ORGANIC FARMING RESEARCH FOUNDATION

P.O. Box 440
Santa Cruz, CA 95061

tel ~(831) 426-6606
fax ~ (831) 426-6670

email ~ research@ofrf.org
web ~ www.ofrf.org

Organic farming research project report submitted to the Organic Farming Research Foundation:

Project Title:

New cover crops and cover crop management for organic vegetable producers in Maryland (yr. 1)

FINAL PROJECT REPORT

Investigators:

Caragh B. Fitzgerald, Co-Principal Investigator
Extension Educator
Agriculture and Natural Resources
Maryland Cooperative Extension
Howard County Office
3525-L Ellicott Mills Dr.
Ellicott City, MD 21043
410-313-2710
cf80@umail.umd.edu

Bryan R. Butler, Sr., Co-Principal Investigator
Extension Educator
Agriculture and Natural Resources
Maryland Cooperative Extension
Carroll County Office
700 Agriculture Center
Westminster, MD 21157.
410-386-2760
bb113@umail.umd.edu

Mark G. Davis, Collaborator
Agronomist, USDA-ARS
BARC-West, Building 001
Sustainable Agriculture Systems Lab, Room 110
Beltsville, MD 20705
301-504-9068
davism@ba.ars.usda.gov

C. Benjamin Coffman, Collaborator
Research Agronomist, USDA-ARS
BARC-West, Building 001
Sustainable Agriculture Systems Lab, Room 326
Beltsville, MD 20705
301-504-5398
coffmanc@ba.ars.usda.gov

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Farmers in the mid-Atlantic are becoming more interested in organic fruit and vegetable production as intense development pressure leads them to consider alternatives to low-value cash grain production. At the same time, non-farmers are purchasing land to pursue a dream of farming. Both groups see organic farming as an attractive production system, able to co-exist peacefully with nearby non-farm neighbors while also taking advantage of the purchasing power of the nearly 8 million people in Maryland, Washington, D.C., and northern Virginia. The recent 12 – 20% annual growth in the number of farms involved in Maryland's organic certification program also attests to the potential of this market and the growing popularity of organic products.

As the market for organic produce increases in Maryland, farmers are exploring methods to improve and expand their operations. As cash crop production expands, growers are particularly interested in maintaining their soil resources by increasing the number and types of cover crops they use on their farms. However, most of the cover crop research in the mid-Atlantic has focussed on the corn-soybean-small grain cropping system or the use of cereal rye and/or hairy vetch for horticulture crops. While rye/vetch meets a production need, these cover crops are not adequate to address the various times and situations when intensive vegetable farms would benefit from cover crops. Organic farmers are curious about other cover crops that may provide weed control and an increase in soil quality, but much is unknown about their growth habit, vigor, and utility in Maryland.

The use of cover crops in Maryland has become an even more important issue since the introduction of the Maryland Water Quality Improvement Act of 1998. This law, which begins full implementation in January of 2002, will restrict the amounts of nutrients used on all crops grown in Maryland. The law will have an especially profound effect on organic vegetable producers, who have often used compost as a primary nutrient source. Using compost to supply an adequate amount of nitrogen for crop production typically has resulted in the application of more phosphorus than is needed. Thus, many organic vegetable farms now have very high levels of soil phosphorus. In coming years, these organic farmers may no longer be able to use compost to meet their crop nitrogen needs, and this will make it very difficult for them to achieve acceptable yields. Organic sources of nitrogen are often expensive, and so there is an increased need to find nitrogen-supplying cover crops that will fit into vegetable rotations.

This project was designed to provide the organic farmers with information they are seeking and have requested, specifically regarding the use of cover crops other than cereal rye and hairy vetch. This information will help organic farmers increase their farm productivity while using natural, sustainable, on-farm methods to minimize weeds, maintain soil quality, and provide nitrogen.

