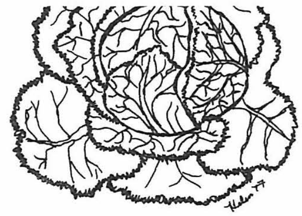
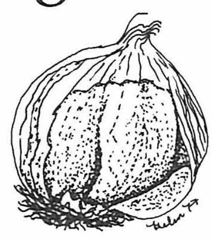
Land and Its Use

Our gardens seem to get better each year. Over the past few years, Hilde Maingay has incorporated the use of raised beds and sheet composting to our repertoire of general organic gardening practises. She has concentrated on intensive growing techniques and on high productivity. Hilde describes the work in her article entitled "Intensive Vegetable Production." Susan Ervin's attitude toward agriculture like that of her cooking reflects characteristic practicality in learning what crops are adapted to an area in terms of productivity, soil health and nutritive value. Her articles on "Experimenting with Growing Beans", "Mulching", and "Irrigating with Fertile Fish Pond Water" are the results of her attempts to achieve useful data in a field in which folklore and hearsay tend to predominate.

Photos on this and previous page by Hilde M



Intensive Vegetable Production



– Hilde Maingay

Introduction

Intensive vegetable production utilizing raised beds has proved suitable for both the small farmer and the backyard gardener. Unlike agri-business, it uses simple, low cost equipment, does not rely on non-renewable fossil fuels for fertilizers and pesticides, uses the soil area and the sun's energy effectively and recycles materials from the local community. Over the years the soil is improved and the production and quality of food is increased. The demand on materials from the outside and on labor remains stable or in some cases declines. This type of horticulture uses companion and succession planting, raised beds, mulching and composting, techniques which have been established over thousands of years in conjunction with the new understanding and knowledge gleaned from modern science.

Current American intensive gardening techniques are derived from a combination of two European horticultures; biodynamic techniques developed under the influence of Rudolph Steiner in Europe in the 1920's and French intensive techniques begun in the 1890's in the suburbs of Paris. Biodynamics contribute raised beds, companion planting and organic manures. The French intensive method includes close-spacing techniques which reduce weeds and hold water.

Eugene Odum has stated that agricultural scientists have repeatedly found that maximum productivity of broad-leaved crops occurs when the leaf surface area exposed to the incoming light from above is about four to five times the surface area of the ground. Average conventional agriculture falls well below this maximum efficiency. A great portion of the surface area of the ground is left bare to allow for mechanized farming. This, in turn, calls for increased irrigation and other energy-consuming practices to balance the adverse effects of barren soil and heavy equipment.

In an intensive agriculture using a complex planting scheme with variety and succession, maximum productivity of broad-leaved crops can be achieved while demands on water and labor requirements decrease.

Preparation of the Raised Beds

To prepare the beds in the New Alchemy gardens for intensive cultivation, a strip of soil one foot wide was dug to a depth of six to twelve inches. The soil was spread over an area four to five feet in width to form a planting bed. The strips that had been dug out became the pathways between successive raised beds. Twenty such beds were made, each approximately forty to forty-five feet long.

Tools: The garden tools used were a shovel to build the beds and dig the paths and a rake to smooth the surface. Auxiliary tools included a pitchfork to spread leaves, seaweed and other organic matter, a posthole digger for the bean posts, a trowel to set out the seedlings and string as a guide in making straight lines.

Labor: It took one woman of average size and strength two days to build these twenty beds.

Advantages: Raised beds are more convenient to work than those at ground level. There is less bending. A clear distinction is created between pathway and growing area so there is less chance of stepping on freshly seeded rows. Pathways can be a nuisance to keep weeded. With raised beds, a layer of top soil can be added where it is most needed without robbing another growing area.

The sides of the raised beds create more total surface area although the total amount of radiation received by them may be the same as with flat beds. It is distributed differently over the ridges, however. During the day, seeds and small plants, before they are big enough to alter the microclimate, gain sub-

Title Art by Helen Jacobson

Drawings by Hilde Maingay

stantial heat, especially in beds which run north and south as ours do. The plants respond to the extra heat by sprouting sooner and growing more quickly. Once established, the plants create a microclimate around and especially under the leaves, which protects the soil surface from becoming overheated, drying out or eroding.

The sides of the beds are still exposed to the weather, wind, sun and rain, and protection is necessary. This can be achieved by placing wooden boards against the sides. They are effective but costly and make a less flexible garden set-up. A thick mulch works well, but the slope of the sides of the beds must be gentle for the mulch to stay on, which takes a fair amount of space. The solution we adopted was that of sheet composting.

Sheet Compost in the Pathways

Sheet composting differs from a standard compost pile in that thin layers of organic materials are spread over the soil, rather than being piled in one heap. It has an advantage in that gathering and spreading can be done at any time whereas a regular compost pile must have all the material within a one or two day period. We were able to take all material except grass clippings from unknown sources, since they often contain residues of herbicides and other lawn fertilizers. When possible a layer of manure was added after two layers of green matter. Our manure is mainly from stable horses bedded on woodchips. The rest of the organic materials consisted of dry leaves, unwashed seaweed, garden wastes like weeds, vegetable parts and flowers, and once a few loads of straw from the local county fair with an exotic selection of elephant, tiger and goat manures.

