FNE02-442: Using a Winter Cover Crop of Rye and Hairy Vetch for Soil Conservation and Weed Control in a Mixed Vegetable System
Final Report April, 2004

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Project Summary and Goals:

The intent of this project was to evaluate the effectiveness of a rolled-down fall cover crop of rye and hairy vetch as a mulch for vegetable crops planted the following summer. Winter squash, melons, and tomatoes were planted into the killed, unincorporated cover crop. These were compared with the same vegetable crops grown in plots of mowed, incorporated rye. Test plots were compared in the following aspects: yield for each crop, percent salable yield, water use, and the effectiveness of weed control. Some assessments of end of season soil quality were also made.

In the 2003 tomato crop, yields were roughly equal between the cover-crop mulch plot and the tilled plot, but the crop quality was reduced in the mulch plot by slug damage. Weed control took significantly more labor hours in the mulch plot than in the tilled field due to our inability to use hoes or cultivation in the mulch. Water use was reduced in the mulched tomato plot, and the end of season soil quality was significantly better. Tractor time for spring soil preparation was significantly less in the experimental mulch plot.

The 2003 squash and melon plots gave similar results. The cover-crop mulch plot yielded less squash overall, and a lower percentage of high quality fruit, perhaps due to the cooler conditions of the covered soil, or crop establishment difficulties. Weed control took more labor hours in the mulched plot, and water use was roughly equal between the mulched and tilled patches. Tractor time for spring soil preparation was also significantly less in this experimental mulch plot.

The ultimate goal of this project was to determine whether planting summer vegetables into killed winter cover crops is a practical and efficient way to control weeds and conserve soil structure in a chemical-free system. Our conclusion is that this production system has significant potential, based on reduced tractor traffic in the spring, potential for reduction of water use, and noted improvements in soil quality. However, weed and slug control issues will need to be addressed before this system is widely applicable.

Farm Background:

Fulton Farm is a working produce farm and an educational program of Wilson College. The farm raises mixed vegetables, small fruits, flowers, and herbs on seven acres in Franklin County, PA. All produce is raised without chemical pesticides or fertilizers, and the farm strives for resource and energy sustainability in all practices. Produce is marketed to the college dining hall, a 130 family CSA program, and a local farmer's market.

Each year, we use approximately five acres for production, with an additional two acres in summer fallow/ cover crops. The farm has access to water for both drip and overhead irrigation. We raise our own transplants from seed in two passive solar greenhouses, approximately 4800 square feet total. Other special projects of Fulton Farm include biodiesel fuel production, strawbale construction, and solar and wind energy demonstrations.

Our farm has a high level of visitor traffic, making it an ideal site for educational outreach. Each week during the growing season, we are visited by 130 CSA families, college students, and passers-by from the community. We also host farmer field days, an intern training group day, and a community picnic annually. College classes in sustainable agriculture and environmental studies regularly visit the farm as well.

Cooperators:

The technical advisor for the project was Steve Bogash, Penn State (Franklin County) Extension agent for vegetable crops. Steve helped to draw up and plan the original proposal and provided general advisory support. As it turned out, Steve was very helpful in deciding to mow off surviving rye in the experimental patches at a critical point before planting. He later visited the farm during our 9/30 PASA field day to assess the results of the project.

We also consulted with other members of the regional farming community for advice. Mr. R. Glen Jamison is a vegetable grower in our county who practices the planting of pumpkins into a roll-killed rye/vetch mix. We borrowed the field roller used to kill the rye-vetch cover from Mr. Jamison, and consulted with him on the timing of that operation. Matthew Ryan and Jeff Moyer of the Rodale Institute provided advice on cover crop seeding rates and general methodology.

Project Activities:
2002:

Test plots were seeded to the winter cover crops in the fall of 2002. Two distinct fields were chosen.

Field "1" is an area of historically high weed pressure (pigweed-amaranth, lambsquarters, grasses). The total area of field 1 is .5 acres. Composted manure was spread evenly over the entire field. The field was then bisected into two quarter-acre sections, A and B. Section A was chosen to be the test plot for the hairy vetch/ rye mix, section B to be the control planting of rye only.

