

1. Title: Comparative Study of Weed Management Tools in Vegetables and Berries: Old and New

FNE03-474

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2. Goals of Project: The goal of this project is to save farmers in the Northeast from purchasing and maintaining expensive, redundant, and antiquated tractors and equipment. The project also responds to the desires of market growers in the Northeast to reduce dependence on herbicides for weed control.

For farmers in the Northeast, weed management poses continued challenges that affect the profitability of the entire farming operation. Farmers working on conventional farms often resort to pesticides to control weeds, organic farmers must increase labor to remove weeds, and all farmers rely on numerous tractors and several implements for weed control. I proposed testing a new mechanized method of weed control for vegetable and berry operations that is both efficient and affordable. The proposed method is simple in design and application. It requires the availability of one reliable tractor and two new pieces of equipment from Europe. The results should be of interest to both conventional and organic farmers, as it offers an alternative that will increase profitability and reduce the dependence conventional farmers have on pesticides, plus reduce the overall number of tractors (and associated maintenance costs) and equipment needed by all farmers.

This project looked at two new tools owned by Drumlin Farm--the Einböck Flex-tine Harrow and the Bartschi-FOBRO Star-hoe--and compared their use with more traditional mechanized weeding tools used at two nearby farms--The Food Project in Lincoln, Massachusetts, and Land's Sake Farm in Weston, Massachusetts. Land Sake and The Food Project use an array of cultivating tractors including Allis-Chalmers Gs and International Cubs, and tools such as sweeps, basket weeders, finger weeders, and hilling disks for weed control. All three farms collected data pertaining to four crops: potatoes, onions, fall carrots, and first year strawberries. This project quantified the hours needed to cultivate the four crops at the three farms, and evaluated the challenges and successes of each system. The following report examines the strengths and weaknesses of both systems by comparing Drumlin Farm's data with data taken from the two cooperating farms. This project has outlined the capital expenditures and estimated yearly costs for all three systems.

3. Information about our farm: Drumlin Farm's land is owned by Mass Audubon and is managed as an educational farm. We grow 7 to 8 acres of mixed vegetables, raspberries, and strawberries (another 5 to 6 acres are in cover). We market the vegetables at two weekly farmers markets in Boston, through a 60-share CSA in inner-city Dorchester, a 40-share winter CSA in Lincoln, and at a roadside stand on the property. Since 1999 Drumlin Farm has donated over 30,000 pounds of produce to Boston area shelters and food pantries. I am a full time farmer employed by Mass Audubon Society as crops manager. I have worked at the New Alchemy Institute in Hatchville, Massachusetts, the Intervale Community Farm in Burlington, Vermont, Quail Hill Community Farm in Amagansett, New York, and have been at Drumlin Farm for the past 6 years. The 2003

season was my 16th season farming. The agricultural soils at Drumlin Farm are primarily Tisbury and Haven silt loams. In the vegetable operation we use a 40 HP John Deere 5200 tractor. For primary tillage we use a disk harrow and for bed preparation we use an Einbock s-tine harrow. For cultivating we use an Einbock flex-tine harrow and a Bartschi-FOBRO star-hoe. Both tools are 3-point hitch mounted. The Einböck flex-tine harrow is a blind cultivating tool commonly used in Europe and is catching on in popularity in the United States. It is marketed as "an alternative to chemical weed control", and 70 percent of the success of the weeder "depends on burying of the weed in the shoot stage." The implement is available in North America through HWE Agricultural Technology in Embrun, Ontario, Canada. In May of 2002 Drumlin Farm paid \$1,680 for the harrow. The tool was mentioned in Cornell Cooperative Extension's IPM Fact Sheet 102FSNCT (which is available on line), *New Cultivation Tools for Mechanical Weed Control in Vegetables*. A study also available on line of flex-tine harrows was conducted by the Organic Agriculture Centre of Canada and was titled *Field Pea Harrowing -- Flex-Tine Weeder or Tine Harrow?* The Star-hoe is available commercially from Bartschi-FOBRO in Grand Haven, Michigan. We bought the star-hoe in February 2001 for \$5,541. There are no known studies on the Star-hoe in the United States. At our farm we use the two tools to complement each other. The Flex-tine Harrow is used first for stale-bed preparation, breaking up crusts, and blind, in-row weeding. The Star-hoe is used for pre- and post-emergent between-row weeding and hilling. The Star-hoe requires a second operator to steer the cultivators. The cultivators of the star-hoe are similar to those found on the Lilliston rolling cultivator.