As the season progressed, the pathways were filled, deterring the weeds and keeping the sides of the beds covered and cool. There were additional unanticipated advantages:

- Running back and forth with weeds and garden wastes was eliminated
- A single unloading of compost materials
- Improved absorption and retention of water in the beds
- Beds moister and cooler than with mulch

The composting materials absorbed more rainwater and run-off water from the beds than the same amount of materials in a compost pile would have. No additional water was necessary to decompose the materials. If irrigating is done by flooding the pathway ditches, the plants receive water enriched with leached out nutrients from the sheet compost and the decomposition of materials is hastened. We noted a large population of earthworms under the strips.

During the relatively slow decomposition process, CO_2 is given off. Insufficient CO_2 is one major limiting factor in plant growth. In pathway sheet composting, CO_2 is released slowly and constantly. Later, when the compost is buried, the CO_2 remaining is released into the ground, beneath the plants.

With all these advantages, sheet composting still does not completely replace the regular compost pile. In a well-built, balanced pile, the heat created during the first decomposition process can kill grubs, eggs and some pathogenic organisms. In the next steps of the breakdown process, the action of fungi produces antibiotics and growth hormones in higher concentration than is possible in regular soil.

Rotation of the Raised Beds

At the end of the growing season, all the beds were moved a third of their width by digging up part of the beds and putting dirt on top of the sheet compost filled pathways. At the same time new pathways were created.

Incorporating Organic Matter: All the organic materials were buried beneath a layer of top soil where further decomposition occurred over the winter, forming the growing medium for the next year's plants. Over a period of three years, a new layer of humus approximately six inches thick will have been placed under about six inches of top soil. Last spring, due to lack of snow in the winter and rain in the spring, the previous year's layer had not decomposed properly and a residual mat of dry leaves under the soil concerned us. It was decided to plant non-root crops like broccoli, brussels sprouts, eggplant and soybeans there and to seed carrots in plain dirt. All grew well. The leaves and the other organic material under the dirt decomposed fully over the summer.

Stimulating Soil Organisms: To maintain soil health, periodic addition of organic matter has proved to stimulate soil organisms. Earthworms play an important role in this process by stabilizing and even increasing soil fertility. Their numbers, appearance and vigor are good indicators of fertility. They improve the physical structure of the soil and produce nutritive materials for growing plants as well as being in themselves a food for a large variety of birds. Earthworms break down large quantities of leaves and other litter. They contribute to the nitrogen content of the soil as well as to its aeration.

Cultivation

Using the intensive raised bed method, we found little or none of the usual cultivation necessary.

Weed Control:

Mulch - Where and whenever possible, a mulch consisting in the main of a mixture of seaweeds and eelgrass was applied between the plants. Mulch helps retain moisture in the soil and helps prevent weed germination.

Intensive Planting - All plants in the beds were grown as close together as healthy growth would allow. The canopy of leaves produced once the plants have begun to grow shades out undesirable competitors and creates a beneficial microclimate for the plants themselves.

Fertilization

In our raised beds we used four methods of adding nutrients to the soil.

Compost: Several compost piles were built. Some were slow decomposing piles left over winter, others were quicker and decomposed fully in a few weeks. The same proportions of two to one of green and animal manures as in the sheet compost method were used. The finished material was used as a fertilizer, sprinkled around the base of each plant.

Mulch: Most of our mulch consisted of dry leaves gathered during the previous fall and piled up over winter or seaweed collected from the local beaches during the growing season. The seaweed is left unwashed to avoid leaching of nutrients. There is considerable precedence for this as a gardening practice. No tests have been done as yet to establish the salt content of our soil or the possible increase of salinity over the last five years. Depending on the time in the season as well as the year, our mulch consists on the average of 85% eelgrass which is not a seaweed and 15% a mixture of codium and other seaweed species. In the fall it is dug in or covered over by top soil to trigger decomposition.

Rock Minerals: Small amounts of commercial rock minerals were used including glauconite greensand which is an iron potassium silicate and an undersea deposit. Dolomite was applied to raise the pH of the soil.

Sheet Compost: See previous discussion.

Irrigation

To achieve maximum plant growth, water should be available constantly to plant roots. A heavy rainfall can saturate the soil, but even when it fulfills the moisture requirements of the plants it is not consistently available. Most of the water drains away below the root zone or evaporates into the air, making it necessary to replenish water between rainfalls.

Hose Sprinkling: Most of our watering was done by hand with a garden hose and tap water. Each bed received three minutes for a light watering and five minutes for a heavy watering. Hand irrigation has many drawbacks including the expense of tap water, and the application of chlorine and other possible additives with adverse side effects. It is time-consuming. It is also inefficient use of water in that distribution is uneven. There is loss through evaporation and high water pressure requirements. To alleviate some of these problems the following system was tried.