Section 1A was chisel plowed prior to broadcasting the cover seed, in order to loosen any hardpan. On 9/17/02, the section was broadcast with rye and vetch, at a rate of 2.5 bushels rye, 40 lbs. vetch per acre. The seed was then incorporated with a harrow.

Section 1B was broadcast seeded with 2.5 bu. rye per acre on 9/25/02, and incorporated with a harrow

Field "2" is an area of historically low annual weed pressure (it was in sod up until the spring of 2001). The total area of the field is .32 acres. Composted manure and amendments were spread evenly over the entire field. The field was then bisected into two sections, A and B. Section A was chosen to be the test plot of hairy vetch/rye, and section B to be the control planting of rye only.

Section 2A was chisel plowed prior to seeding. The section was broadcast with 2.5 bushels rye, 40 lbs vetch per acre on 9/17/02. Seed was incorporated with a harrow.

Section 2B was broadcast seeded with 2.5 bu. rye per acre on 9/17/02. Seed was incorporated by disking

Cover crops in all plots established well in the fall of 2002, and grew to a height of approximately 9-12 inches before winter freeze-up put them into dormancy.

2003 project activities:

The bulk of the work on this project took place during the 2003 growing season. For a convenient tabular view of the progress over the 2004 season see the attached Excel chart titled "Summary of Activity: Roll-down cover crop experiment". These activities are described in more detail below.

Field Preparations: April- June, 2003.

Experimental Plots: Roll killing rye and vetch. Both experimental rye-vetch plots were allowed to grow till flowering, and were then rolled down on June 2nd. The rye in each patch was in the "milk" stage, having formed seeds that were still soft and wet in their seedheads. The vetch was approximately 30% in flower at the time of rolling. It may have been possible to wait a bit longer for rolling, but weather conditions were right, the roller was available, and our technical advisors suggested that rolling would be appropriate. As it turns out, the rolling effectively killed 95% or better of both cover crops.

There was a small amount of rye that sent up new shoots from its roots. These shoots reached about 15 inches in height before flowering. Extension agent Steve Bogash recommended mowing off the rye shoots with a brush hog to prevent it from becoming a weed. This was done in field 1A (squash planting), but not in field 2A, which had already been planted to tomatoes. However, the rye left standing in field 2A did not present a significant weed problem. There was no significant resurgence of the vetch in either plot.

The roller used to kill the cover crops was borrowed from a neighbor (R. Glen Jamison). The equipment consisted of several small cylinders of approximately 9 inches in length and diameter, mounted on a single axle. Each cylinder rotated independently from the others, and was equipped with 4 inch fins (teeth) mounted parallel to the axle. The effect of this roller was to knock down and crimp the rye/vetch cover in several places along each stem. This was accomplished in one pass, and with a minimum of bunching or bare spots created in the field. The heavy steel roller was approximately six feet wide and easily pulled with our 45 horsepower tractor.

In 2002 we trailed rolling down cover crops using a weighted flat roller. While effective, the flat roller required several passes before we were convinced that the cover crops were killed. This may have contributed to soil compaction underneath the cover crops (the ground was very hard at the time of pumpkin/ squash transplanting). The custom-made toothed roller used in 2003 was far more effective than our flat roller, and convincingly crimped the rye-vetch in one quick pass. Our original proposal listed flail mowing as the planned method of killing the rye/vetch mix. However, experience in 2002 lead us to believe that flail mowing might cause the killed mulch to break down too rapidly, allowing annual weeds to become an early problem.