The project has 3 objectives:

1. Screen a total of 30 – 40 unfamiliar cool-season and warm-season cover crops to evaluate their growth and potential use in Maryland organic vegetable cropping systems. Measure ground cover, growth rate, biomass production, and mulch to evaluate these crops. These factors will indicate the crops' abilities to suppress weeds while growing and as a mulch, to provide organic matter and nitrogen to the soil.
2. Using input from organic farmers, identify the most promising cover crops (approximately 6 fall-seeded and 6 spring/summer seeded) and determine their optimum planting date and nitrogen release.
3. Provide these results directly to organic farmers in the region to help them decide if and how best to incorporate these crops into their farming systems. This will be done through field days, twilight meetings, and written material.

The project will begin in the fall of 2001 and will end in the fall of 2004.

Our overall plan for the cover crops includes 4 experiments, each of which will be conducted for two years. The 4 experiments are:

Expt. 1: Fall-seeded cover crop screening trial.
Expt. 2: Spring/summer-seeded cover crop screening trial.
Expt. 3: Optimum planting dates for select fall-seeded cover crops.
Expt. 4: Optimum planting dates for select spring/summer-summer seeded cover crops.

The timeline is below. The first portion of Experiment 1 (Sept. 2001 – Dec. 2001) was funded from other sources. Fall-planted cover crop experiments (Expt. 1 and 3) will run from August of one year to about June of the following year. Spring/summer planted cover crop experiments (Expt. 2 and 4) will run from about May to November within a year.

Table 1. Timeline of experiments

	Expt. 1	Expt. 2	Expt. 3	Expt. 4
Fall 2001	(year1)			
Spring/summer 2002	year1	year1		
Fall 2002	year2	year1	year1	
Spring/summer 2003	year2	year2	year1	year1
Fall 2003		year2	year2	year1
Spring/summer 2004			year2	year2
Fall 2004				year2

Methods

The research was conducted at the Central Maryland Research and Education Center—Clarksville Farm (CMREC-Clarksville) in Ellicott City, Maryland. A 3-acre parcel of land on this research farm was earmarked for the research and demonstration of organic techniques for farmers and homeowners. In 2002, this entire area became fully certified through the Maryland Organic Certification Program

Table 2 lists the cover crops used in the Fall, 2001 screening trial. Hairy vetch, rye, and crimson clover were considered to be standards for comparison. Table 3 lists the cover crops used in the Summer, 2002 screening trial. Buckwheat and sudangrass were considered to be standards for comparison. Both tables also list the seeding rates and cost of seed.

Table 2. Species used in screening trial, Fall, 2001.

Common name	Scientific name	Crop type	Seeding rate (lb/Ac)	Seed Cost Per Pound*	Seed Cost Per Acre*
Bell Bean	Vicia faba	annual legume	150	$0.41	$62
Fava Bean	Vicia faba	annual legume	175	$1.50	$263
Garbanzo Bean	Cicer arientinum	annual legume	80	$1.53	$122
Berseem Clover	Trifolium hybridum	annual legume	20	$6.25	$125
Crimson Clover	Trifolium incarnatum	annual legume	40	$1.63	$65
Dutch Clover	Trifolium repens	legume	30	$3.20	$96
Subterranean Clover	Trifolium subterraneum	legume	30	$6.15	$185
White New Zealand Clover	Trifolium repens	legume	18	$3.10	$56
White Sweet Clover	Melilotus alba (white)	legume	20	$2.60	$52
Yellow Sweet Clover	Melilotus officinalis (yellow)	legume	20	$0.86	$17
Fenugreek	Trigonella foenum-graecum	annual legume	50	$1.95	$98
Mustard	Brassica spp. (yellow)	annual broadleaf	20	$0.80	$16
Spring Oats	Avena sativa	annual grass	64	not purchased	---
Austrian Winter Pea	Pisum arvense	annual legume	120	$0.52	$62
Miranda Pea	Pisum sativum	annual legume	120	$0.41	$49
Phacelia	Phacelia tanacetifolia	annual broadleaf	5	$11.20	$56
Rape	Brassica napus	annual broadleaf	8	$0.80	$6
Rye	Secale cereale	annual grass	112	not purchased	---
Tyfon	Brassica rapax	annual broadleaf	27	$16.00	$432
Hairy Vetch	Vicia villosa	annual legume	60	$1.90	$114
Woolypod Vetch, Lana	Vicia villosa ssp dasycarpa	annual legume	80	$1.38	$110
Woolypod Vetch, Naomi	Vicia villosa ssp dasycarpa	annual legume	80	$1.25	$100

***Seed costs are likely to be lower for a commercial farmer. Our seed was purchased in small quantities.**
Certified organic seed was purchased where possible.