Because soils with a high percentage of organic matter and good water holding capabilities have a profile of underground water seepage that extends horizontally before it drains down, we hoped that by flooding the pathways with water a significant percentage would penetrate the beds. This proved true. Up to one foot on each side of the paths was replenished with water in this way.

Two wooden boxes, formerly used as fish tanks, 4' x 4' x 4' in size, were placed at the end of the beds (Fig. 1). Each was filled with tap water and left to stand for at least 24 hours to release the chlorine. Flexible black plastic tubing 1½" in diameter and at least 20' in length was attached to the bottom of the box. The tubing was placed along the pathway. In five to ten minutes the contents of the box drained into the pathway. Slowly the water soaked into the beds as well as draining into the ground. We were pleased that the soil had the capacity to hold the water for long enough to fill the 40' pathway ditch and to retain it for a while. The preceding summer, water in a trench would not flow further than three feet before draining straight down.

We found this watering system to be quite satisfactory. The plastic tubing was moved easily from one path to another. The low pressure, gravity-fed application is gentle and evenly distributed. Loss by evaporation is kept to a minimum. In late summer when the paths became increasingly filled with mulch, the need for irrigation lessened. The next step is to gain direct access to water, either from the water table or a nearby pond. We shall most likely use wind power as the energy source.

Drip Irrigation: We tried making seeping hoses from black plastic pipe. We placed the small holes in the hose at the base of each plant. The hose was fed by gravity from one of our cement fish ponds. Even the slightest unevenness in the ground, however, affected the water flow.

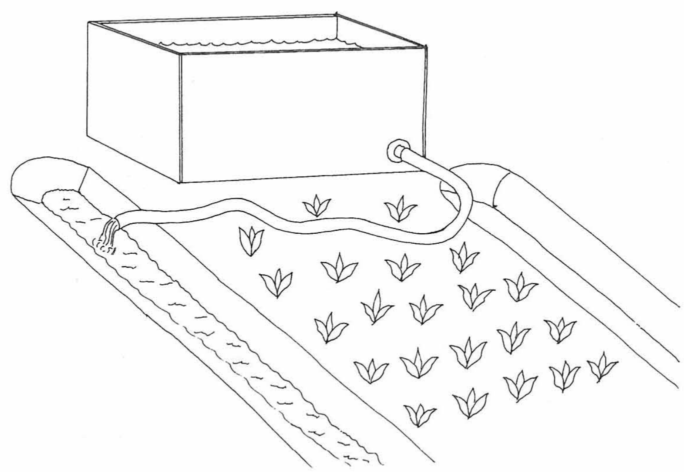
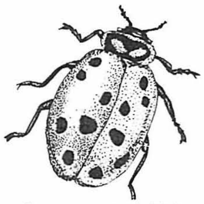
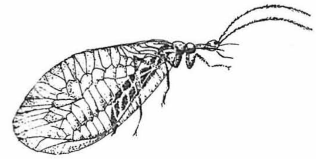
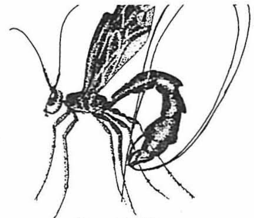


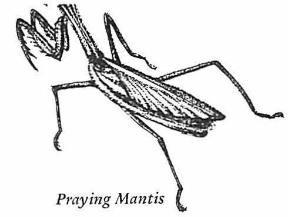
Fig. 1
Wooden Irrigation Box and Ditch or Pathway Between Raised Beds


Convergent Ladybird


Gold Eye Lacewing


Robin


Parasitic Wasp


Praying Mantis

Pest and Disease Control

Insects Observed: The following is a list of the most significant insect pests observed in the intensive gardens, the problems they represented and what was done about them:

Pests

White Flies, Aphids, Flea Beetles: no significant damage
Cabbage Worms, Squash Borers: hand picked, minimal damage
Corn Borers: no picking or other control, damage in about 1/3 of the ears, limited mostly to tips
Cucumber Beetles: no control, resulting in cucumber wilt which killed at least 75% of the plants
Mexican Bean Beetles: decreased production, all plants eventually killed, extensive hand picking done

Beneficial Animals Observed

larva and adult of Lady Bird Beetle
praying mantis
toads: created cool, muddy places to attract them, but they found their own favorite places elsewhere between the vegetables
birds: many types of bird houses tried, as well as fences and posts, and sunflowers as a food source

Responses

Cultivation Methods: Traditional methods were used. No extreme methods such as flooding or burning were necessary.

Planting Schemes: Plant varieties were chosen for disease and pest resistance. When possible they were grown from purchased seeds produced in climatic conditions similar to ours, without chemical fertilizers and pesticides. A wide range of seed varieties was used for each type of vegetable.