4. Information about project collaborators: Don Zasada manages the vegetable operation at the Food Project in Lincoln, Massachusetts. The Food Project's mission is to create a thoughtful and productive community of youth and adults from diverse backgrounds who work together to build a sustainable food system. They produce healthy food for residents of the city and suburbs, provide youth leadership opportunities, and inspire and support others to create change in their own communities. There are five adult agricultural staff along with two youth interns. Two thousand volunteers assist with the spring planting and the fall harvesting. There are also sixty youth on the farm every day for seven weeks in the middle of the summer. They plant 16 acres of mixed vegetables, herbs, raspberries, and strawberries. Another five acres are in cover crop. They market their produce through a 250 member farm-based CSA, two markets in Boston, and 10 food pantries and shelters in the greater Boston area. Don has been farming for nine years. He worked for two years at Brookfield Farm in Amherst, Massachusetts and has been at The Food Project for seven years. The soil at the Food Project is mainly Merrimack fine sandy loam. The primary tillage at the Food Project is done with a three-point hitch disc harrow mounted to a John Deere 5200. Beds are made using a 1969 International Cub, which has a belly-mounted Budding basket weeder. To help define the beds, rear cultivators are used. The basket weeder is also used for stale bedding and cultivating. Also used on the Cub are belly-mounted sweeps. To hill up crops and to throw soil in rows, Don uses belly-mounted sweeps on the Cub. A 1947 Allis Chalmers G is used for seeding (belly-mounted Planet Juniors) and for cultivating (belly-mounted sweeps).

Mike Raymond is the manager of Land's Sake, which is located in Weston, Massachusetts. Mike has worked at Harlow Farm in Westminster, Vermont, Heifer Project in Perryville, Arkansas, and Holcomb Farm in Granby, Connecticut and has been at Land's Sake for the past 5 years. Mike has been farming for a total of 12 years. The soil at Land's Sake is a rocky sandy loam. They plant 10 acres of mixed vegetables, raspberries, strawberries, and flowers. Another 15 acres are in cover crops. Land's Sake uses a John Deere 2155 (45 HP) for its primary tillage with a disc harrow, moldboard plow, and chisel plow. They also use the John Deere 2155 with three-point-hitch mounted tiller discs and c-tine cultivators. Land's Sake also uses an Allis Chalmers G for belly-mounted basket weeding and cultivation with spring-tooth harrow.

5. What we did in this project: Each participating farm kept data on weed control for onions, first year strawberries, potatoes, and fall carrots. Data was not taken in field preparation, planting, and harvest times. Data collection sheets were provided (see appendix). The data collection tracked the linear feet planted, tractor hours required per planting, number of operators, the equipment used, and hand labor hours.

With the collected data, I've equated hours spent on each crop for each farm and the tools used. From this, a ratio of linear feet to hours/minutes spent has been determined. With this information, the report will compare more traditional weed management tools used in this project with the combination of the two European tools.

