller/crimper in a no-till soybean system where the cover crops did not include hairy vetch. As with the corn cover crop trial the strips were flagged and sub dived into 3 treatments lengthwise for data collection and evaluation. Every strip was planted with small grains and one with buckwheat, the differentiation of the treatments from strip to strip was determined by the small grain cover crop that was planted. The strips were planted **{9/19/02}** These small grains used as cover crops were (winter cereal rye, winter wheat, winter barley, and spring oats) buckwheat was planted in the spring into the strip that had spring oats growing in the fall which winter killed. The small grains were planted at a seeding rate of 2.5 Bu/Ac. All cover crops were planted with a John Deere 450 Grain Drill, 17 rows, with 7.5" wide rows. Four of the strips were planted with winter cereal rye strips, one used as a moldboard plow and one as a chisel plow treatment to compare both a cultivated and minimum-till cultivation to the No-till treatments. One rye strip was also set up to be flail mowed as another comparison to the rolling. Two strips were planted with winter wheat, one to be rolled and one to be flail mowed as a comparison.

< West

road to orchard

< 1 pass of rye half way into the grass strip to act as a buffer >

	Rep 1 (<------- 300 foot ----->)	Rep 2 (<------- 300 foot ----->)	Rep 3 (<------- 300 foot ----->)	
20 ft.	Rye (Moldboard plowed 5/20) planted 6/6/03		emergence 6/11 -6/12	1
	Spring drilled Buckwheat after fall planted Oats (Moldboard Plowed 5/20)	Treatment 2 modified 6/5 to be Drilled Soybeans, with the John Deere 450 Grain Drill (2 passes)	drilled 6/6/03 emergence 6/11/-6/12	2
	Barley (roll down) Rolled & planted 6/3/03		emergence 6/9-6/10	3
	Rye (roll down) Rolled & planted 6/3/03		emergence 6/9-6/10	4
	Rye (flail mow) Planted & mowed 6/3/03 difficulty in mowing, led to clumping		emergence 6/9-6/10	5
	Wheat (flail mow) Planted & mowed 6/3/03		emergence 6/9-6/10	6
	Wheat (roll down) Rolled & planted 6/3/03		emergence 6/9-6/10	7
20 ft.	Rye (Chisel plowed 5/20) planted 6/6/03		emergence 6/11 -6/12	8

4/29/2003 – In Treatment strip #2 Buckwheat (Mancan variety) was planted at the rate of 35 lbs. /acre with the John Deere 450 Grain Drill, 7.5 inch row spacing. This was done to evaluate a spring planted cover for weed suppression.

5/20/2003 - An evaluation of the cover crop treatments was conducted. Treatment # 2 (Fall Oats, spring buckwheat) did not have adequate weed suppression. There was no residue present from the oats. There all ready was a heavy population of spring weeds (Brome grass, shepherds purse). It was decided that the buckwheat planted 4/29 about 1" high on 5/20 would not grow fast enough to compete with the spring weeds and also it was decided that this treatment most likely would not produce enough biomass to serve as a weed suppressing mat by the time the soybeans will be planted (next week beginning of June) So therefore it was decided to moldboard plow this treatment and drill beans into this strip as a drilled comparison.