Companion Planting: This was used extensively to optimize space in relation to incoming sunlight and available nutrients and water. Many combinations of plants have been suggested as beneficial in pest control because of their ability to attract or repel certain insects by color, taste, smell or by chemical excretions from the roots. For example, marigolds are thought to control nematodes for as long as three years.
Meadow nematodes are microscopic worms which feed on roots of many different plants. For maximum effectiveness marigolds should be rotated with food crops. This has been a problem for us as we have an aesthetic preference for flower borders around vegetable plots. Most companion planting is not scientifically documented but is based on the collective experience of gardeners over many years.

Even less well documented are the ratios in which companion plants should be grown together. One study has shown that planting one onion to every five or ten cabbages promoted growth in cabbages, but that more onions inhibited growth.
The aromatic powers of the food and companion plants have to be synchronized for effectiveness. Other flowers particularly those of the Compositae family, like the sunflower and many herbs, are helpful in pest control by providing shelter and nectar for predators or pests. We used them for this purpose.

Biological Sprays: In general, our focus has been on improving the soil rather than experimenting with home-made or commercial biological sprays. This cautious approach is not without reason. In the past, our experiences with home-made garlic and pepper type sprays were never sufficiently successful to continue their use. Any successful techniques known to our readers would be welcome.

Because there is little extensive long-term knowledge of the effects of so-called natural insecticides like pyrethrum and rotenone on animal life in general and of their residues in the soil in particular, it is difficult to accept these natural insecticides as harmless on the basis of their ability to break down in a short period of time. Because of this, all natural insecticides were avoided in the intensive beds although rotenone was used elsewhere in the gardens.

Since the Cucumber Beetle and the Mexican Bean Beetle were our major pest problems and could not be controlled by hand picking, an effort was made to grow those vegetables affected by them elsewhere in the gardens with the help of rotenone. In these cases the vines were hand picked as soon as the beetles appeared, which is always when the first flowers show, no matter when the seed is planted. Even with extensive picking, the numbers of beetles seemed just as high the following day.

After hand picking, rotenone dust was sprinkled on the leaves by hand. Insect damage was halted. Less than two weeks after the first application, the beetle population had again reached a proportion damaging to the plants. A similar application was made and no more was needed. Using this combination of hand picking and natural pesticide, two 30' rows of green beans provided us with green beans for fresh food and for winter preservation as well. For unknown reasons, the beetles were more persistent on the dry beans than on the green bean plants and more applications of rotenone were necessary.

CLOCHES

Introduction:

Extending the growing season is an efficient way to utilize the sun's energy. As our last killing frosts of the season on the Cape are in mid-May and our first often in mid-September, the growing season for many plants is considerably shorter than six months.

A cloche may be defined as a bell-shaped glass cover which is placed over a plant to protect it from frost and to force its growth. A modern plastic version is on the market under the brand name "Hot Caps." These are expensive and do not last longer than a season.

To maximize our growing period, we made modified cloches. They consisted of simple covers for the plants made from left-over pieces of Kalwall, the fiberglass material used on our greenhouse structures. In size and appearance they fall between a cloche and a greenhouse. They were made as follows:

Cloches with Frame

A rectangular frame of 2 x 4's was made for the base. Kalwall fiberglass was curved to form an arc and attached to the wood base. Doors were attached to the ends leaving space for free air flow and eliminating overheating problems (see Figures 2 and 3).

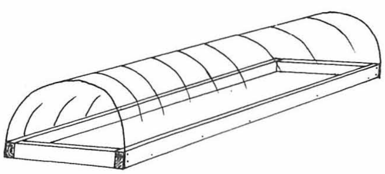


Fig. 2
First Cloche with Wooden Framework and Kalwall Permanently Attached to it

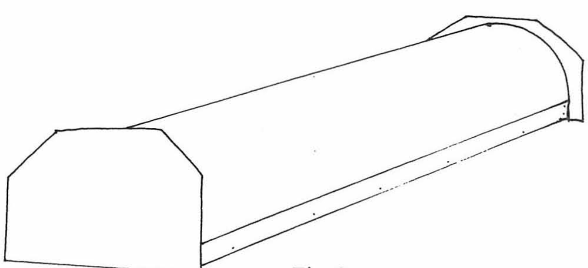


Fig. 3
First Cloche Showing Kalwall Cover and Ends

On April 19, 1976, five Savoy King Cabbage seedlings and five Broccoli de Cicco seedlings were planted in a row. Bloomsdale Spinach was seeded to the left, Ruby Queen Beets on the right. A cloche was placed over them. On April 19, 1976, five Broccoli de Cicco seedlings were planted beside the cloche as control plants. The cloche acted as a windbreak giving some protection against the winds and the cold air stream from the hill in a low spot of the garden valley.

Evaluation:

The difference in growth was striking. A month after setting out, the plants under the cloche were two to three times as big as the controls. Two months after the planting date, the first broccoli was harvested. The plants kept producing until the second week of October. The cabbages were ready for harvest by the last week of July. Vegetables planted a month early and placed under the protective cover of a cloche were mature a month earlier than had a cloche not been used.