6. Results and accomplishments:

Drumlin	potatoes	onions	strawberries	carrots
tractor minutes	395	105	627	45
labor minutes	0	945	2325	1065
total work minutes	395 445	1050	2952	1110
linear feet	11970	2730	7392	5460
minutes/linear foot	.033 .037	0.385	0.399	0.203
seconds/linear foot	2.23	23.08	23.96	12.2
Food Project				
tractor minutes	345	30	45	45
labor minutes	0	1140	705	720
total work minutes	345	1170	750	765
linear feet	11400	7200	1800	4000
minutes/linear foot	0.03	0.163	0.417	0.195
seconds/linear foot	1.82	9.75	25	11.48
Land Sake				
tractor minutes	300	60	780	60
labor minutes	450	1020	2760	960
total work minutes	750	1080	3540	1020
linear feet	2000	3150	4000	3600
minutes/linear foot	0.375	0.343	0.885	0.283
seconds/linear foot	22.5	20.57	53.1	17

In the following text I will explain how each farm used their tractors and tools on each crop, relate anecdotes from the farmers, and share their perceived challenges and successes.

Drumlin Farm:

General comments: Drumlin Farm's beds are 60" wide. Crops such as onions, beets, and carrots are planted 3 rows per bed, with rows 17" apart. Crops such as broccoli, leeks, peppers, and potatoes are planted 2 rows per bed, with rows 34" apart. Crops such as tomatoes, peas, and cucurbits are planted one row in the center of the bed. Drumlin Farm tries to get out at least every week with both the Flex-tine Harrow and Star-Hoe. Depending on the stage of the crop, the Flex-tine is used (it is not used on crops smaller than about an inch or after plants become so large that they get knocked over). For the most part, the Star-Hoe is used at all stages of plant development, from the pre-emergent phase of direct-seeded crops, to the fully mature stage of crops such as peppers and eggplants. With crops such as potatoes and brassicas, the Star-Hoe is used until the rows fill in.

Potatoes: Potatoes were first cultivated on May 15 with the Flex-tine Harrow. This was 15 days after the spuds were planted. Some weed seeds had germinated, but the potatoes had not yet emerged. Just after the potatoes emerged, we flex-tined on May 29th. The action of the tines broke up a crust that was on the soil due to heavy rainfall in the previous couple of weeks and thus accelerated the emergence of the potatoes. The following day we brought the star-hoe through the field primarily to try to get rid of some chickweed that the flex-tine did not kill. The star-hoe did a great job on the chickweed. We flex-tined one more time on 6/3. After this, we hilled the spuds on 6/10, 15, and 27. We did no hand weeding in the field. The field was very clean (i.e. no weeds) until the potato plants started dying back in late August. We used hiller furrowers in mid-September, and again in early October on the late spuds so weeds wouldn't foul the potato digger.

Onions: Regular stale-bedding in the month preceding the transplanting of onions produced relatively clean beds and resulted in a successful harvest. We waited for nearly a month before we used the flex-tine for the first time. It probably could have been used earlier, but I wanted to wait until I was sure the plants were well established. After the third cultivation we had to do hand in-row weeding. In total, we hand-weeded four separate times. We continued using the flex-tine and the star-hoe weekly until 7/21. At that point, the onions were getting knocked over by the flex-tine. In the last two cultivations, we used the Star-Hoe in the paths only because the plants were too large

within the bed and would have been damaged by the rolling cultivators.



Figure 1. flex-tining 1st year strawberries at Drumlin Farm

Strawberries: The strawberries were cultivated with the star-hoe and the flex-tine starting on 5/7 and continuing weekly until 7/27. Leading with the star-hoe helped break

up crusts (2002 was a wet year), and the flex-tine did a good job getting rid of in-row weeds. On 8/15 we went through with just the star-hoe to help define the rows for the following season. The strawberries were hand weeded four times throughout the season mainly for buckwheat, which had been the previous season's cover crop.



Figure 2. star-hoeing just emerged carrots at Drumlin Farm

Carrots: The carrot beds were stale-bedded with the flex-tine four times before we seeded the carrots. For cultivating equipment we used the star-hoe exclusively and we hand weeded three times. On our last hand weeding day we also thinned the carrots.

