Angela Baker
Project # FNE 97-160

Sustainable Agriculture Research and Education Program
Farmer/Grower Grant Final Report Format

Final Report

1. Restate the goals of your project.

The long range goal is to determine optimum, sustainable growing conditions for Echinacea angustifolia and Echinacea purpurea and to develop agronomically suitable and medicinally superior non-hybridized cultivars of Echinacea angustifolia and/or Echinacea purpurea for cash crop production in the Northeast. ***This project will determine optimum field conditions for establishing first year Echinacea angustafolia and E. purpurea plants. Field trials will address variations in crop density, pH, weed suppression, covercroping, and interplanting. Nutrient availability and soil composition will be relatively constant.***

2. Update the information on your farm since you received a farmer/grower grant. Include acres farmed, crops/livestock.

I have begun collaborating with a local organic farmer and plan to put an additional acre into production of medicinal herbs and flowers in 1998.

3. Who were your cooperators and what were their roles in the project.?

NAME/ADDRESS	**ROLE in this project**
Kathy McKeown, Graduate Research Associate Department of Plant and Soil Sciences French Hall, Box 32910 University of Massachusetts Amherst, MA 01003-2910 413 545-2243 fax: (413) 545-3075	Soil tests Advised Provided E. angustifolia seedlings
Dr. Robert Bernatzky Associate Professor Department of Plant and Soil Sciences French Hall, Box 32910 University of Massachusetts Amherst, MA 01003-2910	Advised Soil tests
Lynn Kline 467 Hill Road Ashfield, Ma. 01330	Provided land

4. Tell us what you actually did in your project and how it was done.

I conducted trials addressing variations in crop density, pH, weed suppression, covercroping, and interplanting. Also reported here are stratification trials and second year field trials not covered in the grant proposal. ***See question 5 for how.***

5. What were your findings and accomplishments?

Stratification

Cold, moist stratification of *Echinacea* significantly increases germination. Mix 1 part seed to 3 parts vermiculite, by volume, and moisten until only 2-3 drops of water will squeeze out of a handful.

Store at a temperature of 35-40 degrees for 10 weeks. Store in a closed container and keep away from exposure to light. Check your stratification medium every two weeks for moisture content. Near the end of the stratification period check more frequently. Ten weeks is a standard for stratification. Sow seed once two or three sprouts emerge in the stratification medium.

Stratification trials of both *E. purpurea* and *E. angustifolia* seed in strata medium of sand, vermiculite, and moist paper towels demonstrated equivalent germination rates in the three mediums. Vermiculite, however, had benefits other than germination rate. It is light, holds moisture well, and can be easily separated from the stratified seed by rinsing through a sieve. Sand is heavy to work with and less able to maintain consistent moisture. Paper towels are the most difficult of the three mediums for maintaining consistent moisture. Separating seed from the towels is very labor intensive. Paper towel stratification does have the advantage of ease of observation of the seed. A small amount of seed in paper towels makes it possible to determine precisely when seeds begin to sprout. Duration of stratification will vary according to seed lot, especially for *E. angustifolia*.

Seed may be planted with the vermiculite without hindering germination. Simply spread the mixture on the soil surface. If controlled spacing of the seed is desired, separate the seed from the vermiculite. To separate: place seed and vermiculite in a sieve and rinse with a spray nozzle until all the vermiculite has passed through the sieve and the seed remains. Surface sow the *Echinacea,* light increases the germination rate. Use deep plugs or flats for seedlings. *Echinacea* germinates at temperatures of 68 degrees or higher. Sow seed 4-6 weeks before anticipated transplant date.

E. purpurea

Stratified 10 weeks, *E. purpurea* emerged in 2-5 days in compost based potting soil at a rate of 87% when held at a daytime temperature of approximately 80 degrees and night time temperature of approximately 70 degrees. The fibrous root structure of *E. purpurea,* (as opposed to the *E. angustifolia* tap root) enables the seedlings to tolerate remaining in flats for 8-10 weeks, if necessary, without compromising field establishment.

E. *angustifolia*

E. angustifolia, was seeded in a "mist house" at a constant temperature of 75 degrees and misted every 60 seconds. There were significant differences in percentage of emergence depending on seed source. Seed from two separate sources were stratified as indicated in the chart below.

Source	Stratification (days)	Emergence
#1	30	30%
#2	30	20%
#1	100	75%
#2	100	25%

Seed #1 had an increase in emergence from 30% to 75% with increased duration of stratification. Seed #2 increased only from 20% to 25% with increased duration of stratification.