Neither watering nor weeding a cloche this size created a problem. The watering was done with a regular garden hose and an accurately regulated spray. As it was very light, the cloche was easily lifted and put aside for weeding.

Cloche Without Frame:

Encouraged by our first success, a larger cloche was made. To avoid the storage problems of the previous model, this one was made to be disassembled (see Figure 4).

In late April, 1976, kohlrabi, eggplant, tomato, basil and Bibb lettuce seedlings as well as onion sets were planted under this cloche.

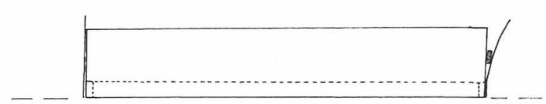
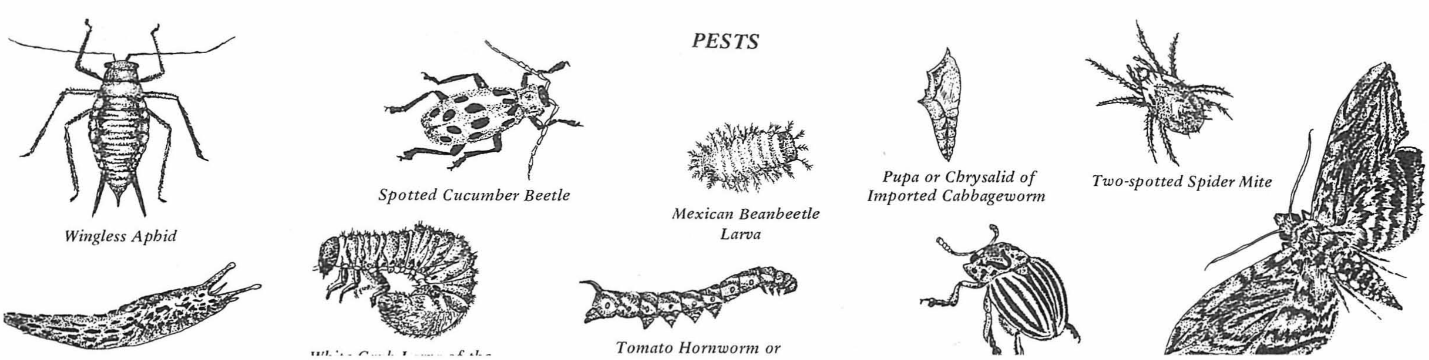


Fig. 4
First Cloche: Sideview Showing End Flaps Only Attached on the Bottom

PESTS



Evaluation:

By May 4, all plants were thriving. Watering was difficult because of the length of the cover. On a calm day two people, by undoing the top bars, could take off all the fiberglass and put it aside or roll it up temporarily. This was necessary the few times weeding and/or mulching had to be done. A more practical design is needed which would enable one person to open and close it, yet would have sufficient strength to resist high winds. An untested prototype is included in the drawings (see Figures 5-7). In areas

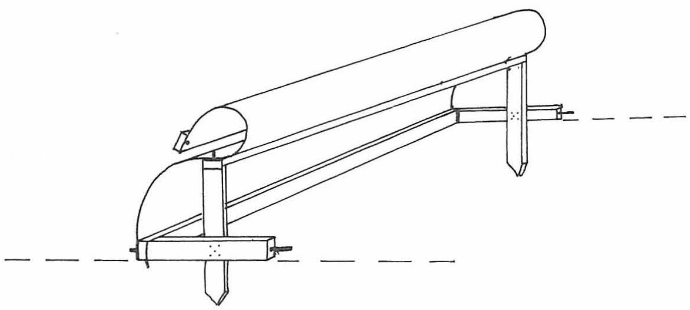


Fig. 5
New Cloche in Opened Position

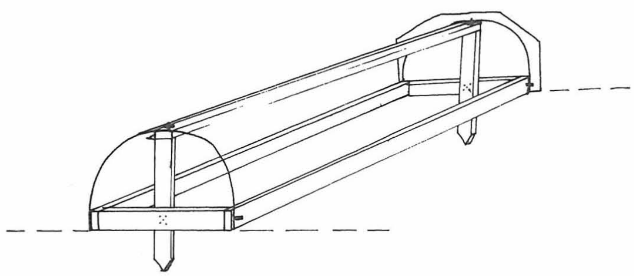


Fig. 6
New Cloche Showing Framework and Kalwall and One of the End Flaps

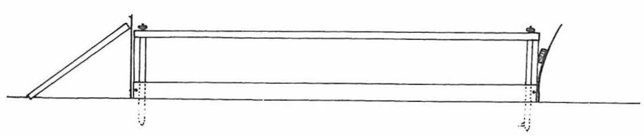


Fig. 7
New Cloche: Sideview Showing Basic Framework and Side Flaps Open and Closed

with strong winds, posts should be placed close together. In weighing the advantages of those with and without frames, the former are stronger and easier to lift but require some carpentry skill and are harder to store.