Food Project:

General Comments: The Food Project plants crops in either one or two rows in beds 40" wide. The one-row crops are larger plants, such as potatoes and sweet corn. Smaller vegetables such as beets, carrots, and onions are planted in two rows. Using the Cub, the one-row crops are basket-weeded once seven to fourteen days after planting, and then sweeps are used on the Cub once a week for two weeks. A week or so after the

second sweep, discs are used on the Cub up to three times to throw soil in the row. Two-row crops are basket-weeded twice using the Cub, seven to fourteen days after planting, and again after a week. Then the G is used with the mid-mounted sweeps in a seven to ten day succession. Depending on the depth of the sweeps and the speed of the tractor, soil can be thrown with sweeps. In the second pass, more soil is thrown.

Potatoes: Similar to Drumlin Farm, the Food Project started cultivating using the Cub and basket-weeder before the potatoes emerged on May 2nd. They then used the Cub with sweeps for the next two weeks, and on June 16th they hilled the potatoes for the first of three times. The Food Project, like Drumlin Farm, did no hand weeding in the potatoes.

Onions: The onions were cultivated twice at the Food Project. On both June 2nd and 16th the Allis Chalmers G was used with sweeps. The onions were hand weeded four times. Hoes were used for the last four hand weeding. Don noted the first hand weeding took longer than the others because he put row covers over the plants to prevent root maggot. The cover saved the onions from the root maggot, but prevented early cultivation and allowed weeds to flourish before the cover was removed.



figure 3. Allis Chalmers G with sweeps in onions at the Food Project

Strawberries: On May 2nd, the Food Project used the basket weeder on the Cub to cultivate the berries, and on June 3rd the sweeps were used on the Cub. That was all the tractor cultivating they did. They hand weeded the strawberries beginning May 10th almost every two weeks until August 14th. Don noted that of all the crops in this study, strawberries were the one he had the

most problems keeping weed free. This is the only crop that Don can't hill-up because the sweeps would cover the strawberries.

Carrots: The Food Project used the Cub with basket weeder on July 14th and then the G with sweeps on August 5th. Don noted that the carrot beds were very clean from the start. They hand weeded twice on August 12th and August 19th.

Land Sake

General Comments: Land Sake has beds on 60" centers. Strawberries and potatoes are planted in one row and carrots and onions three rows per bed and 14 inches apart. On their carrots and onions, they twice use the Budding basket-weeder mounted on the G, twice and then rely on hand weeding. In the potatoes, they use the Allis Chalmers G with a spring-tooth cultivator, and for hilling, the John Deere 2255 with hiller disks. Mike plants winter rye strips between potato rows, and mows them in the

summer to create mulch between the rows. For the strawberries, he relies on the G with a basket-weeder, and then the G with spring-tooth cultivator. He then defines the rows with a BCS tiller. Mike also uses a backpack flame-weeder to make stale-beds. Middle school children perform many of Land's Sakes hand-weeding hours.

Potatoes: Potatoes were first cultivated on May 20th with the spring-tooth cultivator and again on June 1st. They were then hilled once on June 13th. On June 15th and July 7th the edges between the rye mulch and the potato hills were mowed. The potatoes were hand weeded twice on June 5th and July 1st.

Onions: Mike basket-weeded the onions twice with the G (June 1st and 18th) and then relied on hand weeding three times (June 2nd, 20th, and July 10th).

Strawberries: Land's Sake relied on the G with basket weeders (May 12th) and spring-tooth cultivator (May 19th, 27th, June 4th, and 15th), a BCS tiller (July 1st and August 1st), and hand weeding (May 20th, June 3rd, July 1st and August first) to cultivate the strawberries. Mike noted that some of these hours included picking off blossoms while hand weeding.

Fall Carrots: Mike used the Allis Chalmers G with basket-weeder twice (July 15th and August 1st), flame weeded once on July 8th, and hand-weeded on July 25th and August 15th. He noted that there seemed to be a lower than average weed pressure.