Table 3. Species used in screening trial, Summer, 2002						
					------Seed Cost------	
Common name	**Scientific name**	Code	Crop Type	**Seeding rate (lb/Ac)**	**Per pound***	**Per acre***
Blackeye Pea	Vigna unguiculata	**BEP**	Legume	50	$1.13	$57
Buckwheat	Fagopyrum esculentum	**Bw**	Non-legume	80	$2.37	$190
Chicory	Cichorium intybus	**Cy**	Non-legume	5	$9.50	$48
Cowpea, Chinese red	Vigna unguiculata	**CpCR**	Legume	60	$3.23	$194
Cowpea, Papago	Vigna unguiculata	**CpP**	Legume	60	$2.85	$171
Crotolaria	Crotolaria juncea	**Crt**	Legume	40	$3.99	$160
Forage Soybean		**Fsoy**	Legume	130		
Lablab	Lablab purpureus	**LL**	Legume	13	$2.00	$26
Phacelia	Phacelia tanacetifolia	**Ph**	Non-legume	5	$11.20	$56
Pinto Bean	Phaseolus vulgaris	**PB**	Legume	120	$1.00	$120
Sesbania	Sesbania macrocarpa	**Ssb**	Legume	25	$2.15	$54
Sudangrass ('Piper')	Sorghum bicolor var. sudanesnse	**Suds**	Grass	40	$2.18	$87
***Seed costs are likely to be lower for a commercial farmer. Our seed was purchased in small quantities. Certified organic seed was purchased where possible.**						

In both experiments, treatments were 10 feet by 10 feet and were arranged in a randomized complete block design, with 4 replications (only 5 replicates of the Fall screening experiment were sampled before January, 2002). The fall experiment was planted September 14, 2001 (Sept. 19 for tyfon, berseem clover, yellow sweet clover) following clean-cultivated with a rototiller. The previous crop was Sudex. The summer experiment was planted June 6, 2002, following plowing and spading. The previous crop was mixed grass and clover pasture. All fall crops and some summer crops (buckwheat, chicory, crotolaria, phacelia, sesbania, sudangrass) were broadcast spread, and the plots were then lightly raked by hand. The cowpeas, pinto bean, and forage soybean were seeded using an Earthway seeder. The lablab was planted by hand. All legumes were inoculated, except for the fall sweet clover.

Visual estimates of % ground cover offered by the cover crops and by weeds were made weekly in each plot during periods of active growth. Once flowering began, % crop in flower was estimated. Crop height was measured approximately every 2 weeks during periods of active growth, with 5 measurements per plot. At flowering, biomass samples were cut at flowering at 1 inch above soil level and hand-collected from two 0.1 m^2 sections. These samples were analyzed for carbon and nitrogen content using standard laboratory methods. The remainder of the plot was cut by hand, and the residue was left on the surface. Percent ground cover provided by the residue was measured weekly after cutting. Because of the irregular distribution of the residue, it was not possibly to measure residue thickness.

Results and Discussion

Data are presented for those crops that achieved at least 50% ground cover during the year. Data collection typically ended when the plots were cut.

Fall Screening Experiment, 2001-2002

Non-Legumes. Figure 1 shows that mustard and tyfon rival rye for rapid growth and ground cover during the fall. Mustard is not winter-hardy, but its fall growth was substantial, and it appeared to limit growth of weeds in early spring (data not shown). Tyfon, a cross between rape and turnip, grew more slowly and less vigorously than mustard. However, it provided at least 50% ground cover until the end of March, and observations suggest that it reduced weed growth. Phacelia is not winter-hardy, but it maintained ground cover later in the spring than did mustard. Rape did not show notable growth benefits over mustard or tyfon. Rape, rye, and tyfon all showed some regrowth after cutting. Spring oat seed had very limited viability. Its performance was not representative and so was not included.