First harvest days of the plants tested were as follows:

Kohlrabi	July 1
Eggplant	August 1
Tomato	June 24
Basil	June 21
Bibb	June 21
Onion	August 20

Of the varieties tested under cloches and compared with those grown simultaneously in the open, the most successful were broccoli, cabbage, tomato and eggplant.

It is also possible to extend the season in the fall over small plants such as lettuce, parsley, kohlrabi, beets and many of the herbs. We were still picking vegetables from under the cloches in mid-November.

LABOR/TIME, WATER AND PRODUCTION ANALYSI

This year an attempt was made to record the number of hours spent working in the garden, the amount of water used for growing a certain quantity of vegetables and the total weight of vegetables harvested from these intensive beds.

Labor:

The number of work hours are somewhat inexact as such interruptions as a phone call, visitors or a dog chase made it hard to be precise. But a pattern is emerging.

The following activities were included in the recorded hours: seeding, weeding, unloading of organic materials, mulching and filling paths, watering, transplanting, bug picking, staking and stringing. Not included were: digging and building of beds (done previous fall), seeding flats and caring for seedlings before setting out, trucking in organic materials (manure, seaweed, straw), harvest time and winter storage of vegetables.

Time:

Number of work hours spent in the twenty intensive beds:

April	18½ hours
May	34 hours
June	78½ hours
July	86¼ hours
August	13 hours
September	5 hours

This totals 235¼ hours over a six-month period, an average of forty hours a month or one hour and sixteen minutes a day.

In October, the old plants were pulled and put in the pathways which by that time had become level with the tops of the beds. This time was not recorded. In November, the beds were moved, re-built, shaped, raked and made ready for the next season. This required a total of twenty hours or approximately one hour per bed.

Water Use:

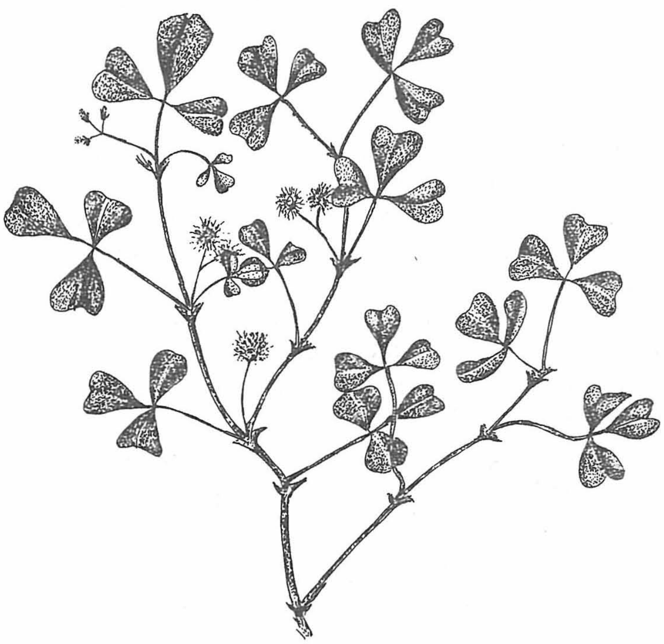
The amount of water used to irrigate the raised beds can only be estimated. The greatest variable may be the change in water pressure from day to day or hour to hour. Under constant water pressure, the average flow from a standard 5/8 garden hose was four gallons a minute. The number of beds receiving water and the approximate time per bed was recorded from April until October. A light watering took three to five minutes per bed, a heavy watering six to ten minutes. In the chart the upper limit of five minutes for a light watering and ten minutes for a heavy watering was used.

	Light Waterings			Heavy Waterings			Average	
Months	Number of Beds	Total Amount of Minutes	Total Number of Gals. of Water	Number of Beds	Total Amount of Minutes	Total Number of Gals. of Water	Min/ Day	Gal/ Day
April	None	---	---	None	---	---	---	---
May	30	150	600	46	460	1840	20	81
June	84	420	1680	86	860	3440	43	170
July	180	900	3600	55	550	2200	46	193
Aug.	20	100	400	20	200	800	10	40
Sept.	None	---	---	None	---	---	---	---
		1570	6280		2070	8280		

It took a total of 3640 minutes or 60 hours and 40 minutes to irrigate this area over the entire growing season. This represents almost one-fourth of the total amount of labor hours. 14,560 gallons of water were used. Light waterings of small areas or individual spots often done with a watering can have not been included in the previous chart.

Garden Size:

The total area of the intensive raised beds was 110' x 40' or 4400 ft^2 which is approximately 1/10 of an acre. Each bed had a width of four feet and a length of forty feet.



Medicago Hispida - "Bur Clover"

Only thirty feet of most beds were truly productive as plants in the last ten feet had to compete with the thick roots of the briar bushes, weeds and trees from the adjacent woods. Few plants survived or grew substantially there.