Despite a much lower emergence rate, #2 had a similar survival rate in the field at 4 weeks as did #1, when sizable transplants were set out. (longest leaf greater than 1-3/16) It survived at a higher rate than #1 when both were planted out as very small seedlings. (longest leaf 8/16ths) This demonstrates that seed should be evaluated on several variables over the course of its 3 year growing cycle. Seed #2 may have had low emergence due to premature harvest or some other factor, and yet may produce plants that will prove to be superior in any number of other ways.

Roots will develop quickly and should not be allowed to wind around the bottom of a shallow pot as this will retard its growth. (After four months in the ground, E. angustifolia that had been started in standard shallow plugs still showed a coiled tap root.)

Field Preparation

When planting a three year crop it is very important to address soil fertility and weed management prior to planting. *Echinacea* is a deep rooted crop. A biennial sweet clover is helpful as a preceding crop. The deep rooted clover, in addition to fixing nitrogen, will loosen the soil allowing the *Echinacea* easier access for root growth. Strive for a moderately rich, well drained soil with a well balanced nutrient content.

Considering that *Echinacea* can be planted well into early summer it is possible to use a stale seed bed technique to reduce weeds for the long run. Prepare the soil significantly in advance of planting and cultivate several times as weeds begin to emerge. In this way, many of the weed seeds in the top several inches of soil will be eliminated prior to planting.

E. purpurea

Echinacea purpurea thrived at a pH as low as 5.0 and as high as 6.1. It grew well in full sun and partial shade. Significant drought tolerance was evident even by young transplants. Irrigation is not necessary for *E. purpurea* transplants unless attempting to establish in extremely dry conditions.

E. angustifolia

E. angustifolia requires full sun and very good drainage. Research indicated that *E. angustifolia* prefers a pH from 7.0 to 8.0 (Foster, 1991). However, we were unable to achieve a balanced nutrient level with a pH higher than 6.1 in these trials. Some losses may be a result of this factor. Plan for irrigation to establish *E. angustifolia* seedlings.

Transplanting to the Field

E. purpurea and *E. angustifolia* were planted at separate sites. Although listed as separate species they are not fully distinct and may cross.

Transplant trials were carried out in non-irrigated fields for *E. purpurea*. Trials for *E. angustifolia* include both irrigated and non-irrigated fields. Trials addressed the following variables: density, cultivation, preceding cover crops, and interplanting.

***E. purpurea*--transplants**.

Seedlings can be transplanted to the field in as little as 3-4 weeks after sowing, or once a true leaf is well established. Young transplants tolerate lower temperatures in the field than the 68 degrees required for germination. Second year plants emerge in the field as early as 4-6 weeks before the last frost date. First year seedlings can be set out as early as two to four weeks before last frost date. They will tolerate a light frost if hardened off prior to planting. Growth is very slow in early plantings. *E. purpurea* will also establish well in significant heat and dryness. This allows for flexibility in incorporating it into a variety of operations.

In 9 distinct trials that were successful for overall health and vigor and low plant loss, seedling were transplanted from 5/29 to 7/23 without irrigation. Total average plant loss was 13.69% at the end of the season. Average losses were highest in the first two weeks after planting (4.8%).

E. angustifolia--transplants

Transplant date, size and irrigation were the main factors in successful establishment of E. angustifolia. Allow seedlings to get as large as possible in the flats without allowing the tap root to wind around the bottom of the cells. Transplant E. angustifolia after the last frost date. Irrigate through the first season and allow to dry out between watering.

Seedlings were set out two weeks before the last frost date and at last frost date. Transplants did not establish well when planted prior to last frost date. There were significant signs of phosphorus deficiency when attempting to establish in cold temperatures or wet soils.

There was also a strong correlation between transplant size and survival rate.

Transplant size (average length of longest true leaf)	**Survival rate at 2 weeks**
1-3/16 inch	86%
8/16 inch	71%.

Irrigation was the third significant factor in establishment of *E. angustifolia*.

Survival @ 16 weeks irrigated	**Survival @ 16 weeks non-irrigated**
85%	6%

Direct Seeding

The need for stratification, surface sowing, and a warm temperature all contribute to make direct seeding very challenging. By the time it is warm enough here in New England for seed to sprout we are often in a dry period. The seed is sown on the surface and can burn up before germination if the weather turns dry. Seeds sown directly from their moist stratification are difficult to separate for even sowing resulting either in labor intensive planting or thinning of seedlings. Seed separated from the stratification medium requires some drying for ease of handling with the potential to dry them too much and destroy viability.