Results of biomass sampling and analysis are shown in Table 4. As expected, rye produced the greatest amount of biomass. However, with a C:N of 25, it would not be likely that this residue would decay very quickly. This was observed by the persistence of its residue (data not shown). Rape and tyfon provided little biomass and contained little N.

Mustard, phacelia, and tyfon may be useful before an early spring vegetable crop by providing some weed control and biomass. The first two would not need to be suppressed prior to planting, while tyfon would require minimal suppression. For farms that can handle the tremendous growth of rye and are not concerned about slow decay of its organic matter, rye clearly remains a good choice.

Clovers. Crimson clover grew faster than the other clovers tested (Figure 2). The sweet clovers (yellow presented here) and berseem clover (demonstration plot only) still achieved nearly 100% ground cover at flowering. Yellow sweet clover produced the most dry matter of the clovers (Table 4), and its mulch was very persistent (data not shown). Dutch clover and white New Zealand clover achieved close to 80% ground cover. All clovers regrew after cutting. Interestingly, berseem clover regrew to 100% ground cover after the first cutting, but it died after being cut a second time.

Yellow sweet clover provided nearly half again as much dry matter and as much or more nitrogen as the standards, hairy vetch and crimson clover. However, the crimson clover matured earlier and provided a greater ground cover at all times. The yellow sweet clover appears to be a useful option as a cover crop to produce a large amount of nitrogen and biomass. Combining it with a nurse crop would combine fall growth and weed suppression with nitrogen production. Berseem clover, which was not replicated in this trial, also warrants further experimentation. The perennial Dutch and white New Zealand clovers provided over a ton per acre of dry matter and over 80 pounds/acre of nitrogen, but they were not very competitive in this annual cropping system.

Vetches. The two woolypod vetches (Naomi and Lana) grew more quickly in the fall than did hairy vetch (Figure 3). However, they both suffered from winter injury and were less vigorous and productive in the spring. None of the vetches regrew after cutting. Hairy vetch produced the greatest amount of dry matter and nitrogen of the vetches. It also contained more nitrogen than crimson clover, although it must be noted that it was harvested a month earlier. Using a nurse crop in the fall would minimize hairy vetch's disadvantage early in the fall.

Other Cover Crops. The beans (bell, fava, garbanzo), peas (Austrian winter, Miranda), and fenugreek never reached 50% ground cover and so do not appear promising in this region.

Table 4. Biomass and nitrogen content, Fall Screening Expt., 2001-2002

	Date Harvested	Dry Matter, lbs/acre	% N	Nitrogen, lbs/Ac	C:N
Crimson Clover	5/3/02	4638	2.53	117	17.0
Dutch Clover	6/28/02	2717	2.95	80	14.9
White New Zealand Clover	6/28/02	2717	3.11	86	14.3
Yellow Sweet Clover	6/6/02	6083	2.72	165	16.7
Austrian Winter Pea	6/6/02	1998	3.30	68	13.3
Rape	4/4/02	1358	3.38	46	12.8
Rye	4/23/02	9499	1.76	169	25.3
Tyfon	4/15/02	907	2.59	24	16.8
Hairy Vetch	6/6/02	4573	3.31	152	12.8
Woolypod Vetch--Lana	6/6/02	2801	2.57	114	15.0
Woolypod Vetch, Naomi	6/6/02	2717	2.85	87	14.7

Summer Screening Experiment, 2002
The summer of 2002 proved to be a good chance to screen for drought tolerance, since it was one of the driest summers on record.

Buckwheat showed the most rapid growth of all the cover crops tested (Figure 4). It did not regrow significantly after cutting due to the extremely dry season. Its dry matter production and nitrogen content were not spectacular (Table 5).