Summary of Results and Accomplishments:

Potatoes: Both Drumlin Farm and the Food Project were able to keep the seconds/linear feet ratio low (Food Project 1.82 sec/lf and Drumlin Farm 2.23 sec/lf). The Food Project managed to do this by using their Cub with Basket weeders to reduce early weed pressure (pre-emergent) and then hilling the spuds three times with the Cub and Discs. This effectively smothered most weeds, leaving the crop clean without requiring any hand weeding. Drumlin Farm accomplished the same end using the flex-tine harrow on the pre-emergent potatoes and then aggressively hilling them 3 times. This crop was weed free as well without any hand weeding. Because Land's Sake had to perform in-row hand weeding, their seconds/linear feet ratio was much higher (22.5 sec/lf). They also managed the crop using a soil conservation technique (rye strips between rows) that added two hours of tractor work to their data.

Onions: Land's Sake and Drumlin Farm had very similar numbers (Land's Sake 20.57 sec/lf and Drumlin Farm 23.08 sec/lf) while the Food Project showed a much greater efficiency with 9.75 sec/lf. Land's Sake and the Food Project approached cultivating the ~~carrots~~^{onions} similarly—they both went through with a basket weeder soon after planting. The difference was in their second and last cultivation: Land's Sake went through again with the basket weeder, while the Food Project went through with sweeps, which threw enough soil to cover in-row weeds and thus reduce hand-weeding time. All farmers had similar hand weeding times (Food Project 19 hours, Land's Sake 17 hours, and Drumlin Farm 15.75 hours). A big difference in the management of this crop was that Drumlin Farm went through six times with the star-hoe (May 20th, 30th, June 6th, 16th, and August 4th and 21st) and five times with the flex-tine May 30th, June 17th, 26th, and 28th and July 5th). It is important to keep in mind how the different farms planted their onions. The Food Project and Land's Sake both planted their onions four to six inches apart in the rows while Drumlin Farm planted three onions in a group every six inches.

In doing so Drumlin Farm compressed the amount of space needed to grow the crop, but in doing so made the hand weeding more intensive and thus slower.

Strawberries: One crop that was a challenge to cultivate for both the Food Project and Land's Sake was strawberries. Mike mentioned he sometimes uses the spring-tooth cultivator to throw soil in-row and then goes through by hand to uncover the plants. Don mentioned that strawberries were the one crop in this study that was "not completely clean". Drumlin Farm, on the other hand, had a lot of success keeping the strawberries



