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

**Project Title:**

# *Forage Brassicas as a Component of Organic Production Systems*

FINAL PROJECT REPORT

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**Table of Contents**

## *1. Project Summary*

The Montana State University Western Agricultural Research Center (WARC) and the non-profit Alternative Energy Resource Organization (AERO) conducted on-farm research on the introduction of brassicas for green manure and/or forage into organic agricultural systems in Montana. This project follows studies conducted by WARC that demonstrated a potential for forage brassicas to enhance soil fertility and nutrient uptake by the subsequent crop (7). In addition, studies done at Northwestern Agricultural Research Center in Kalispell, Montana showed a potential to extend the grazing season with high-nutrient, cold tolerant brassicas (5).

The current research is being conducted on three organic farms in Montana, as well as at the WARC (see photographs on pages 13-15). All cooperators grew replicated plots of a forage brassica, 'Barnapoli' rape, and one other non-brassica green manure of their choice. Green manure dry matter production and tissue nitrogen were measured, and growers completed a questionnaire on crop growth, weed suppression, pest incidence, and observations on suitability to their cropping system (pages 9-12). The first part of this study was completed in the spring of 2002 with soil analysis.

In the first year of this two-year study we were able to assess performance of 'Barnapoli' rape in a wide variety of farming situations. The success of the brassica crop was highly dependent on soil fertility, particularly nitrogen levels. In a dryland situation, crop establishment was highly variable because of limited soil moisture. On one of the farms initially included in the study, crop emergence was so poor, probably due to depth of seeding, that the crop was tilled in and the experiment discontinued. In locations with adequate moisture, a sufficiently high seeding rate, and adequate soil fertility, the brassica crop produced abundant biomass and provided good weed suppression. There appears to be a great deal of potential for improving stand establishment by adjusting seeding methods, rates and timing.

## *2. Introduction to the Topic*

Organic cropping systems rely on sustainable agricultural practices including crop rotations, residue management, and green manuring to maintain soil tilth and fertility levels, to break disease and weed cycles, and to provide diversity in operations and markets. While leguminous crops have been widely used in rotations for building and maintaining soil nitrogen, other nutrients may be limiting, particularly phosphorous. Forage brassicas managed as green manures can be highly efficient in plant nutrient uptake and have been shown to increase yields of subsequent crops, especially in nutrient deficient soils (6). Brassica green manures contribute to P availability by storage in plant tissue, with subsequent release upon decomposition. Studies have shown that brassicas have the ability to increase soil solution P concentrations and enhance P uptake (1, 3, 4). Furthermore, grazing restrictions and increases in grazing fees on public land are requiring ranchers to be more efficient producers of hay and pastures. Forage brassicas may provide livestock producers with more flexible grazing systems for the cool environments of Montana. In addition, brassicas produce a class of chemicals known as glucosinolates, which have the potential to suppress soil-borne pathogens and weeds (2).

### *3. Objectives Statement*

A. To identify organic farming systems that will benefit from the introduction of brassicas.

B. To gather farmer input on the practical concerns regarding incorporating forage brassicas into their grazing and cropping practices.

C. To evaluate the effects of brassicas on soil nutrients and subsequent nutrient uptake by crops.

### *4. Materials and Methods*

Replicated plots were established in a randomized complete block or paired comparison design and initial soil samples taken according to guidelines supplied by WARC. Initial soil samples consisted of 15-20 subsamples distributed evenly within the sampling area. Each location had four replications of 'Bamapoli' rape and a comparison crop of the grower's choice. Cooperators based their seeding rates on past experience. Farm plots were long strips located side-by-side in the field, replicated four times. Plots were mapped and marked on the ground. At WARC, both an early spring and an early summer planting were established. Seed of Bamapoli rape was donated by Barenbrug USA, Tangent, Oregon.