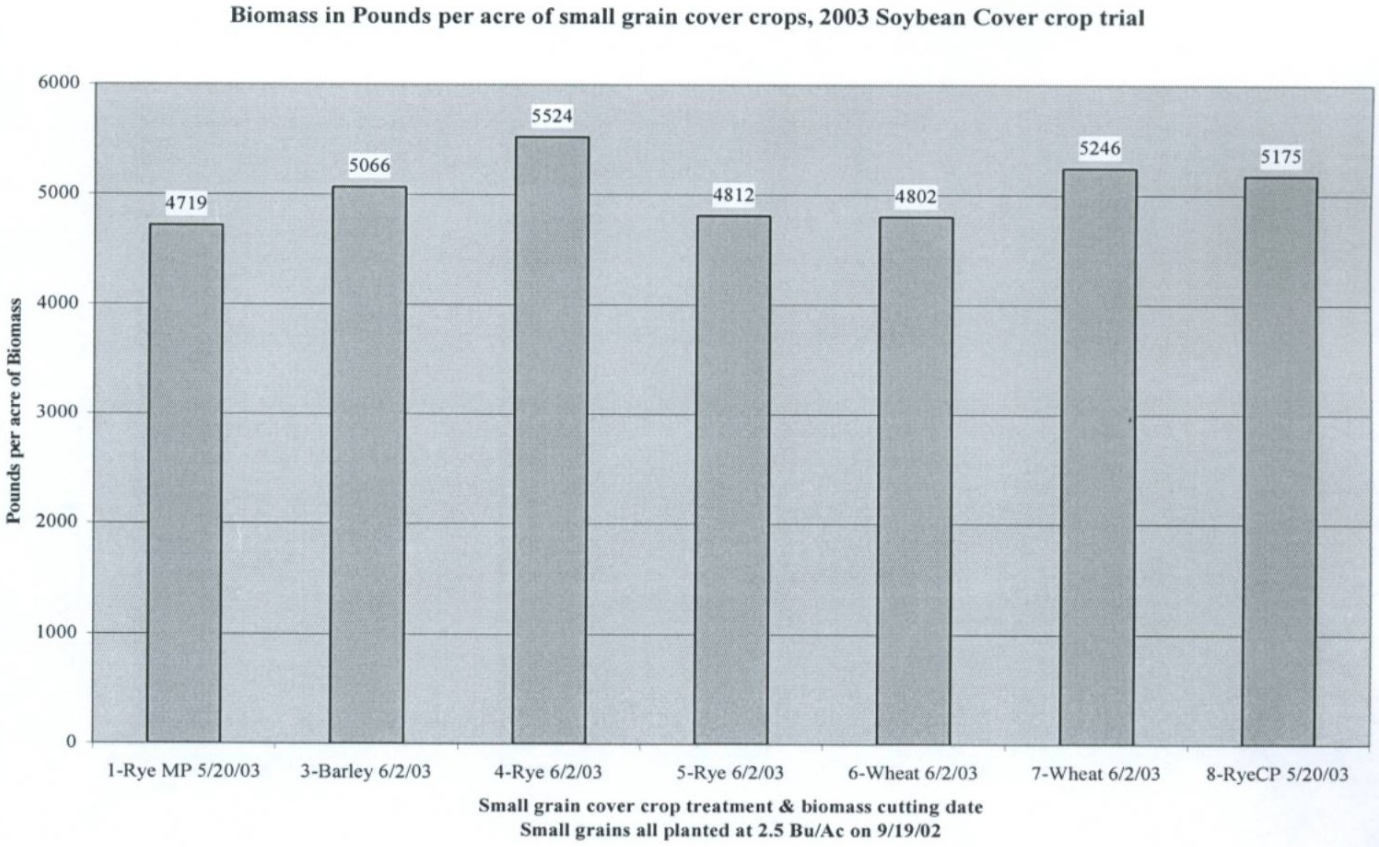
We think the buckwheat will have to be frost seeded (if possible) earlier or perhaps drilled in over winter to be able to get a quick jump on spring weeds. These possible options will have to be looked into. The Oats will have to be planted in the beginning of August to produce adequate biomass to have a remaining residue that makes it through the winter.

The rye and barley are both heading out. Biomass cuts were taken in the two treatments that were to be cultivated, Treatment 1 (Rye Moldboard plow) and Treatment 8 (Rye Chisel plow). Two sample biomass sample cuts were taken per each Rep. Six total samples per Treatment were taken. After the biomass sample cuts were taken Treatment 1 was moldboard plowed and Treatment 8 was Chisel plowed. Treatment 2 was also Moldboard plowed and beans were drilled in this strip as another comparison, the buckwheat was 1" tall when plowed.

Observations made during plowing Treatment 1 & 2. While moldboard plowing the rye, the soil after plowing was very clod-dy and dried out compared to treatment 2 that had no rye. The rye strip which was immediately adjacent to the fall oats/Buckwheat plot was visibly noticeably different in the amount of moisture and the tilth of the soil. The rye strip being clod-dy, the fall oats/buckwheat (which was more like a fallow field with spring weeds) moldboard plowed smoothly and had visibly more moisture and was less clumpy. Also while chisel plowing the rye (Treatment 8) the chisel plow got clogged up 3 times. This particular chisel plow is very aggressive and was obtained especially to handle heavy crop biomass amounts typical of organic farming. The rye clogged up the chisel plow; we had to stop 3 times while plowing. There was concern about being able to plant into the chisel plow rye without clogging up the planter. I recommended that treatment 8 be disked twice after chisel plowing to try to break up the clods and further chop up the rye biomass in the plow layer.