figure 4. star-hoe cultivated strawberries

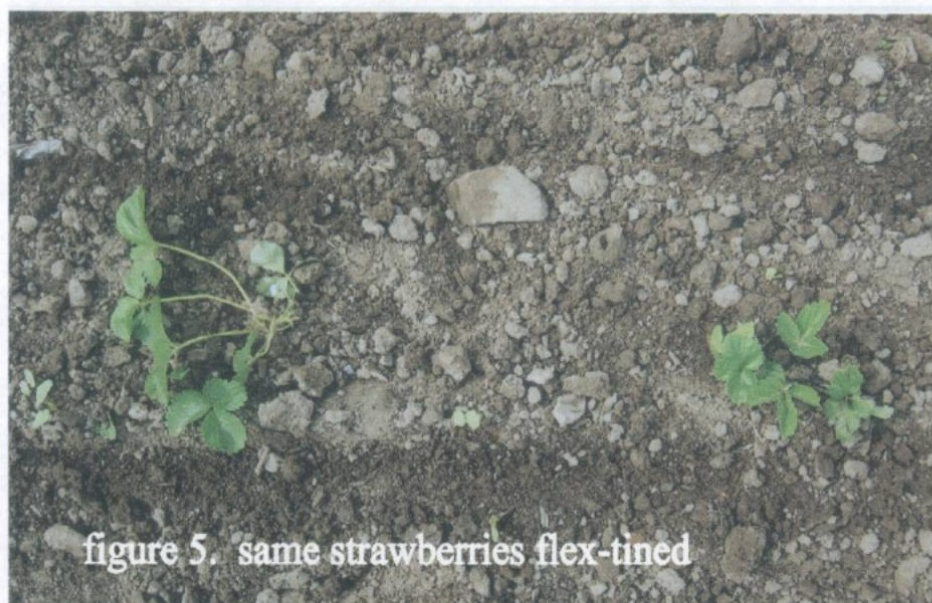


figure 5. same strawberries flex-tined

clean with the use of the flex-tine harrow for in-row weeding.

Carrots:

The carrot data came out very similar with the Food Project at 11.48 sec/lf, Drumlin Farm at 12.20 sec/lf, and Land's Sake at 17.00 sec/lf. All the farms did some sort of stale-bedding, followed by two cultivations and some hand weeding. Don mentioned that the stale-bedding (which he does throughout the summer in preparation for the carrots) is much more important than the equipment he uses to cultivate the carrots. Don

used the Cub/basket weeder combination to stale-bed while Land's Sake used their backpack flame-weeder twice, once before seeding and then once just before germination, while Drumlin Farm used their flex-tine harrow.

7. Site specific conditions: There were no site conditions or aspects of the 2003 growing season that affected the results.

8. Economic findings: Below you will find a spreadsheet of the original costs of the equipment and tractors used on each farm in the study. Also included are the approximate yearly maintenance costs of each item as well as a yearly cost for each piece of equipment over a 10-year period. Each then totaled the yearly costs for each farm. Not included in this are the costs of each of the farm's Diesel tractors. Assumed is that the general cost of those tractors is similar.

The spread sheet shows that the capital expenditures for tools and cultivating tractors by the participating farms varies from a high of \$9,225 to a low of \$5,400 and the projected yearly cost varies from a high of \$1,832 to a low of \$817. Where the three farms differ is that the Food Project and Land's Sake will incur maintenance costs on their cultivating tractors every year for as long as they keep them. For Drumlin Farm the yearly maintenance costs are substantially lower. A cost of these systems that is hard to figure is when a cultivating tractor is out of service. A tractor that breaks down during the growing season can have a tremendously adverse effect on the bottom line of a growing season. Both Don and Mike mentioned that their tractors were not the most reliable pieces of equipment while Drumlin Farm has run into no problems with their system (i.e. the tractor has started every morning for the past four years).

The Food Project

Tools and Tractors	Cost	Yearly maintenance	Yearly cost over 10 years
1969 International Cub	\$3,000	\$300	\$600
1947 Allis Chalmers G	\$3,500	\$500	\$850
Budding basket-weeder	\$1,100	10	\$120 \$220
Disks and sweeps for Cub	\$1,125	0	\$112
Sweeps for G	\$500	0	\$50
Totals	\$9,225	\$810	\$1,832
Land's Sake			
Allis Chalmers G	\$3,000	\$500	\$800
Hiller discs and c-tine	\$200	0	\$20
Budding basket-weeder	\$500	\$10	\$60
Spring-tooth cultivator	\$250	0	\$25
BCS tiller	\$1,200	\$20	\$140
Backpack flame-weeder	\$250	0	\$25
Totals	\$5,400	\$530	\$1070
Drumlin Farm			
Bartchi-FOBRO star-hoe	\$5,541	\$75	\$629
Einbock flex-tine harrow	\$1,680	\$20	\$188
Totals	\$7,221	\$95	\$817