Papago cowpeas, sudangrass, and forage soybean all had similarly rapid growth rates. Sudangrass, as expected, produced the highest amount of dry matter. Its high C:N (48.4), though, indicates that this organic matter will be very slow to break down. The legumes both produced over 130 pounds/nitrogen per acre in above-ground biomass. The legume crotolaria had by far the highest nitrogen content (333 pounds/acre) of all the plants tested. This was a combination of a high % N and very high dry matter content, second only to sudangrass. Although it did not grow as rapidly as the other cover crops listed above, the high biomass and nitrogen content makes it very attractive as a potential cover crop. Although farmers should strongly consider incorporating this into their systems, they should be aware that it is very attractive to Japanese beetles.

Black-eye pea, sesbania, pinto bean, and Chinese red cowpeas (data not shown) all suffered from leafhopper damage during the summer. The Papago cowpeas did not appear to have a reduction in yield, despite the presence of leafhoppers. This highlights the importance of cultivar selection with certain cover crops, a factor overlooked by many farmers and seed companies.

Once established, lablab was very vigorous, even pulling down pokeweed plants with its viney growth. However, the sparse seeding rate used meant that it was slow to develop significant ground cover. For the first month, it lagged behind all other crops. Perhaps a denser seeding rate would help, although this might cause too much competition between plants.

Chicory (a perennial, designed for grazing systems) and phacelia never reached 60% ground cover.

Table 5. Biomass and nitrogen content, Summer Screening Expt., 2002

	Date Harvested	Dry Matter, lbs/acre	ave % N	Nitrogen, lbs/Ac	ave C:N
Black-eye pea	10/20/02	4984	2.43	122	18.0
Buckwheat	7/29/02	3618	2.88	103	14.8
Chicory	10/20/02	2603	2.50	65	16.1
Cowpea--chinese Red	10/20/02	2915	2.41	71	18.2
Cowpea--Papago	10/20/02	6030	2.25	136	19.3
Crotolaria	9/6/02	15019	2.22	333	20.3
Forage Soybean	10/20/02	7031	2.64	185	17.0
Lablab	10/20/02	4784	2.04	98	21.2
Phacelia	9/6/02	1602	4.02	65	10.1
Sesbania	9/6/02	3538	2.89	102	15.9
Sudangrass	9/6/02	20003	0.96	192	48.4

Fall Screening and Timing Experiments, 2002-2003

These experiments were planted as planned in October, 2002.

Summary of Outreach

We hosted a field days at the research site in April and September. 87 farmers and researchers from the region attended. We explained the experiment, toured the plots, and gave a survey about the current cover crops and future trials to obtain input. We have also hosted a tour for a small group of USDA and USDA-SARE personnel and a tour for new educators for Maryland Cooperative Extension. An article in the Carroll County Times resulted from an individual tour with a reporter. Individual tours have also been given to 2 farmers and 1 USDA researcher.

In 2002, presentations about these experiments were given at the following meetings, reaching 99 farmers:

- Central Maryland Vegetable Growers' Meeting in January
- Southern Maryland Vegetable Growers' Meeting in February
- Gunpowder Farm Club (Baltimore County) in May.

A poster was developed to present this data at the National Small Farm Conference in Albuquerque, NM in September. This was also used at a SARE training in September.

Figure 1.