Production Figures:

The following table gives the total vegetable production from the intensive raised beds. It also estimates the total number of servings of each crop.

For a clearer idea of the quantity of food over the span of a year, certain vegetables were grouped together by type. This selection was based on our average eating habits, not on a rating of nutrients.

The total number of servings in each group was divided by 365 to determine the number of people who would have one serving per day per year of one or any combination of vegetables in that group.

Limitations on Productivity

Edible Greens; Some of these were not consumed and therefore not included. These were the greens of kohlrabi, parsnip, rutabaga and turnips, broccoli, cauliflower, brussels sprouts and the outer leaves of cabbage.

Frozen Ground: Some vegetables such as leeks, turnip and rutabaga were stored in the root cellar and others were left in the ground. The weights of those left in the ground are unknown.

Insects: Cucumber and bean plants were heavily damaged by cucumber and Mexican bean beetles. Had rotenone or a biological control been used the harvested weight would have been greater. In our area every year at the end of the season (October) kale and brussels sprouts are infested with aphids. As there is an abundance of food at that time, the interest in harvesting infested vegetables was less, affecting the recorded weights.

Lack of Picking: An effort was made to pick all vegetables as soon as edible size was reached. In some instances, however, it was almost impossible to keep up with the harvest.

Drought: The peas were unproductive due to lack of water. The corn did not germinate well. Seedlings were finally transplanted from shallow ditches that had been mulched with leaves in another section of the garden. Two beds were therefore unproductive for more than a month.

Other Animals: Several varieties of soybeans were grown. As soon as the plants were established, they were levelled by rabbits. Later in the season they left the bean plants alone. A few plants did mature, resulting in a small crop of soybeans.

TABLE 1.

		Total Edible Grams	Grams per Portion	Total Portions per Crop	Total Amount of Portions
Kohlrabi	cooked	23,027	98	234.9 *	
Parsnip	"	9,040	105.5	85.6	
Potato	"	167,316	81.5	2052.9	
Rutabaga	"	14,245	81.5	174.7	
Squash-Winter	"	2,913	122	23.8	
Turnip	"	13,123	98	133.9	
					2705.8
Parsley	fresh	not weighed			
Radish	"	not weighed			
Cabbage-Head	fresh	116,798	36.5	3199.9	
" Chinese	"	11,964	38.5	310.7	
Carrot	"	11,184	65.	172.	
Celery	"	12,874	60.5	212.7	
Chard, Swiss	"	12,021	38.5	312.2	
Cucumber	"	34,774	113.	307.7 *	
Kale	"	8,143	30.	271.4	
Lettuce	"	27,817	77.	361.2	
Spinach	"	13,260	27.	491.1	5638.8
Beans (Lima,Wax,Green)	cooked	14,492	62.5	231.8	
Broccoli	"	26,722	84.	318.1	
Cabbage-Head	"	116,798	73.	1599.9	
Chinese	"	11,964	95.	125.9	
Cauliflower	"	9,798	62.5	156.7	
Celery	"	12,874	77.	167.2	
Chard, Swiss	"	12,021	95.	126.5	
Eggplant	"	25,725	106.5	291.5	
Kale	"	8,143	95.	85.7	
Peas	"	1,065	81.5	13.0	
Pepper	"'	1,474	83.5	16.6 *	
Okra	"	759	88.5	8.5	
Spinach	"	13,260	100.	132.6	
Sprouts, Brussels	"	9,189	77.5	118.5	
Squash-Summer	"	16,994	119.	168.9	
					3510.5
Beets	cooked	18,383	90.	204.2	
Carrot	"	11,184	80.	139.8	
Corn	"	226 ears	2 ears	113.	
Leek	"	6,473	88.5	73.1 *	
Onion	"	39,128	98.5	397.2	
Tomato	"	68,613	81.	847.	
					1674.3

Portion figures were based on *The Handbook of Food Preparation* published by The American Home Economics Association, 1964. Those marked with an (*) were not mentioned in this handbook and are our own estimates.

TABLE 2.

	Number of People - One Portion - Each Day of the Year	Significant Amount of Portions Unrecorded
Cooked Root Crops	7.4	x x x x
Uncooked Fresh Salad Vegetables	15.4	x x x x
Cooked Vegetables	9.6	x x x
Cooked Non-Green Vegetables	4.58	x x x x

The table shows that ten people would have at least one serving or the equivalent of raw, cooked green and cooked starchy vegetables every day of the year.

Discussion:

The preceding figures give some idea of productivity. The amount of harvest of one garden row of vegetables can be projected to a figure per acre, then compared with a state or national average.

Such comparisons have little validity unless differences in energy consumption with standard agricultural practices are considered in such areas as mechanization, irrigation, pest control and fertilization, as well as in attention and attitude toward the land. Where companion planting, interplanting and succession planting are practiced, comparing square footage or linear footage of growing area are nearly impossible. Comparing one garden with another is even less valid. Original soil structure, natural fertility, growing season, micro-climate and immediate environment all play an important role. Many of these are not easily controlled and differ from place to place.