9 and 10: Assessment and adoption: This study pointed towards two improvements that Drumlin Farm could make. One is to explore other flex-tine harrows on the market. The Einbock, with its 8mm gauge tines, tends to be a little too aggressive (i.e. it knocks over and/or unearths plants). I have also used a Lely flex-tine cultivator, which has 6mm gauge tines and tends not to be aggressive enough. A problem I have found (and other farmers I have spoken to have mentioned the same thing) is that the 6mm tines follow the groove made by the preceding tine. When this happens, the beds are left with a series of grooves of partially disturbed soil. I saw an interesting flex-tine harrow (see photo) at Pioneer Gardens in South Deerfield, Massachusetts. The Dutch Gercon flex-tine harrow uses thin tines like the Lely; however these tines are not fixed but move back and forth (i.e. perpendicular to the direction of the tractor). This zigzag motion across the beds negates the problem of thin tines following the groove made by the preceding tines. Jaap Molenaar of Pioneer Gardens says that this hydraulic driven tine motion allows him to use this tool exclusively in some crops. He said "of all the machines I have this is the best...[but] you need the discipline to use it often". Jaap tries to use it every four days.



figure 6. Gercon flex-tine harrow

The

second improvement I feel we could make at Drumlin Farm is to get a better seeder so we don't have to do as much thinning. Presently we use a gang of three Earthway seeders that tend to seed

crops much too thickly, adding many hours of thinning in the process. The Food Project and Land's Sake use tractor mounted (on their Gs) Planet Juniors. Mike and Don do no thinning. Otherwise, Drumlin Farm will continue to use the combination of Star-hoe and flex-tine harrow.

11. Outreach: Outreach will involve a CRAFT (Collaborative Regional Alliance for Farmer Training) of Eastern Massachusetts visit to Drumlin Farm. The CRAFT visits are open to all farmers and apprentices in the region. The first visit took place in July 2003. Another tour took place in April 2004.

Another part of the outreach was to be the creation of a simple booklet discussing this study and its findings. After completion of this study I realized that an abbreviated booklet would not be coherent enough to explain the study and because of this, and after speaking with Dale Riggs about this dilemma, the booklet was not completed. An article

in the August 2003 addition of The Vegetable Growers News highlighted this study (see appendix).

12. Report Summary: I often use this analogy with the apprentices on the farm. If you had to commute each day to work would you buy a 1940s or 50s era car to get to work? When I look outside my window to the Boston commuters the answer seems to be neither. But why do so many farmers rely on old tractors and old equipment to make a living? Answers I've come up with are as follows:

- a. They inherited the equipment (i.e. it's paid off).
- b. They either learned on the equipment as a worker or have seen similar systems replicated on multiple farms.
- c. Fabricating equipment on the farm is a northeast tradition. It's a challenge answered by homegrown ingenuity (a.k.a. Yankee ingenuity).

Positives and negatives of the system we use at Drumlin Farm.

Positives

- a. It doesn't take years of knowledge to purchase the equipment. Just a credit card and a phone.
- b. Relies on one reliable tractor: This means a tractor that starts up every morning. This is a great positive for farmers who are not mechanically inclined.
- c. Having only one tractor reduces capital expenditures. You can put your money into one very good tractor instead of perhaps spreading out your available capital on two or more tractors.
- d. The pieces of equipment are comparable to using other systems used in this study.
- e. These two pieces of equipment work on numerous crops. You can make stale beds, cultivate between-row and in-row on some pre-emergent crops, you can in-row weed with the flex-tine (this study showed this to be important for efficiency of cultivation in the strawberries and potatoes), and hill crops with the star-hoe.
- f. Doesn't require trial and error. In other words, no time is lost making prototypes, trying them out, modifying, fabricating, etc. You have a working system in a couple of phone calls.
- g. This study shows that this system can be as efficient as using the older, tried and true methods.



- h. The star-hoe and flex-tine cost very little to maintain. This is in contrast to the costs of keeping an old tractor in working order.
- i. This system is easy to purchase and to apply and a highly

attractive option for a farmer who is just starting up.

Negatives

- a. A very significant feature is that it takes two people to operate the star-hoe.
- b. It may not make sense for someone who has a working system already.