**Table 1. Cooperating locations, comparison crops, rainfall, and irrigation.**

| Location | Comparison Crop | Rainfall | Irrigation |
|---|---|---|---|
| WARC | Berseem clover 3.8 5 " first planting | | 1/2-1 " per week May |
| | | 2.77" second planting | through August |
| Montana Arnica | Oats | 3.62" from 5/29-8/10 | 3/4 to I " per week |
| Matheson | Winter rye | 3.2" from 5/28-6/3 | 2" in mid-May |
| Alger | Spring pea | 1.6" in May, 3.54" in June, 3.05" in July, 0.41 " in August, 1.99 in September | None |

At WARC, plots were wheel hoed once after emergence and large weeds were pulled by hand later in the season. Plots were not weeded at the other locations. At WARC, the first planting was sprayed twice and the second planting once with a pyrethrum/soap combination for flea beetles. Insect control was not done at the other locations. To simulate grazing at WARC, rape plants were cut with rice cutter knives at eight inches above soil level on August 6, 2001, leaving at least one node for regrowth. Berseem clover was cut 4 inches above soil level. Regrowth was cut at the soil line on October 10.

Biomass and moisture content were sampled at each location by clipping and drying a 20" square from a representative area of each plot. Nitrogen in plant tissues was determined at WARC using the Kjeldahl method (TKN). Data analysis was by linear regression and analysis of variance by SAS JMP.

Soil samples were taken from each plot in the spring of 2002 and analyzed for N03-N (nitrate nitrogen), P (Olsen phosphorus), K (potassium)and $S0_3$ (sulfur). Analysis was performed by the Montana State University Soil Testing Laboratory.

## *5. Results*

### Western Agricultural Research Center

At WARC, good stand establishment and early season growth occurred with both the early and late planting. Flea beetles were a problem in both plantings. Growth of the rape was excellent, but by mid-season stunting was observed in some of the plots in a rectangular pattern coincident with the location of research plots two years previous. To confirm that the differences in plant growth were due to residual soil nitrogen, sub-plots of good and poor growth were mapped and plant samples were taken (Table 2). Nitrogen levels in plant tissues were found to be correlated with total biomass production of the rape (r-squared = 0.0304) but not of the Berseem clover. The first planting at WARC was sub ected to simulated grazing and demonstrated excellent regrowth where crop vigor was good.

**Table 2. Dry Matter Production and Tissue Nitrogen in Barnapoli rape and Berseem clover at the Western Agricultural Research Center, Corvallis, Montana.**

| | | | First Harvest | | Second Harvest |
|---|---|---|---|---|---|
| Crop | Crop Vigor | Dry Weight (lb/a) | Nitrogen (%) | N (lb/a) | Dry Weight (lb/a) |
| Bamapoli rape | good | 7563 | 2.6 a | 208 a | 3794 |
| Bamapoli rape | poor | 2433 | 1.5 b | 34 b | -- |
| Berseem clover | good | 3954 | 2.2 a | 86 b | 4359 |
| Significance | | ns | ** | ** | ns |

Means within a column followed by the same letter are not different by LSD (0.05)
* = significant at 0.05, ** = significant at 0.01

At WARC, soil samples were taken from the early and late plantings, avoiding the small areas of unsatisfactory plant growth so that differences between the crops could be detected. There were no differences between the soil analyses from the first and second plantings, so data presented is the mean of the two plantings. The Berseem clover green manure contributed considerably more nitrogen to the soil after incorporation than did the rape (Table 3). A significant increase in soil sulfur was seen after the Barnapoli rape crop. Brassica crops are important contributors to soil sulfur fertility (Barraclough, 1989).

**Table 3. Barnapoli rape and Berseem clover green manure influence on soil at the Western Agricultural Research Center, Corvallis, Montana.**

| Crop | N03-N | p | K | Om | EC | pH | S04-S |
|---|---|---|---|---|---|---|---|
| Barnapoli rape | 8.4 | 22.1 | 250 | 2.1 | 0.08 | 7.3 | 5.6 |
| Berseem clover | 14.6 | 20.4 | 227 | 2.2 | 0.08 | 7.2 | 2.3 |
| Significance crop | ** | ns | ns | ns | ns | ns | ** |

* = significant at 0.05, ** = significant at 0.01

### Montana Arnica

Good stand establishment and initial plant growth was also observed at Montana Arnica. Variability in residual soil fertility was similar to that observed at WARC. Montana Arnica is located on the Bitterroot River bottom, in an area crossed by several old gravel bars. Both the 'Bamapoli' rape and the comparison crop of oats showed visible reduction of growth in those areas. Plots were divided into sub-plots of good and poor vigor, and dry matter yield and plant tissue nitrogen was measured (Table 4). Tissue N of both rape (r-squared = 0.5646) and oats (r-squared = 0.4610) was correlated with biomass production.