Control Plots: Conventional tillage of rye to bare soil. Both of the control patches (rye only) were tilled to bare soil before planting the cash crops of squash and tomatoes. The field prep for each patch followed the order listed below, which was more or less the standard tillage routine for our farm at the time:

1. Mowing of Rye
2. 2nd mowing, about 3 weeks later
3. Chisel plow shallow 2 times to break up sod
4. Disk 2 times to incorporate
5. Disk 2 times about 2 weeks later
6. Chisel plow deep to set beds
7. Transplant into chisel tracks

Timing of field tillage was made challenging by the unusually wet weather of the spring of 2003. Frequent soaking rains followed by brief dry spells did not allow the fields to dry out completely before the next tillage operations were due. In order to have the fields ready in time to plant alongside the experimental plots, we had to "push it" more than normal, and some compaction was appearent in the form of ribboning and chunking of soil.

All plots were identified with laminated signs briefly explaining the project and the individual field treatments to visitors and field day participants.

Planting:

Seeding of squash and tomato transplants was completed in May. Seeding for experimental and control fields was performed on the same day to ensure even plant maturity. Transplants were set out in each plot on the same day where possible, or within a few days of each other where challenges arose.

Method of planting:

In the control plots, seedlings were planted into the furrows left by the chisel plow during the last tillage pass. A hand trowel was used to aid in planting. Drip tapes were laid out on top of the row and connected to water in the plants where necessary.

In the experimental plots, the drip tapes were laid out first to mark straight rows in the rolled down cover crop. Tapes were stretched tight between stakes placed at measured distances along each field edge. Seedlings were laid out along the tape, then inserted into holes made in the soil using a hand-held bulb planter. The seedlings were watered in with the drip tape as necessary.

(Making holes with the hand-held bulb planters proved to be quite cumbersome on the scale of this project. We damaged a few planters over time, tired out several wrists, and the process was more time consuming than trowel planting into the bare soil patches. A stand-up foot-powered bulb planter or shovel would probably be better. Our neighbor Glen Jamison plants his pumpkins through rolled down rye/vetch with a waterwheel transplanter. He reports needing to add a lot of weight to the front end of the planter to make decent holes in the mulch).

**A few complications during planting may have resulted in compromised data for the project. These are listed below.

- Exact similarity of varieties and number of plants between fields proved difficult to achieve with a large planting crew and multiple varieties planted.
- In the squash plantings, the experimental plot was planted 3 days after the control plot (6/21 vs. 6/18 respectively). This was due to the question over whether or not to mow off resurging rye with a brush hog before planting, which took a few days of consultation to resolve amid the other work of spring. In the interim between planting the control patch and the roll-down patch, there was a gentle rainstorm that may have helped in the establishment of the squash in the control. Experimental squash also received some rain (and irrigation), but it was noted that they took longer to establish. On 7/3, the control squash were off and running, while those in the roll-down patch were fair to struggling. However, it seems that the experimental squash were also challenged in establishment by the hard nature of the ground beneath the cover crop mulch as compared to the tilled soil in the control.

Irrigation:

Crops in all plots were watered on an as needed basis, and as water was available in rotation with other irrigation needs on the farm. The squash patches (1A and 1B) and the tomato patches (2A and 2B) were on separate water systems, so they were not in direct competition for water during the irrigation season.

All water use for the project was recorded in a data book. Water use for each plot was measured by noting the number of drip tapes run and length of time for each irrigation session. By multiplying these numbers by the length of each tape, and using a factor of 30 gallons per hour per 100 feet of tape (manufacturer's specifications), we were able to calculate the approximate total gallons used per plot.

Weeding and weed counts:

The effectiveness of the rolled down cover crops as a weed controlling mulch was evaluated in two ways. The first was by recording all person hours spent weeding in each field, as well as tractor hours spent cultivating. Each field was weeded as deemed necessary for crop health and to prevent weeds from maturing to seed. For every weeding session, the number of people, length of session, and species of dominant weeds were recorded.

The second means of evaluating weed control was by establishing study squares that were not weeded in each plot. The weeds in each study square were allowed to grow, and were counted early and late in the season by a diligent student from our program. Squares measured 48 inches on a side and were distributed randomly throughout the experimental and control patches, three to five in each plot. The number of weeds of each species was recorded per square and later tabulated to give data for each field.