A tremendous challenge for new farmers is how to mechanize a farm efficiently. How to get every dollar out of the equipment bought. A model embraced by many farmers in the northeast is to purchase old cultivating tractors and attachments for these tractors. Inherent with this model is that older tractors are not as reliable as newer ones. For a new farmer the emotional stress as well as financial stress of an unreliable tractor is great.

This project offers an alternative to existing cultivating systems through the application of European cultivating technology. Here at Drumlin Farm, using the Bartchi-Fobro star-hoe in combination with the Einbock flex-tine harrow has far exceeded our expectations. The combination is versatile and easy to understand and use. The star-hoe is a multipurpose tool used between rows on most every crop; it also hills potatoes, brassicas, and leeks. Comparatively, the other farms in this study used combinations of tractors and equipment to achieve the same goals as the star-hoe. Land's Sake requires a Allis Chalmers G with a basket weeder (pre-emergent and immature crops), spring-tooth cultivator, a BCS tiller for in-row cultivating, a backpack flame weeder to make stale beds, and hiller disks mounted to their John Deere 2255 for hilling. Instead of the star-hoe, the Food Project uses a combination of tools and tractors: an Allis Chalmers G with mid-mounted sweeps for in-row cultivating, the Cub with a Budding basket-weeder on pre-emergent and immature crops, and a disc and sweeps for taller crops that can be hilled. Both farms use hilling discs and sweeps to throw soil in-row. Drumlin Farm accomplishes this end by using either the star-hoe or flex-tine harrow. Both Land's Sake and the Food Project's approach to cultivating is relatively complex in comparison to the simplicity of the star-hoe and flex-tine. We use the flex-tine harrow for stale bedding and for blind, in row cultivating of crops such as potatoes, onions, and strawberries. The flex-tine has been particularly effective in our onion and strawberry plantings and has helped reduce our hand weeding in the potatoes to zero.

Drumlin Farm Income 2000 through 2004

Year	Income	Income change from previous year	Comments
2000	\$23,950		
2001	\$33,460	plus 40%	1 st year star-hoe
2002	\$49,557	plus 48%	1 st year flex-tine
2003	\$59,900	plus 21%	
2004	\$58,275	minus 3%	

The study found that this equipment provides effective weed-control for a wide range of vegetable crops. The study also points out that the equipment is readily available, easy to use, and that this alternative system is as efficient as other, more traditional systems. The study also suggests that the new European tools can provide a more reliable means of cultivation. The study also documents how Drumlin Farm has seen a steady increase in sales since purchasing this equipment. In fact, from the year 2000, which was the growing season prior to acquiring the equipment, Drumlin farm has realized , without additional labor hours, an increase in sales to of 150 percent.



figure 8. Hilling potatoes with the Star-hoe at Drumlin Farm

12/28/2004
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Drumlin Farm Vegetable Donations 1999 to 2004

	1999	2000	2001	2002	2003	2004
Pine Street Inn 444 Harrison Ave. Boston, MA 02118 (617) 521-7136	450 lbs.		800 lbs.	500 lbs.	1640 lbs.	2,250 lbs.
Casa Nueva Vida 53 Gould St. Jamaica Plain, MA (617) 524-6332		1250 lbs.	1380 lbs.	2275 lbs.	2065 lbs.	3,300 lbs.
Parker Hill/Fenway ABCD Food Pantry 714 Parker St. Roxbury, MA 02120 (617) 445-6000		2840 lbs.	2370 lbs.	2170 lbs.	3010 lbs.	2,250 lbs.
Food For Free 11 Inman St. Cambridge, MA 02139 (617) 868-2900					700 lbs.	2,250 lbs.
Total pounds	450 lbs.	4090 lbs.	4550 lbs.	4945 lbs.	7415 lbs.	9180 lbs.
Totals for 1999-2004	30,630 lbs.					