E. purpurea--direct seeded

Stratified seed (kept moist) sown in mid May demonstrated zero emergence. They were planted in a bare field (no interplanting or winter killed cover crops). Temperatures were too cold for germination and by the time it was warm enough, either the seed was no longer viable, or the moisture was inadequate.

Seed sown 5/29 in perennial grasses showed significant success with seedlings emerging for up to two months. There were cultivation and density problems later in the season in this planting.

Despite the difficulty, determining effective direct seeding methods are worth the effort. At the same time that seed was sown directly in the field (5/29), *E. purpurea* transplants were also set out. All other conditions were consistent for transplants and seed. When measured at 8 weeks, direct seeded plants were nearly as large as the transplants.

E. angustifolia--direct seeded

E. angustifolia seed was separated from the stratification medium and hand sown two weeks prior to last frost date. Seed was sown in three different winter killed cover crops: buckwheat, millet and rye. The first true leaves appeared four weeks after seeding (two weeks after last frost date). There were differences noted in emergence in the various cover crops, as shown below.

Cover Crop	Emergence
buckwheat	0%
millet	9%
rye	20%

These trial were on a slight slope with buckwheat at the bottom of the slope and the rye at the top. Variations in drainage may have effected the results.

Field Management: Interplanting & Density

The *Echinaceas* are primarily prairie plants. The various species grow in mixes of wildflowers, grasses and forbs. *E. purpurea* often grows in light woods as well as open prairie. Trials were designed to mimic aspects of the natural environment of the plants and compare the results to standard agricultural practices of monocropping and density designed for maximum plant size. The most outstanding feature of this research thus far is that *Echinacea* clearly thrives on some degree of interplanting. It did best (greatest size, most flowering) near other plants. Plant *Echinacea* in rows or beds depending on cultivation methods to be used.

E. purpurea.

The *E. purpurea* trials demonstrated the most vigorous growth in two situations: intercropped in full sun and grown at high density in partial (late afternoon) shade.

Nine sections were spaced 18 inches apart on center, kept well weeded and cultivated within the beds, other conditions were varied. For one of these sections, (#8), grasses were allowed to grow to a height of two feet on all sides. Section 8 showed the fastest rate of growth and had the greatest number of flower heads.

		Section 8	Section 1-7,9 avg.
average longest leaf length	*@ 8 weeks*	4	3
(in inches)	*@ 16 weeks*	8	5
# flowering	*@ 16 weeks*	12	2

2) The second strongest trial of *E. purpurea* was a 15' by 25' plot of transplants set out at 8 inches on center in partial, (late afternoon) shade. Growth in this section was stronger than in sections 1-7, & 9 (above) but not as vigorous as in section 8 (above). Given that there are two variables, it is not possible to determine whether the success of this plot was due to the increased density or the partial shade. Also the effects of that density on the plants in the second and third year is yet to be determined.

E. angustifolia

Seedlings were set out in high density prairie conditions without irrigation. Establishment and growth were compared to seedlings set out in a well cultivated non-irrigated field. At four weeks the seedlings in high density interplantings were much stronger and had only 25% as many losses as those planted in the well weeded section. The *E. angustifolia* seemed to benefit from the competition and/or the retained moisture from the other plants. Later in the season the competition in the prairie simulation became too much and the rate of attrition was similar at 16 weeks in the two trials. (20% survival in both the densely planted and well weeded sections). Despite equivalent survival rates, the plants in the well weeded sections did not display the vigor of the survivors in the prairie simulation trial.

E. angustifolia seedlings that were transplanted into well cultivated beds with weekly watering had an 85% survival rate. In this trial there was a significant difference in drainage at the two ends of the field. Although attrition was comparable, seedlings in the well drained area were much stronger at the end of the season. In the second year this trial was treated in two ways. Half of each bed was interplanted with herbs and flowers (at a density comparable to a flower bed rather than that of a prairie). The other half was kept well weeded and cultivated. The interplanted sections showed 25% greater plant volume and 6 times as many flower heads.

E. angustifolia will frost heave easily. Many first year plants heaved entirely out of the ground when left unmulched or without being interplanted. Frost heaving was noted even in the third spring on plants with two foot long tap roots.