**Table 4. Dry Matter Production and Tissue Nitrogen in Barnapoli rape and oats at Montana Arnica, Hamilton, Montana.**

| | Crop Vigor | Dry weight (lb/a) | Nitrogen (%) | N (lb/a) |
|---|---|---|---|---|
| Barnapoli rape | good | 6731 a | 2.2 a | 148 |
| | poor | 2279 c | 1.5 b | 33 |
| Oats | good | 7287 a | 1.4 b | 105 |
| | poor | 4543 b | 1.1 b | 48 |
| Significance crop | | ** | ** | ns |
| Significance vigor | | ** | ** | ** |
| Crop * vigor interaction | | ns | ns | ** |

Means within a column followed by the same letter are not different by LSD (0.05)
* = significant at 0.05, ** = significant at 0.01

Soil analysis was conducted at Montana Arnica as at WARC, with separate analyses for the high and low vigor areas. In this location, residual soil fertility and its effect on crop vigor had a greater influence on soil analysis than did the previous green manure species (Table 5). Neither of the green manure crops was leguminous, so no difference in soil nitrogen was observed. No increase in soil sulfur was seen after the Barnapoli rape crop, in contrast to observations at WARC.

**Table 5. Barnapoli rape and oats green manure influence on soil at Montana Arnica, Hamilton, Montana.**

| | Crop Vigor | N03-N | P | K | Om | EC | pH | S04-S |
|---|---|---|---|---|---|---|---|---|
| Barnapoli rape | good | 20.2 | 6.5 | 196 | 3.00. | 09 | 6.3 | 3.8 |
| | poor | 11.9 | 6.2 | 185 | 3.00. | 07 | 6.4 | 4.3 |
| Oats | good | 18.9 | 7.2 | 236 | 3.50. | 08 | 6.5 | 4.9 |
| | poor | 10.5 | 5.4 | 182 | 2.80. | 08 | 6.4 | 3.3 |
| Significance crop | | ns | ns | ns | ns | ns | ns | ns |
| Significance vigor | | * | ns | * | * | ns | ns | * |
| Crop * vigor interaction | | ns | ns | ns | ns | ns | ns | ns |

Means within a column followed by the same letter are not different by LSD (0.05)
* = significant at 0.05, ** = significant at 0.01

**Matheson Farm**

Seedling stand and productivity of 'Barnapoli' rape at Nancy Matheson's farm was substantially lower than at WARC or Montana Arnica. Weed competition was severe, and irrigation was limited. The most uniform parts of each plot were mapped and plant and soil samples will be taken from those areas. The grower felt that she would have obtained a better stand by using a higher seeding rate and drilling the seed instead of broadcasting it. Previous experience on this farm with canola, a related crop, indicates that there is potential for obtaining an excellent stand by making these improvements.

**Alger Farm**

Seedling emergence was slow and spotty at Jess Alger's dry-land farm. He planted in early April but did not achieve substantial germination until mid-summer. Montana experienced drought in 2001, but a flush of emergence was observed after three inches of rainfall was received in July. Dry matter production in the best parts of the Alger planting matched the comparison crop of field peas. The area was grazed in October, and the cows found the rape to be highly palatable.

**Table 6. Dry Matter Production of Barnapoli rape and comparison crops at the Matheson and Alger farms.**

| | | | Barnapoli rape dry weight | Comparison Crop | |
|---|---|---|---|---|---|
| Location | Planting Date | Harvest Date | (lb/a) | Crop | dry weight (lb/a) |
| Matheson | May 30 | July 15 | 2019 a | Winter rye | 3673 b |
| Alger | April 17 | October 5 | 2635 a | Spring peas | 3088 a |

Means within a row followed by the same letter are not different by LSD (0.05)
Samples taken from areas in which crop established satisfactorily

### *6. Conclusions*

This project introduced forage brassicas to organic farmers and began to quantify their potential as a green manure crop. It also served to evaluate limitations to their use and to bring farmers and scientists together to explore further research needs. Our initial results indicate that under conditions of adequate soil moisture and nitrogen fertility, as at WARC and Montana Arnica, rape would be an excellent choice for either forage or green manure. As a forage it has a high feed value and palatability. Rape has the potential to extend the grazing season, and plant material from the simulated grazing at WARC was enthusiastically consumed by some neighboring sheep. As a green manure crop, the high nitrogen levels of the rape would aid its breakdown when incorporated. On low fertility soils or where soil moisture was inadequate, the brassica did not produce sufficient biomass to be considered a viable crop for forage or green manure.