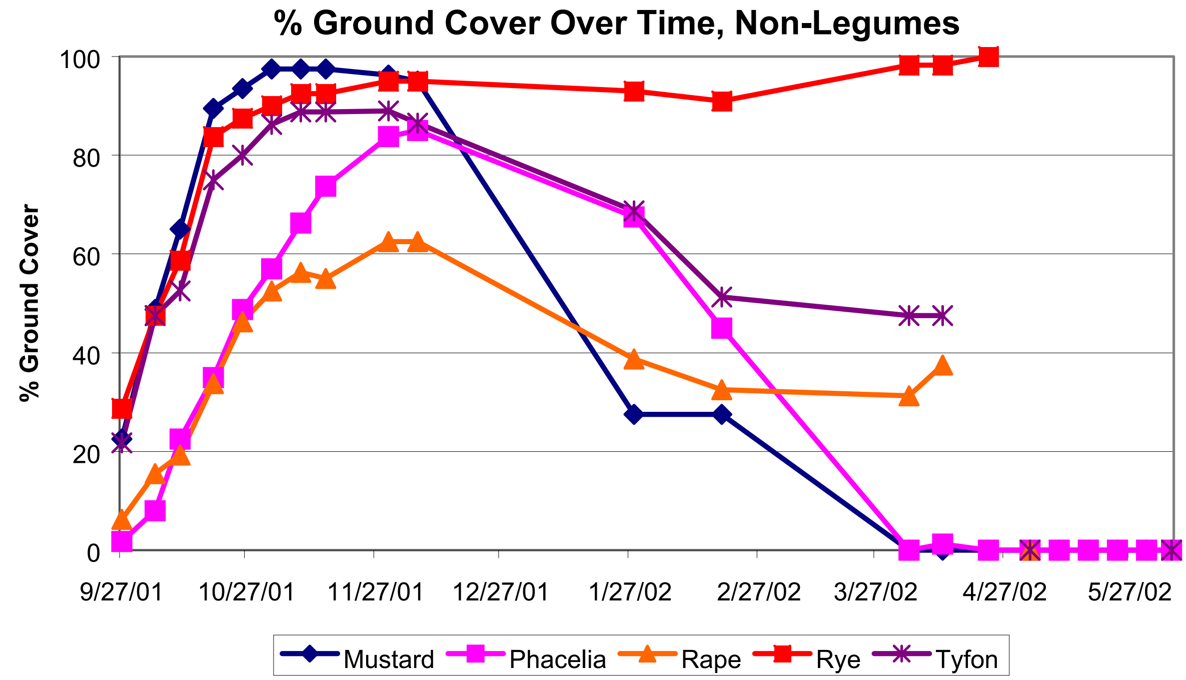

Figure 2.