Field Management: Insects and Disease

E. purpurea

There was a small percentage of plants that had a virus, possibly spread by leaf hoppers. Other fields and gardens were observed and it was determined that the virus was a regional phenomenon, not limited to *E. purpurea* or to the specific field. Counts taken in 3 different trials on 9/25 demonstrate the following. Virus counts were higher on earlier plantings. Density or partial shade may have been factors as well.

Density	Sun	Transplant date	Percentage of plants with virus
- 8 inches on center	Partial Shade	Late May	7.25%
- 18 inches on center	Full Sun	Late May	4.50%.
- 8, 12 &18 inches	Full Sun	Late July	.50%

Leafhopper emergence, hibernation practices and natural predators are all factors to consider if this problem occurs. Late plantings miss the early spring emergence cycle of the leafhoppers. Leafhoppers hibernate in weeds but tend to avoid perennial grasses. Good fall weed cleanup reduces leafhopper hibernation. Reduce thistles, dandelion and plantain. Well placed perennial grasses can reduce damage. Introduce plants that attract leafhopper predators which include syrphid flies and parasitic wasps. Syrphid flies are attracted to members of the daisy family. The carrot family, buckwheat and white clover attract parasitic wasps. Employ strategies that attract birds, particularly chickadees, purple finches, sparrows, swallows, titmice and wrens, to your fields, all of which consume leafhoppers. (Rodale Flower Garden Problem Solver).

Plants showed no evidence of the virus upon emergence in the second year of growth.

E. angustifolia

E. angustifolia showed almost no insect or disease damage (less than 4%) even when plants were highly stressed. There was, however, a marked sensitivity to low phosphorus when combined with cold, wet conditions. When transplants were set out two weeks prior to frost date, phosphorus stress (red leaves) was evident at a rate of 24% after two weeks in the field. When transplants were set out at last frost date, only 4% showed phosphorous stress after two weeks in the field.

Did you have unexpected results? If so, what were they?

The results were much as I expected.

6. Is there any specific site information relevant to your project or the results?

It is difficult to reach the high pH levels that E. angustifolia prefers in this region.

7. What were your economic findings (if relevant to your project).

Organic cultivation of *Echinacea* is a viable undertaking for reasons of economics, quality herbal production and species preservation. It lends itself well to small scale production. New England is an excellent location for production due to the presence of many small diversified farms and large scale gardens. *Echinacea purpurea* is well adapted to the Northeast and easy to grow. Plant in beds or rows alternating with other cash crops, cover crops, wildflowers or grasses to three feet in height. Introduce plants that will attract beneficial insects either in or surrounding the field or garden. Rely on transplants while experimenting with direct seeding. *Echinacea angustifolia* is not well adapted to the Northeast. Keep trials small to avoid economic losses.

I was not addressing the economics of production. I do not, at this time, have specific data to back up my belief that this is an economically viable undertaking.

8. Have the results from your project generated new ideas about what is needed to solve the problem you were working on? Yes. What would be the next step?

There are other factors than the eventual size and appearance of *Echinacea* that need to be considered when growing the plants for the health care market. What is the relationship between *Echinacea* and the grasses, forbs and wildflowers it grows with? How do the chemical constituents of these plants interact? Do they synthesize to make better "medicine"? Can there be more "medicine" even when there may be less *Echinacea* plant produced at higher interplanting densities? Does *Echinacea* thrive best with certain plants or is there latitude in determining what to use for interplanting? Can it thrive interplanted with a second crop such as cut flowers or other medicinal herbs? This is an important land use issue considering that plants will be in the field for three years. What is optimum density? What are the effects on the root when aerial parts are harvested? Many aspects of these questions cannot be answered until the chemical makeup of *Echinacea* is better understood.

9. Will you continue to use the practice you investigated? Why or why not?

Yes. I intend to continue to research Echinacea cultivation. There is much to learn and I believe it is a viable cash crop well suited to small scale farming. It is also important to cultivate herbal medicinals to reduce wild harvesting and possible species extinction.

10. What do you tell other producers about your project and the results?

I give them the enclosed article.

11. Explain what you did in your outreach program? Send a copy of any articles written about your project.

A full report has been submitted to Kathy McKeown and Robert Bernatzky. - A presentation of the project given at the 1997 NOFA summer conference in Amherst, MA. to an audience of approximately 25. A post-harvest growers article, (enclosed) was submitted to 4 local newspapers, Country Folks Magazine, the New England Herbal Association, and The Natural Farmer.