Forage rape shows good potential as a green manure given adequate soil moisture and fertility. In addition, the forage value of the brassicas is excellent. While the contribution of the forage rape green manure to a subsequent crop is not yet known, the sulfur content of the soil at WARC was increased. This is significant because sulfur is deficient in many western Montana soils.

Follow-up studies are being conducted in 2002 at all locations to complete our original research plans and to examine some questions that arose from our initial plantings . At WARC we planted 'Barnapoli' rape, 'Berseem' clover, and three different combinations of these crops in soil enriched with organic matter and soil that was depleted by growing and removing a cover crop. With this experiment we will begin to assess the fertility needs of the brassica crop, and determine whether intercropping of brassica and clover would be a viable green manure strategy on these soils. At WARC and the Montana Arnica fan-n Gallatin seed barley was planted and samples will be taken to determine P levels in the seed crop. At the Matheson and Alger farms 'Barnapoli' rape has been planted and at the Matheson farm Berseem clover was planted to duplicate the comparison planting done at WARC in 2001. Observations will be made as to the growth, vigor, weed competitiveness, and forage quality of the brassica and comparison crops. Further research in this area will depend on results of analysis of P levels in the barley crop at WARC and Montana Arnica, continuing grower interest, and availability of funding

### *7. Outreach*

Our project results will be published in AERO's quarterly publication "The Sun Times." This publication reaches 650 AERO members, of which half are farmers and ranchers.

AERO serves as the hub of the club network, facilitating inter-club communications. Results of this project will be shared with other farm clubs.

The Montana State University Publications and News Service will produce articles about this research.

## *8. References*

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**Questionnaire for Forage Brassica Farm Club, 2001 - Answers from participants**

**Cooperator Farms:**

| | WARC | Montana Arnica | Matheson | Alger |
|---|---|---|---|---|
| Soil type | Burnt fork loam | Sandyloam pH 7.0 | Sandyloam, rocky in spots | Judith loam. 2" of topsoil, then clay |
| Brassica planting date / seeding rate | 5/7/01 and 6/8/01 10 lb/acre | 5/29/01 40 lb/acre | 4/30/01 18 lb/acre | 7 lb/acre |
| Comparison crop | Berseem clover | Oats | Winter rye | Peas |
| Comparison crop planting date / seeding rate | 5/7/01 and 6/8/01 10 lb/acre | 5/29/01 85 lb/acre | Fall 2000 60 lb/acre | 4/17/01 90 lb/acre |
| Irrigation | 1/2 - 1" per week | 3/4 - 1" per week May - August | 2" in May as needed | none |
| Rainfall | 1st planting 3.9" 2nd planting 2.8" | 3.62" | 2.2" | 10.6" |

**Describe the field history for the past two years, ie. previous crops, weed pressure, soil amendments added, etc.**

WARC — In 1999 the plot area was planted in plots of sweet corn and in 2000 the plot area was fallow.

Montana Arnica — The plot was in echinacea purpurea for the last 2 years with heavy weed pressure in the low spots. The crop was tilled in in late fall of 2000.

Matheson — 1999-Seed coriander-very weedy following alfalfa plowdown.
2000-fallow for weed control. Cows fed weedy hay in this spot by previous landowners.

Alger — 1999: barley. This field (6-49) was the conventional field for my SARE grant. It had fertilizer and 2-4d + banvel in both 1999 and 2000. 1999 was spring wheat, and 2000 was barley.

**Crop Performance:**

**1. How long did it take for each crop to emerge?**

WARC — Brassica - I week
Clover - 7 - 10 days

Montana Arnica — Brassica - 9 - 12 days
Oats - 7 - 9 days

Matheson — Rye emerged the previous fall and survived the winter well. Brassica did not emerge well. We irrigated to get it up. Did not achieve full emergence until the end of May.

Alger — Brassica: some in May, some in June, some never did.
Peas: Most emerged in early May, some never did.