Our original proposal contained plans to measure fresh weights of weeds in each square at the end of the season, but we failed to do this due to seasonal harvest pressures and our feeling that the data would have been inaccurate (the student responsible for the squares was unable to harvest and weigh all weeds within a close enough period of time).

Harvest Data:

All squash and melons harvested from fields 1A and 1B were counted at the time of harvest, and their weights were extrapolated by weighing counted representative samples of each harvest. Squash from both patches were all harvested and counted on the same day (9/22). Any unharvestable squash were left in the field and recorded as "number 3's" in the data book. All harvested squash were sorted into "number 1's" (high quality, salable) and "number 2's" (marginal quality, less salable). Melons were harvested and counted throughout September.

Tomatoes in both plots 2A and 2B were harvested twice a week throughout the season, and data were recorded over the period from 8/23 to 9/23. Tomatoes were divided into number 1's, 2's and 3's as above. Number 3's were left in the field and noted only anecdotally. Number 1's and 2's were harvested together, then sorted and weighed at the field edge or packing house. Sorting and weighing the volume of tomatoes produced on our 1/3rd acre plot proved to be more time consuming than was expected and was terminated after 9/23 after significant data were gathered. Cherry tomato harvest was measured in number of quarts picked in each field.

Field "harvest data stations" planned in the original proposal were not constructed, as sorting and weighing of produce in our existing packing shed proved more convenient.

Field assessment:

The health of crops and characteristics of the soil in each patch was consistently reviewed by farm staff throughout the project. Some anecdotal data are reported in the results section below.

Soil quality was compared between the tomato patches 2A and 2B at the end of the project, before planting the field to fall cover crops. Parameters assessed include porosity, soil structure, compaction (fork test), depth of A horizon, rooting depth, root development, and average worm counts per spade split. These measurements were not planned in the initial proposal, but were conveniently done by an Agroecology class using the farm for field studies. The data proved quite interesting and are discussed below in the results section. Unfortunately weather and time did not allow for comparative assessment of Fields 1A and 1B before they were tilled to plant the fall cover crop.

RESULTS:

Results for the project were measured in both recorded data and casual observations listed below.

Soil conservation benefits of planting into roll-down cover crops:

One of the first differences between the roll-down and bare tilled plots that became clear was that there was significantly less spring field work involved in preparing the roll-down plots. The bare tilled fields required seven or more tractor passes with various tillage tools to get the fields ready for planting, as compared to only one pass to roll-kill the rye/vetch experimental plots.

This was especially relevant when it came to timing field operations with the weather. The spring of 2003 was exceedingly wet in Pennsylvania, with several heavy rains per week, and little opportunity for the soil to dry out between rains. Consequently, we found ourselves "pushing it" in the control plots, often chiseling or disking when fields were more moist than we would have liked in order to have the ground ready for planting time. In fact, planting of all fields was delayed due to the stalled field operations from wet conditions. Compaction was evident throughout spring tillage, particularly in Field 2B (bare tilled-tomatoes) which is a heavier clay soil.

Thus, while we were struggling to find a dry day to prepare ground in the control plots, and constantly were worried about compaction, the experimental plots were left to grow their rye/vetch cover crops unmolested. When it came time to roll down the experimental plots, the mature cover crops helped to dry out the soil, and provided a spongy surface on which to drive, reducing compaction concerns.

Some compaction was noted at the end of the season when comparing the soil in fields 2A and 2B (**Table 1**).

Table 1: Rough soil assessments, Field 2 (Tomatoes).