12. Please include 2-3 slides or photographs of your project. Please include clear information describing the slides or photographs. Use the attached slide ID form, please. There was no attached slide ID form in this packet. Labeled photos are enclosed.

Project # FNE-97-160

MAY 22 1998

Organic Cultivation of *Echinacea* as a Cash Crop

The *Echinaceas* are perennial wildflowers. There are nine species of this genus. *Echinacea purpurea* and *Echinacea angustifolia* are both highly valued as medicinal plants. Media coverage of the immunostimulatory benefits of *Echinacea* is extensive, as are reports of increasing sales. This plant merits attention as a high-value cash crop. To date, however, little research has been published on the organic cultivation of *Echinacea* as a medicinal crop, the focus of this article.

The goal of this research is to determine optimum sustainable growing conditions for *E. purpurea* and *E. angustifolia* and to develop agronomically and medicinally superior non-hybridized cultivars for cash crop production in the Northeastern United States. Trials reported here took place in the Berkshires of Western Ma., in zone 5.

Echinacea grown for root production is harvested at the end of the third growing season. The main focus of this article is on first year establishment. Topics covered are: purchasing seed, stratification, field preparation, planting, field management, harvesting and marketing. Partial funding for the work reported here was provided by a grant from the USDA Sustainable Agriculture Research and Education Program (SARE, formerly LISA).

Purchasing Seed

" *Echinacea angustifolia* is fast approaching endangered status due to unrestrained harvesting of the wild plant" (McGregor, 1996). At the current rate of harvesting it is conceivable that entire wild populations will be eradicated. Although *Echinacea* has proven therapeutic qualities, the relationship of chemical constituents that contribute to its medicinal value are unknown. Because of this, maintaining the diversity of genetic populations is necessary or we risk eradicating what contributes to the efficacy of *Echinacea* as a healing herb. Important genetic traits may be permanently lost. Given the scarcity of wild populations it is important to question whether "conscientious wild harvesting" of any *Echinacea* species is possible any longer. Determine the source of your seed. At a minimum, I recommend that any wild harvested seed that you may purchase be from suppliers that have a harvesting permit.

Cultivated seed is available. Be cautious of claims such as "the best seed for medicinal production". Again, too much is unknown to substantiate such claims. Also, seed bred for ornamental use may not be the best choice for a medicinal crop. Important medicinal constituents may have been bred out of it in favor of ornamental characteristics.

Purchase seed well in advance of your growing season to allow for a stratification period. When determining quantities to purchase, expect 80% germination from *E. purpurea* and 25-75% germination from *E. angustifolia*. *Echinacea purpurea* is well adapted to the Northeastern United States. *Echinacea angustifolia* is difficult to grow in this region.

Stratification & Indoor Seeding

Cold, moist stratification of *Echinacea* significantly increases germination. Mix 1 part seed to 3 parts vermiculite, by volume, and moisten until only 2-3 drops of water will squeeze out of a handful. Store at a temperature of 35-40 degrees for 10 weeks. Store in a closed container and keep away from exposure to light. Check your stratification medium every two weeks for moisture content. Near the end of the stratification period check more frequently. Ten weeks is a standard for stratification. Sow seed once two or three sprouts emerge in the stratification medium.

Stratification trials of both *E. purpurea* and *E. angustifolia* seed in strata medium of sand, vermiculite, and moist paper towels demonstrated equivalent germination rates in the three mediums. Vermiculite, however, had benefits other than germination rate. It is light, holds moisture well, and can be easily separated from the stratified seed by rinsing through a sieve. Sand is heavy to work with and less able to maintain consistent moisture. Paper towels are the most difficult of the three mediums for maintaining consistent moisture. Separating seed from the towels is very labor intensive. Paper towel stratification does have the advantage of ease of observation of the seed. A small amount of seed in paper towels makes it

possible to determine precisely when seeds begin to sprout. Duration of stratification will vary according to seed lot, especially for *E. angustifolia*.

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***E. purpurea*--transplants**.

Seedlings can be transplanted to the field in as little as 3-4 weeks after sowing, or once a true leaf is well established. Young transplants tolerate lower temperatures in the field than the 68 degrees required for germination. Second year plants emerge in the field as early as 4-6 weeks before the last frost date. First year seedlings can be set out as early as two to four weeks before last frost date. They will tolerate a light frost if hardened off prior to planting. Growth is very slow in early plantings. *E. purpurea* will also establish well in significant heat and dryness. This allows for flexibility in incorporating it into a variety of operations.