**2. When did you (or are you planning to) till in the plots?**

| | |
|---|---|
| WARC | October 6, 2001 |
| Montana Arnica | Plots were mowed then disked in before repeated quacking. The tillage began in late August. |
| Matheson | Plots were tilled under on 7/15. The brassica was knee high. The rye was fully headed and in the milk stage. |
| Alger | I plan on tilling the plots in April. |

**3. What do you see as the greatest advantage of planting a brassica crop in your farming operation?**

| | |
|---|---|
| WARC | Potential for high biomass and forage production. Possibility for enhancement of P uptake by subsequent crop, and additional diversity for crop rotations. |
| Montana Arnica | Weed control in areas where the soil was fertile and moist, and it is a great indicator of soil fertility. |
| Matheson | As a break crop, to add diversity to the rotation, and hopefully to make phosphorous available to subsequent crops. |
| Alger | It stayed green clear up to end of October long after most other plants had turned brown and shriveled up. This could possibly used for fall grazing to put weight on calves, or keep the cows in good shape going into the winter. Must be very drought tolerant. With good moisture you would probably want to hay it. |

**4. What do you see as the greatest disadvantage?**

| | |
|---|---|
| WARC | Insect problems, poor growth due to low soil fertility, high need for water during intense heat of summer. |
| Montana Arnica | Flea beetles, and its intolerance to drought. Seedlings seem to need adequate moisture which is tough in sand or gravel bars in the field. |
| Matheson | No livestock yet for grazing. Would need to plant a big enough area to drill the seed in. |
| Alger | The seed is so small it is hard to plant it at accurate rates. I feel it needs good moisture to establish itself. Cost of the seed? It seems to be a slow starter. I was real disappointed in June with it. It took me until August to even start to consider it as a worthwhile crop. |

**5. How do you feel you could improve the performance of the crop and its usefulness for your farm?**

| | |
|---|---|
| WARC | Adjust timing of planting to avoid flea beetles. Evaluate winter hardy forage brassica varieties that could be planted after a cash crop. |
| Montana Arnica | More uniform soil fertility to ensure a more uniform stand with better weed suppression. Would like to try it as a grazing crop. |
| Matheson | If the crop behaves like canola, with a good stand it should provide excellent weed control, and phosphorous availability. I will not use canola anymore because of the danger of transgenic contamination, so this would be a good substitute. If I had livestock I would graze the crop. |
| Alger | Timely rains and a wet spring would really improve the performance of this brassica. Possibly the brassica could be used for weed suppression in Canadian thistle. You could possibly hay it. It could be used as a plow down crop if the seed is not too expensive. |

**6. Please rate the brassicas and the comparison crop for the following:**

| | Brassica | | | | Comparison Crop | | | |
|---|---|---|---|---|---|---|---|---|
| | WARC | Montana Arnica | Matheson | Alger | WARC | Montana Arnica | Matheson | Alger |
| Weed suppression | 3 | 4 | 1 | 3 | 3 | 4 | 2 | 2 |
| Insects | 4 | 4 | 3 | 1 | 2 | 2 | 1 | 1 |
| Plant stand | 3 spotty | 3 spotty | 2 | 2 | 4 | 4 | 4 | 4 |

Weed suppression: 1=none, 5=excellent
Insects: 1=none, 5=severely damaged
Plant Stand: 1 =very weak, 5=highly vigorous

**7. If you grazed animals on your plots, how did they respond to the brassicas and to the comparison crop?**

| | |
|---|---|
| WARC | Sheep showed a liking for brassicas that were harvested and dried like hay |
| Montana Arnica | n/a |
| Matheson | n/a |
| Alger | We grazed the brassica plot south 1/3, June 25 until 12 July. This area was grazed because of Russian thistle weed problem, We saved the north 2/3 of 49 acre field to combine peas. July 17 and July 21 we had real bad hail stonn I " diameter hail. This really knocked the peas for a loop. (flattened em') The brassica was fairly short so it didn't bother it too bad. Overall the moisture from hail helped the Brassica crop more than the hail hurt it. Cattle love peas but it seemed like the cattle grazed the brassica first although there was not much of the brassica present. It was probably about 1/4 of a stand, and it had really poor germination. It was very dry and it didn't rain much until June. The wettest part of the year was when it hailed in JULY.<br>October 7th I took pictures of the Brassica and dried out peas and weeds. This is when soil samples were taken.<br>October 1 4 we combined the peas. We did not get very much production because of hail and drought.<br>October 26 we turned the cows into the brassica and peas the cattle slicked the brassica right down to the ground, because it was green and everything else was brown. |