Parameter:	**Rolled down rye/vetch 2A**	**Bare-tilled rye 2B**
Porosity* (average)	259 cm-seconds	1140 cm-seconds
Structure (good-fair-poor)	Good	fair-good, clumpy in spots
Compaction (fork test)	easy- fairly compacted	more compacted
Depth of A horizon (avg.)	39 cm	24 cm
Rooting depth (avg.)	21 cm	17.5 cm
Root development (tomatoes)	Good	good-moderate
Worms/ spade split** (avg.)	4.0	.4
Other observations	surface worms and moss	some moss

The parameters used to assess the soil in fields 2A and 2B were adapted from Gershuny and Smillie's book *The Soul of Soil*, 1999.
* Porosity was measured by rapidly pouring one quart of water onto the soil surface, then counting the time it took for all surface water to penetrate the soil. Once the water had entered the soil, the wet spot was measured in diameter. The time and diameter dimensions were multiplied to give a rough assessment of porosity (higher numbers indicate surface compaction).

** Earthworm populations were assessed by taking a "spade-split" (a 2-3 inch thick section of soil to the depth of a round-point shovel). Worms in each spade split were counted, then a mean for each field was derived. Gershuny and Smillie report that each worm in a spade split indicates 100,000 worms per acre.

General plant performance:

With the exception of melons, all crops in the control plots established and greened up faster than in the roll-down plots. We presume that our planting method for the experimental patches could be improved upon. Planting with a hand-held bulb planter was tiring for the crew, and also seemed to effect crop establishment. We made sincere efforts to close up the planting hole around the root ball of transplants, but the rigid hole left by the bulb planters made good root-soil contact somewhat challenging. The ground in the bare tilled plots, though compacted, was easier to close around the rootballs of transplants. Delayed establishment was particularly noted in field 1A, where the squash were still struggling 12 days after planting. Though we had frequent rains during planting time, the weather at the end of June was fairly hot, and this combined with poor root-soil contact appeared to hurt the experimental squash and later impact yields. A few weeks after planting, we walked the squash fields to replace any dead or weak plants. While in the control plot, we only replaced 17 squash plants, in the roll-down patch we had to replace more than 40.

Once established, the cash crops in all fields performed quite well. It was exciting to see the squash and tomatoes growing in the experimental fields without spring tillage. One intern remarked that at harvest time, the tomato plants in field 2A were generally healthier than the control, and bearing more fruit.

Harvest data:

Squash/ melons:

Cucurbit harvest in both plots was moderate by our standards, perhaps impacted by delayed planting due to wet spring conditions. In all measurements for squash (overall yield, percent marketable yield, and number of rotten fruit) the control patch fared more favorably (**see table 2**). Only melons yielded better in the experimental plot.

These results were contrary to our expectations. We had predicted that the mulch in the roll-down plot would protect fruits from rotting against the soil, and would promote plant health through more even soil moisture. The reduced yields in 1A may have been due to any of the following:

- Crop establishment difficulties in the untilled soil (see above).
- Cooling of soil in a generally cloudy and wet summer reducing plant vigor.
- Fruit rotting in wet mulch (double the number of unharvestable fruit in 1A vs. 1B).

The melon crop was significantly better in the experimental patch. We presume that this was due to more even soil moisture in the rolled down mulch. The control melons also suffered heavily during a time of rapid annual weed growth, which was less of a problem in the experimental patch. The melons in the control were weak by our standards, while the experimental melons yielded adequately and were generally healthier.

Table 2: Squash/ melon harvest data. Winter squash and pumpkins from fields 1A and 1B were harvested on the same day. Fruit from each field were sorted into #1's and #2's and by size. All fruit were counted, then the count from each field and quality group was multiplied by an average weight. The average weight figure was derived by weighing a representative sample of squash from each size grouping. Any rotten or unharvestable squash were considered to be #3's and were counted where they lay in the field.

Melons were harvested as they ripened, whereupon they were counted.

Field / treatment:	1A / Roll-down rye/vetch	1B / Bare-tilled rye
Squash/ pumpkins: 1st quality:	1178 lbs.	1806 lbs.
2nd quality:	367 lbs.	101 lbs.
Total yield:	1545 lbs.	1907 lbs. 23% more overall yield in 1B
% marketable yield:	76%	94%
3rd quality, rotten in field:	144 each	73 each
Melons: Total yield:	149 each	46 each
Comments:	Melons generally of better quality in 1A, larger & healthier.	Melons suffered during time of heavy annual weed pressure.