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E. angustifolia--transplants

Transplant date, size and irrigation were the main factors in successful establishment of E. angustifolia**.** Allow seedlings to get as large as possible in the flats without allowing the tap root to wind around the bottom of the cells. Transplant E. angustifolia after the last frost date. Irrigate through the first season and allow to dry out between watering.

Seedlings were set out two weeks before the last frost date and at last frost date. Transplants did not establish well when planted prior to last frost date. There were significant signs of phosphorus deficiency when attempting to establish in cold temperatures or wet soils.

There was also a strong correlation between transplant size and survival rate.

Transplant size (average length of longest true leaf)	**Survival rate at 2 weeks**
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Survival @ 16 weeks irrigated	**Survival @ 16 weeks non-irrigated**
85%	6%

Direct Seeding

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E. purpurea--direct seeded

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The *E. purpurea* trials demonstrated the most vigorous growth in two situations: intercropped in full sun and grown at high density in partial (late afternoon) shade.

Nine sections were spaced 18 inches apart on center, kept well weeded and cultivated within the beds, other conditions were varied. For one of these sections, (#8), grasses were allowed to grow to a height of two feet on all sides. Section 8 showed the fastest rate of growth and had the greatest number of flower heads.

		Section 8	Section 1-7,9 avg.
average longest leaf length	*@ 8 weeks*	4	3
(in inches)	*@ 16 weeks*	8	5
# flowering	*@ 16 weeks*	12	2

2) The second strongest trial of *E. purpurea* was a 15' by 25' plot of transplants set out at 8 inches on center in partial, (late afternoon) shade. Growth in this section was stronger than in sections 1-7, & 9 (above) but not as vigorous as in section 8 (above). Given that there are two variables, it is not possible to determine whether the success of this plot was due to the increased density or the partial shade. Also the effects of that density on the plants in the second and third year is yet to be determined.

E. angustifolia

Seedlings were set out in high density prairie conditions without irrigation. Establishment and growth were compared to seedlings set out in a well cultivated non-irrigated field. At four weeks the seedlings in high density interplantings were much stronger and had only 25% as many losses as those planted in the well weeded section. The *E. angustifolia* seemed to benefit from the competition and/or the retained moisture from the other plants. Later in the season the competition in the prairie simulation became too much and the rate of attrition was similar at 16 weeks in the two trials. (20% survival in both

the densely planted and well weeded sections). Despite equivalent survival rates, the plants in the well weeded sections did not display the vigor of the survivors in the prairie simulation trial.

E. angustifolia seedlings that were transplanted into well cultivated beds with weekly watering had an 85% survival rate. In this trial there was a significant difference in drainage at the two ends of the field. Although attrition was comparable, seedlings in the well drained area were much stronger at the end of the season. In the second year this trial was treated in two ways. Half of each bed was interplanted with herbs and flowers (at a density comparable to a flower bed rather than that of a prairie). The other half was kept well weeded and cultivated. The interplanted sections showed 25% greater plant volume and 6 times as many flower heads.

E. angustifolia will frost heave easily. Many first year plants heaved entirely out of the ground when left unmulched or without being interplanted. Frost heaving was noted even in the third spring on plants with two foot long tap roots.

Field Management: Insects and Disease

E. purpurea

There was a small percentage of plants that had a virus, possibly spread by leaf hoppers. Other fields and gardens were observed and it was determined that the virus was a regional phenomenon, not limited to *E. purpurea* or to the specific field. Counts taken in 3 different trials on 9/25 demonstrate the following. Virus counts were higher on earlier plantings. Density or partial shade may have been factors as well.

Density	Sun	Transplant date	Percentage of plants with virus
- 8 inches on center	Partial Shade	Late May	7.25%
- 18 inches on center	Full Sun	Late May	4.50%.
- 8, 12 &18 inches	Full Sun	Late July	.50%

Leafhopper emergence, hibernation practices and natural predators are all factors to consider if this problem occurs. Late plantings miss the early spring emergence cycle of the leafhoppers. Leafhoppers hibernate in weeds but tend to avoid perennial grasses. Good fall weed cleanup reduces leafhopper hibernation. Reduce thistles, dandelion and plantain. Well placed perennial grasses can reduce damage. Introduce plants that attract leafhopper predators which include syrphid flies and parasitic wasps. Syrphid flies are attracted to members of the daisy family. The carrot family, buckwheat and white clover attract parasitic wasps. Employ strategies that attract birds, particularly chickadees, purple finches, sparrows, swallows, titmice and wrens, to your fields, all of which consume leafhoppers. (Rodale Flower Garden Problem Solver).