6/2/2003 - Biomass cuts were taken in the Treatments that were to be rolled and mowed (Treatments- 3, 4, 5, 6, & 7) {2 cuttings, East & West, per Rep.} Six cuttings per treatment. A plant population count was conducted, (Rye - 1.75 million plants/acre) (Barley - 1.45 million plants/acre)(Wheat - 1.7 million plants per acre). We surveyed the field for the soil moisture condition for planting soybeans tomorrow. The 2 row double disk opener Monosem planter was adjusted for planting, we will use a 60 hole planter plate for the planter to plant the Soybeans at the population rate of approx. 209,000 seeds/Acre.

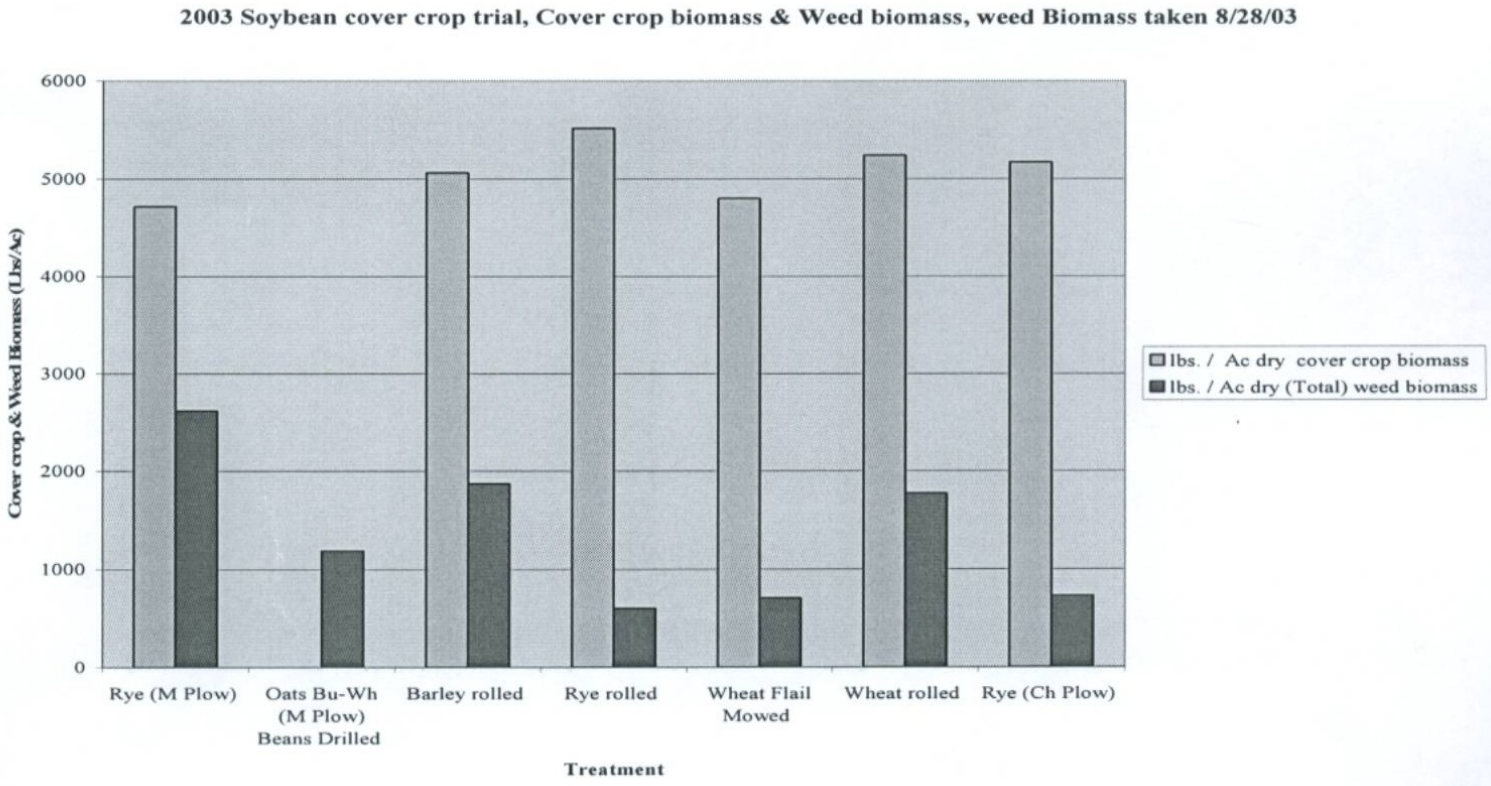
Attached Graphs of Biomass of Cover Crops:



Evaluation: **6/3/03** The small grain cover crops were rolled and planted into with the beans, an evaluation of the effectiveness of the rolling and planting soybean operation was made. The roller/crimper operated with excellent results of rolling and killing the small grains. The roller still had the added weight of the water that was added to the roller. We adjusted the finger rollers on the 2 Row Kinze no-till planting unit so that the finger rollers on the front were not in as deep and were just barely touching the ground, we adjusted the finger rollers in the back to a sharper angle to pull the rye cover crop in closer to cover the slit were the seeds were planted. Starting with Treatments 7 we rolled and planted the wheat, then Treatments 3 {barley} & 4 {Rye} were rolled and planted. The wheat & barley treatments had no problem; with the heavy longer biomass of the rye we began to experience some wrapping of the rye around the finger gatherers and around the double disk openers. Treatments 5 & 6 were planted first and then flail mowed, we were able to mow the wheat but the rye was too thick and wrapped around the mower too much, clogging and binding the mower, we were only able to mow one pass in this treatment and stopped because of wrapping.

HP204 Organic Soybeans were planted 1" deep, 1" apart for a projected population of 209,000 seeds/Ac. Three planter passes were made per Treatment (6 Rows) of Soybeans were planted with the 2 row planter, we had planned for 8 rows (4 passes), but with the 2 row planter we gained too much space between passes (not being able to judge were the tractor tire was exactly because of the rolled down cover crop) and therefore we ended up with 6 instead of 8 rows per 20 foot strip.

Weed Suppression evaluation: 8/28/03 Weed biomass samples were taken in the soybean strips and evaluated to compare the total weed biomass in lbs/ac between the varying treatments.



The moldboard plow treatments (1 & 2) entailed plowing, disking, cultipacking, planting, and then rotary hoeing, and two passes of cultivation (total 7 field operations). The Chisel plow treatment entailed Chisel plowing, disking twice, cultipacking, planting, rotary hoeing, and two passes of cultivation. (Total 8 field operations). The no-tilled rolled treatments (3, 4, and 7) with the small grains (Barley, Rye and Wheat) had more weed suppression than the conventional tillage moldboard plow treatment. Among these three rolled treatments, the rolled rye produced the least amount of weed biomass, then the wheat and finally barley. As the biomass of the cover crop increased, weed suppression increased with lower weed biomass amounts. These no-till treatments entailed Rolling/Crimping-planting, and 1 field cultivation after the weeds were breaking through the weed suppressive mat (total only 2 field operations) this saved both time and energy resulting in better weed control compared to the conventional moldboard treatment. Treatment #2 that was conventionally tilled then drilled (4 field operations) had a lower amount of weed biomass compared to both the rolled wheat and rolled barley, but not compared to the rolled rye. The Chisel plowed ground had a low weed biomass but this entailed 8 operations. Treatment 6, the flail mowed wheat, had a low amount of weed biomass, this entailed 3 operations (planting, mowing and 1 cultivation) but the mowing operation took more time being a slower operation.

Conclusion: The roller/crimper is an effective implement in managing a no-till organic soybean system. It effectively rolled and crimped the small grain cover crops and prepared a mat of plant material for a weed suppressive soil cover. It effectively reduced the number of field operations to obtain weed biomass amounts that were lower compared to the moldboard plowed conventionally tilled operation. Soybean yield data will be taken and compared for all the treatments.