Tomatoes:

The tomato harvest in both plots was quite respectable by our standards, despite delayed planting due to wet spring conditions. Over the period of recorded harvest data, the overall harvestable yield was virtually equal between the bare-tilled patch (1544 lbs.) and the roll-down (1551 lbs.)(**see table 3**).

Slugs were a significant problem in both fields due to the unusually wet season. It was common to find tomato fruits with slugs rasping holes in the skin. These and other damaged fruit were downgraded to number 2's, or number 3's (unharvestable) as the slug holes became sites for rotting. The slugs were a much bigger problem in the roll-down patch (2A), presumably because the rye/vetch much provided a more favorable habitat. Thus, the marketable yield of tomatoes in the roll down (67%) was significantly reduced compared to the control (79%). This was contrary to our expectations, as we presumed that the mulch would reduce soil splash and subsequent blight and spoilage. We dusted plants in both fields with diatomaceous earth in an attempt to control slugs, but the effectiveness of this treatment was questionable.

Marketable yield may also have been adversely impacted by the wet conditions underneath tomato plants in the roll-down patch, where it seemed that fruit sitting in the moist mulch were more prone to rotting. Plants in both plots were trellised equally.

It did seem that the tomatoes in the rolled down rye/vetch were a bit more productive. Thus, perhaps marketable yields would be higher in a drier year with fewer slugs and less rotting.

Table 3: Tomato harvest data. Tomatoes from fields 2A and 2B were harvested twice weekly. Fruit were then sorted and weighed at the CSA packing shed. Any significantly damaged or rotting fruit were left in the field and noted casually as #3's. Only harvests from the period of 8/23/03 to 9/23/03 were recorded.

Cherry tomatoes were recorded as pints harvested. However, the figures for cherry tomatoes should be considered inconclusive, because they were not harvested with appropriate regularity.

Field / treatment:	2A / Roll-down rye/vetch	2B / Bare-tilled rye
Standard tomatoes: 1st quality:	1039 lbs.	1223 lbs.
2nd quality:	512 lbs.	321 lbs.
Total yield:	1551 lbs.	1544 lbs.
Percent marketable yield:	67 %	79%
Comments:	Very productive, but heavy losses to slugs and rot, significant #3's	Less slug damage and rot
Cherry tomatoes: recorded harvest:	(54 pints)	(50 pints)

Water use:

We had expected that the rolled down cover crop mulch would conserve soil moisture and thus reduce water use. This was in fact apparent in the tomato fields, where the bare control field required about 53% more water for optimum plant health.

The mulched squash/ melon field used about 5% more water than the control. We attribute this to our efforts to nurse along the transplants struggling to establish in the cover crops (**table 4**).

Table 4: Irrigation Summary: Water use was recorded over the entire irrigation season. To estimate the number of gallons applied to each field, the number of drip tapes run and the duration of irrigation were recorded for each watering session. These were then multiplied by the length of each field and a factor of 30 gallons per hour per hundred feet of drip tape (manufacturer's specification).

Field Number:	1A: Squash	1B: Squash	2A: Tomatoes	2B: Tomatoes
Treatment:	Roll-down rye/vetch	Bare tilled rye	Roll-down rye/vetch	Bare tilled rye
Total water use (approximate):	11760 gallons	11235 gallons	10263 gallons	15774 gallons

Weed control:

This is another area where the project disproved our initial expectations. We were attracted to the idea of a rolled-down cover crop mulch as way to control weeds without having to expend labor applying mulch to the field. Additionally, being able to grow the mulch in place seemed advantageous to importing it from other fields. We predicted that the dead rye/vetch cover would smother weeds until our cash crops could canopy and shade out the area, thus reducing labor spent on weed control.