Plants showed no evidence of the virus upon emergence in the second year of growth.

E. angustifolia

E. angustifolia showed almost no insect or disease damage (less than 4%) even when plants were highly stressed. There was, however, a marked sensitivity to low phosphorus when combined with cold, wet conditions. When transplants were set out two weeks prior to frost date, phosphorus stress (red leaves) was evident at a rate of 24% after two weeks in the field. When transplants were set out at last frost date, only 4% showed phosphorous stress after two weeks in the field.

Harvesting & Marketing

When making harvesting decisions consider that you are taking energy from the plant if you remove parts. The leaves are photosynthesizing and feeding your valuable root. At the end of the growing season, energy from aerial parts of the plant is drawn back down into the root for winter storage. Harvesting aerial parts will affect long term root growth.

Echinacea provides multiple marketing possibilities. Seed, leaf, and root are all valued on medicinal markets. Seedlings that require thinning can be sold as perennials. Although the flowers may have some value on the cut flower market the value of the seed they produce if left uncut is significantly greater. Determine your markets prior to making these decisions. Marketing aerial parts requires drying. Most companies require that root be dried as well, although some companies are interested in fresh shipment. In

addition to drying, many companies purchase only cut and sifted product. Once you have an idea of quantity, contact potential buyers to determine what their requirements are. Depending on your facilities you may dry and process the Echinacea yourself or contract the processing with a third party. Consider marketing collectively with other growers. Determine your values when selling your product. Is price your main consideration? Is the quality of the eventual product important to you? The end price to the consumer? The politics of the company? Hmmm.

Seed

Harvest when seed heads are brown and the mature seed separate easily from the cone.

Foliage

Harvesting aerial parts for market results in the loss of seed heads as well as loss to the root. The economic viability of this measure should be carefully weighed. It is one way to obtain early returns on the investment and alleviate some of the financial stress implicit in growing a 3 year crop. There is also the possibility of growing *Echinacea* as a foliage crop and eliminate the labor intensive root harvesting.

Roots

Harvest roots in the fall of the third year of growth. Wait until the seed heads have dried. Some of the foliage may still be green. In Zone 5 harvesting generally occurs between October 1st and November 1st. Harvest gently with a fork to keep the root intact, including feeder roots.

Do not let lack of harvesting machinery stop you from planting *Echinacea*. There are many ways to make harvesting a community project. Consider a harvesting benefit or school project. Also, *Echinacea* is a very late harvest. In zone 5 harvest date ranges from October 1st to November 1st. Try collaborating with other growers with earlier harvests and organize a roving harvest team.

Conclusions, Recommendations & Further Study

Organic cultivation of *Echinacea* is a viable undertaking for reasons of economics, quality herbal production and species preservation. It lends itself well to small scale production. New England is an excellent location for production due to the presence of many small diversified farms and large scale gardens. *Echinacea purpurea* is well adapted to the Northeast and easy to grow. Plant in beds or rows alternating with other cash crops, cover crops, wildflowers or grasses to three feet in height. Introduce plants that will attract beneficial insects either in or surrounding the field or garden. Rely on transplants while experimenting with direct seeding. *Echinacea angustifolia* is not well adapted to the Northeast. Keep trials small to avoid economic losses.

There are other factors than the eventual size and appearance of *Echinacea* that need to be considered when growing the plants for the health care market. What is the relationship between *Echinacea* and the grasses, forbs and wildflowers it grows with? How do the chemical constituents of these plants interact? Do they synthesize to make better "medicine"? Can there be more "medicine" even when there may be less *Echinacea* plant produced at higher interplanting densities? Does *Echinacea* thrive best with certain plants or is there latitude in determining what to use for interplanting? Can it thrive interplanted with a second crop such as cut flowers or other medicinal herbs? This is an important land use issue considering that plants will be in the field for three years. What is optimum density? What are the effects on the root when aerial parts are harvested? Many aspects of these questions cannot be answered until the chemical makeup of *Echinacea* is better understood.