**8. Please describe the overall performance of the brassica and comparison crop, and give any additional comments.**

| | |
|---|---|
| WARC | Both crops germinated well and gave a good uniform stand initially. As the growing season progressed, differences due to residual soil fertility appeared and became very pronounced later in the season. Brassicas exhibited heat stress and wilting in the intense summer heat. |
| Montana Arnica | They performed pretty well but were dependent on soil fertility. |
| Matheson | I had planted the whole field the previous fall to winter rye. I cultivated out the rye to plant the brassica. The brassica stand was spotty. I took the biomass samples from the best spot in each strip, and will take soil samples from the same spots. |
| Alger | Some of the Brassica ended up 18 inches tall. It was real variable; some was only three and four inches tall and lots of it was probably 9 inches tall. I do not think it germinated until the hail storms July 21. 2001 was very dry, not a good test for any crop. |

**9. Would you be Interested in continuing with this project as a member of an AERO Farm Club? What would you do differently?**

| | |
|---|---|
| WARC | Yes. We would work with cooperators to assist them in improving seeding methods. |
| Montana Arnica | Yes. The addition of a legume in the mix might minimize the dependence on soil fertility. |
| Matheson | Yes. I would seed the brassica with a drill. I would need enough seed to charge the drill, or I could mix the seed with wheat bran or another inert ingredient. It would be easier to compare the rape to a spring seeded crop. |
| Alger | Push my buttons, of course I would be interested in an AERO Farm club with Brassica. What do differently? Possibly plant it in an area where I have lots of Canadian thistle. My original plan was graze the hay barley and the peas after the hay crop is off, then plow thistle under. I could plant brassica in this field. I have a 28 acre field that I plan on putting in hay barley and peas for hay so that I could hay the brassica and use electric fence to keep some of it from being grazed. Then I would have a better test to see if there is any weed suppression. Also this would be real close to the house so I could watch it closer. I could use hay barley and peas as the comparison crop. I think the brassica could go in a separate drill so that I could spread the plots in a little different pattern so it fits my equipment better. |

**10. What would you like to see included in the project?**

| | |
|---|---|
| WARC | (see our interim report) |
| Montana Arnica | Legumes |
| Matheson | I would like to try the same thing again to see if we could get better stands of rape across all the farms in the experiment. |
| Alger | More seed, more money. I think if ground corn cobs were added to the seed I could get a better disbursement of the seed over the land. 25 lbs barely covers bottom of drill. plot = 49 acres. |

## Western Agricultural Research Center

Barnapoli rape was grown in 2001 in replicated plots at the Western Agricultural Research Center in Corvallis, Montana. Berseem clover was grown as a comparison crop. Plots were subjected to simulated grazing and the forage was fed to lambs, who found it highly palatable. Differences in residual soil nitrogen fertility from crops grown in 1999 resulted in variability in growth of the rape, but had no effect on the clover.

Barnapoli rape (foreground) and Berseem clover plots

Berseem clover

Regrowth of Barnapoli rape after simulated grazing

Vigorous growth of Barnapoli rape at left of Sue Wall-MacLane and Sharon Luibrand, weak growth on right

**Montana Arnica.** Replicated strips of Barnapoli rape alternated with oats at Montana Arnica, Hamilton, MT. Stand establishment and growth of both crops was excellent in most of the planting.

Montana Arnica, August 10, 2001

A healthy stand of rape and oats

Flea beetles were a problem in several locations

Rod Daniel and Sue Wall-MacLane

**Jess Alger's Farm** in the Judith Basin of eastern Montana provided an opportunity to evaluate forage brassica under dryland conditions. Here, strips of Barnapoli rape and peas were compared.

Jess Alger's planting on October 7, 2001

Barnapoli rape responded to fall rain

**Nancy Matheson** planted a crop of winter rye in the fall of 2000 for comparison with spring-planted Barnapoli rape.

Nancy Matheson in her planting of Barnapoli rape (center) and winter rye, July 9, 2001

Barnapoli rape

Barnapoli rape and winter rye