Unfortunately, the cover crop mulch did not satisfactorily control weeds in either field, and weeding labor was necessary. Indeed, time spent weeding was significantly more in both experimental patches (**see table 5**). We attribute this to the fact that we could not hoe or cultivate amongst the mulch, so all weeding in the roll down patches was done by hand-pulling, which was quite time consuming. Conversely, we were able to tractor cultivate both control patches one time, and the rest of the weeds were cleaned up with oscillating hoes and hand-pulling.

Table 5: Weeding Log: Weeds were controlled by pulling, hoeing, and cultivating as deemed necessary according to our standards for crop health and preventing spread of weed populations. All weeding done in project areas was recorded in terms of the number of people weeding and the length of each weeding session, which were multiplied to derive a figure for person hours. Tractor hours were also recorded when cultivation was used to control weeds.

Field Number:	1A: Squash	1B: Squash	2A: Tomatoes	2B: Tomatoes
Treatment:	Roll-down rye/vetch	Bare tilled rye	Roll-down rye/vetch	Bare tilled rye
Person hours:	52.4	25.3	16.5	4.6
Tractor hours:	0	1	0	1
Predominant weeds:	Canada thistle, bindweed, chickweed	Pigweed, lambsquarter, grass	Bindweed, Canada thistle	Bindweed
Weeding methods:	Hand pulling	Hoeing, hand pulling, cultivation	Hand pulling	Hoeing, hand pulling, cultivation
Observations:	Late season annual weed control was better in roll-down patch		Late season perennial weed control was worse in roll-down patch	

While the experiment did not meet our expectations in terms of reducing labor, it would be fair to say that the mulch was effective at reducing some annual weed pressure. Particularly in the squash fields (1A and 1B) which had a historically high level of annual weeds, the pressure from pigweed and lambsquarter was significantly worse in the control patch. While some annuals did poke through the mulch and become a problem, they were nothing compared to the massive flush of annual weeds in the neighboring bare soil. As the squash crop matured (when we typically back off of weeding), the mulch provided decent late season weed control, while the control had some escaped annuals that set seed.

The roll-down mulch was less effective at preventing perennial weeds from becoming a problem. It seems that the repeated spring tillage in the control patches sufficiently disturbed perennials such as Canada thistle and bindweed. The undisturbed habitat of the mulch patches allowed these weeds to thrive and become quite problematic.

The comparison between fields of high annual weed pressure (1A and 1B) vs. those with few annual weeds (but apparently some perennials) (2A and 2B) is illustrated by the data from weed counts **(table 6).** Weeds were not controlled in small, randomly selected patches in each plot, and were later counted. Field 1B (bare) had an average of almost two times as many weeds surfacing compared to the experimental field 1A. Average weed height and number was reduced in the mulch plot throughout the season. However, in field 2A (mulch), the number and height of perennial weeds remained higher than the control throughout the season. Thus, it appears that the rolled down cover crops were effective at reducing annual weed pressure, but not particularly effective with perennials like bindweed and Canada thistle.

Table 6: Weed counts. Three to five weed monitoring squares were established in each field with 48 inch strips of wooden lath. The weeds in these squares were not pulled, hoed, or cultivated regardless of their impact on crop health or the future weed seed bank. A student counted and measured the weeds in each square on two separate occasions, early and late in the crop season.

Monitoring date	Field Number: Treatment:	1A: Squash Roll-down rye/vetch	1B: Squash Bare tilled rye	2A: Tomatoes Roll-down rye/vetch	2B: Tomatoes Bare tilled rye
7/26- 7/30, 2003	Average # of weeds per square:	24.6	42.3	28	23.5
	Average height of weeds in squares:	13.2 inches	16 inches	9 inches	8 inches
	Predominant weeds:	Pigweed	Pigweed, lambsquarter	Canada thistle	Bindweed
9/1- 9/10, 2003	Average # of weeds per square:	32	60.3	45.6	35
	Average height of weeds in squares:	26.4 inches	40 inches	16.8 inches	15 inches
	Predominant weeds:	Pigweed	Pigweed, grass	Canada thistle	Bindweed

CONDITIONS:

The 2003 growing season was exceptionally wet in our area, making up for several years of drought. It was difficult to time spring tillage of the control patches for this project, resulting in both delayed planting and some soil compaction. Once cash crops were planted, continued rains delayed tomato production, and promoted slug and fungal problems in all plots, but particularly in the experimental plots. We suspect that the results for yield, crop quality, and weed control would be different in a comparatively drier year.