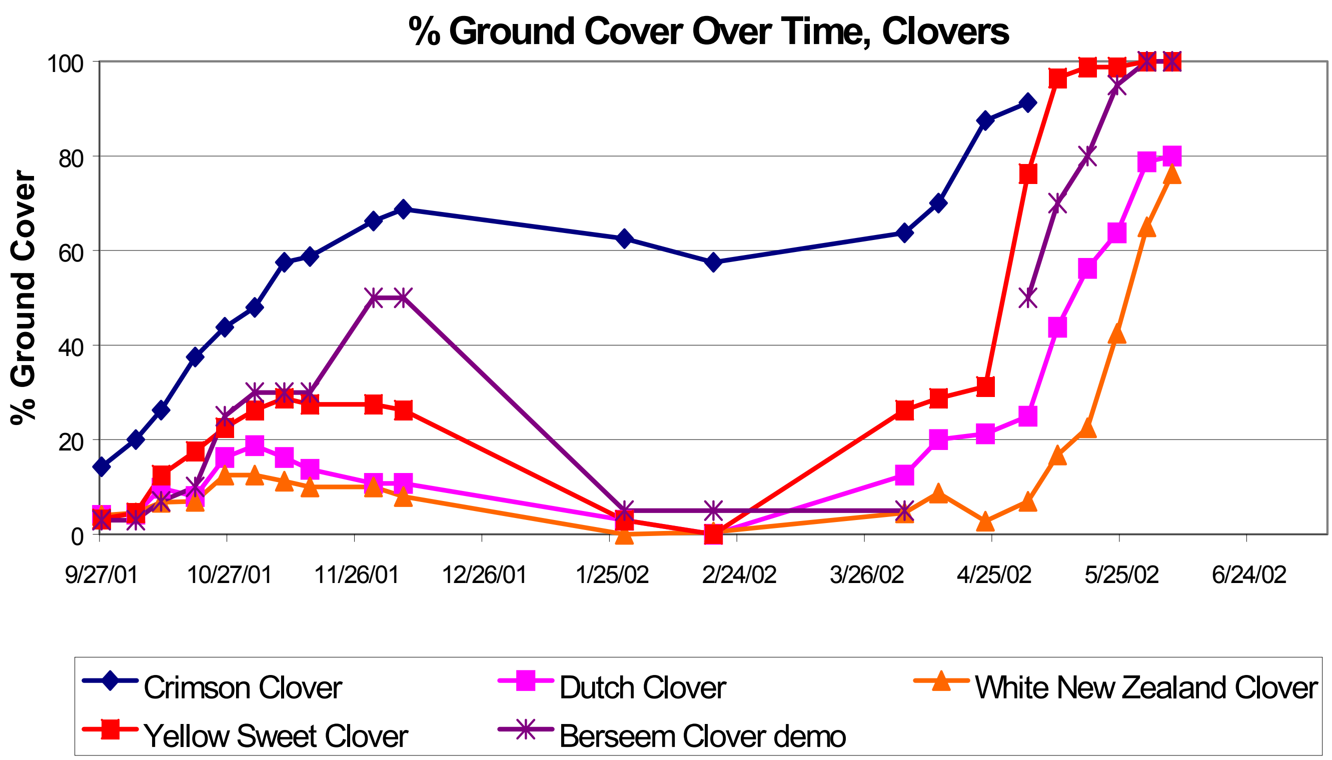

Figure 3.

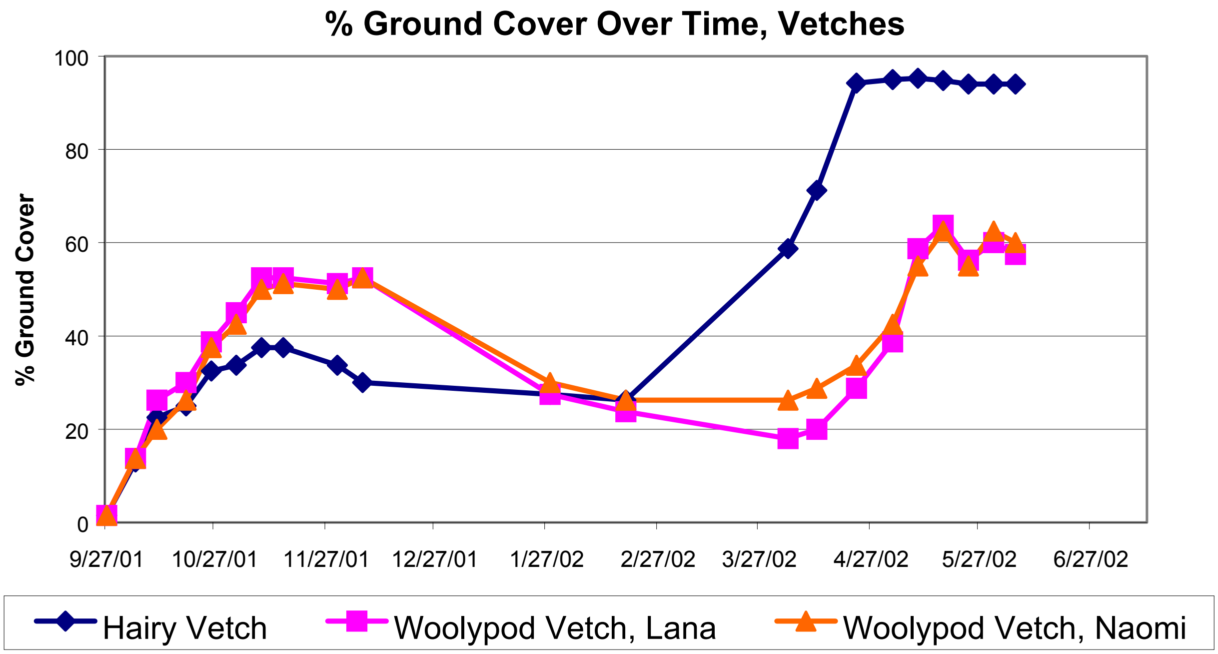
% Ground Cover Over Time, Vetches
% Ground Cover
100
80
60
40
20
0
9/27/01
10/27/01
11/27/01
12/27/01
1/27/02
2/27/02
3/27/02
4/27/02
5/27/02
6/27/02
Hairy Vetch
Woolypod Vetch, Lana
Woolypod Vetch, Naomi

Figure 4. % Ground Cover Over Time, Summer Screening, 2002