ECONOMIC FINDINGS: N/A.

ASSESSMENT: Despite the fact that the experimental plots did not live up to our expectations in weed control and promotion of crop quality, we feel that the roll-down cover crop production system still has plenty of potential. Particular results of the project that we found to be noteworthy include:

- ***It is possible*** to raise a decent crop of tomatoes and squash without spring tillage.
- Tractor traffic for spring field preparation is significantly reduced in the roll-down cover crop system. This has the potential to simplify spring field management and reduce compaction and timing concerns, particularly in a wet year.
- The roll-down cover crop system demonstrated a potential for improved end of season soil health as compared to conventional tillage (tomatoes).
- The roll-down system also demonstrated some potential for reducing annual weed pressure.

Factors that still need to be addressed include the potential for slug damage to cash crops in a wet year, planting challenges, and the inability to use hoes or tractor cultivation for weeding in the roll-down cover crop mulch.

Knowing the risk of slug damage, a grower could take preemptive measures in the proceeding season, including pasturing chickens in the field to reduce slug populations.

As suggested earlier, planting might be improved by using a foot-powered bulb planter, tree spade, or shovel. Larger scale production systems would warrant experimentation with water-wheel or other mechanical transplanters.

Effective weed control in an organic roll-down system could prove the most challenging limitation to overcome. Often times during the 2003 season, we joked that the project would have worked much better if we were a farm that used herbicides. Perhaps one of the new organically approved herbicides such as vinegar or the Bioganic (Eco-smart) products would prove effective in combination with the cover crops for keeping weeds down. Matt Ryan at the Rodale institute reports that they are experimenting with concentrated vinegar sprays for weed control in their roll-down test plots. He explained that total weed control is not necessary, but that knocking weeds back until the cash crops establish a canopy will significantly improve performance. Of course, prior season measures to reduce the weed seed bank, including bare fallow with cultivation, would also be recommended. Perhaps an effective variation on the project *would* be to flail-mow the cover crops instead of roll-killing. This might allow for some tractor cultivation of weeds later in the season as the mulch begins to break down.

ADOPTION: At this point, we have not yet embraced the roll-down cover crop system as a practical method for our farm, mostly because of the weed control challenges. We are not planning significant acreage of roll-down cover crops for vegetable planting in the 2004 season. However, we have not given up on the idea and will continue to trial it in smaller plots throughout the coming years.

OUTREACH:
Project Publicity/ Outreach Notebook:

Date	Activity
(2003)	
8/X	Field signs created to describe project/ identify plots for tours and passers by
8/X	Community tour: "Organic Farming Double-header" with visiting professor Tim Bromilow, open to farmers and community, approximately 15 attendees
9/1-9/6	Wilson College student tours, including Agroecology class field trip highlighting SARE project
9/13	Fulton Farm CSA community picnic with farm tour, approx. 50 attendees
9/30	Farmer's field day: PASA sponsored field day with Elizabeth Henderson, tour of farm highlighting SARE project, approx. 45 attendees
(2004)	
2/6-2/7	Pennsylvania Association for Sustainable Agriculture Conference, 1400 attendees: • Displayed poster describing SARE project in prominent location • Mr. Steiman described SARE project with slides during workshop on sustainable agriculture curriculum at Wilson College.
4/30	(Pending)- Article "Organic No-till Vegetables" submitted to *Growing for Market.*

References:

Gershuny, G., and J. Smillie. *The Soul of Soil*. White River Junction, VT: Chelsea Green Publishing Company, 1999.

Any questions or requests for more information should be referred to Matt Steiman, at the contact address listed on page 1.

Matt Steiman
April, 2004.