Conclusion:

On a plot of less than a tenth of an acre, one serving each of a raw vegetable, a green cooked vegetable and a root or other non-green cooked vegetable was grown for ten people for each day for a year, with some surplus.

This took 235 work hours over a six-month period or an average of one hour and sixteen minutes a day for one person. Included are sixty hours and forty minutes of hand watering.

Approximate water use was 14,560 gallons over a period of six months.

No chemical or biological pesticides were used.

Only traditional non-commercial insect control methods were used, including companion planting and hand picking.

No chemical fertilizers were used.

Rock minerals, seeds, hand tools, garden hoses and black tubing were the only commercial items used.

No equipment requiring fossil fuels was used.

The only energy was human labor.

Future Projections:

It is our hope that the same twenty beds could produce the same combination and types of vegetables for fifteen people instead of ten next year. This is based on the fact that several crops failed or were severely damaged by rabbits, insects and/or drought, all of which could be controlled to some degree.

With improved soil and more effective growing space in the area closest to the woods, there is a possibility of growing all the vegetables for twenty people on this one-tenth of an acre two years from now.

Gardening intensively on a small acreage, using such practices as extending the season with cloches and solar-heated greenhouses, selecting local plant varieties for pest and disease resistance and for suitability to soil and climate, improving soil fertility, the establishment of food-producing forests and animal husbandry are all strategies within our reach to heal the earth and to secure the existence of future generations. All that is needed is people willing to tend the land and nurture the plants that in turn sustain them.

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Photo by Hilde Maingay

Experimenting with Growing Beans

– Susan Ervin

At New Alchemy, we are interested in the growing of dried beans, both for their nutritive value and because, as nitrogen-fixing legumes, they restore rather than deplete the soil. Our bean experiments are attempts to realize our conviction that adequate protein is a basic human necessity and that to produce protein ecologically is equally essential.

This past summer we grew sixteen varieties of beans for drying. In addition to the standard kidney bean, these included several old New England varieties, a Mexican black bean, a black bean which has been grown locally for many years by Delinda LaBeet, who is of Wampanoag Indian descent, two Oriental sprouting beans and a half-dozen of the many beautiful kinds of beans grown in Costa Rica. Rather than design a controlled experiment, we chose, at this stage, to do a pilot study relying mostly on observation, and a sampling and comparison of yields from the different varieties at harvest. The sixteen varieties grown were:

1. Dark Red Kidney
2. Light Red Kidney
3. Charlevoix Kidney
4. Trout (New England)
5. Soldier (New England)
6. Main Yellow Eye (New England)
7. Navy (New England)
8. Mexican Black Bean
9. Local Black Bean
10. Adzuki
11. Mung
12. Costa Rican Black
13. Costa Rican Red "Colorado"
14. Costa Rican Pink "Coloradito"
15. Costa Rican Yellow "Mantequilla"
16. Costa Rican Purple Striped "Tigre"

Each variety was harvested when the majority of the beans on the plant was dry. Before harvest, six plants were chosen at random from each row and the weight of the beans recorded. Also, the total weight of beans for each variety was recorded. All yields given below are for two 25' rows unless otherwise specified.

Throughout the season, the plants bearing the Light Red Kidneys were the largest and the healthiest green and were least damaged by rust or attack by Mexican Bean Battles with the exception of the Mung and Adzuki beans which received virtually no beetle damage, probably because of their hairy leaves. Consistent with their generally healthy condition, the Light Red

Kidney Beans had the highest yield of any variety at 8 pounds. The Maine Yellow Eye Beans had serious rust and some yellowing at various stages but gave the second highest yield at 6½ pounds. There was a general yellowing of most of the bean plants in early June, but the deep green color returned within a week. Rust was quite extensive on some varieties and persisted throughout the summer, causing premature loss of leaves in a few cases, the Navy beans being the worst affected. The Mung beans were the third highest in yield at 3 pounds from one 25' row. Early planting in their case is essential therefore. They were very slow growing and not all of the beans were mature by frost.

Of the three black beans, the local variety did the best (5 pounds). The Mexican Black Bean produced 4 pounds. Though neither was as high yielding as the varieties already listed, yields were in line with those predicted for a 50' row of beans by Johnny's Selected Seeds Company in Maine.

The Costa Rican beans did not grow as large as the same varieties do in Costa Rica and they were much smaller than the temperate varieties. However, the Mantequilla, at 4½ pounds, yielded nearly as much as the best temperate varieties.

Looking over the yields, all varieties were up to average with the exception of the Soldier beans which germinated poorly, the Tigre from Costa Rica (which are, however, very pretty), the Colorado, the Costa Rican Black and the Adzuki, which had many pods that were not fully mature by frost. Thus, even with some disease and insect problems, a number of varieties were average or above average in production.

Highest yield is not the only criterion for suitability of a crop. Light Red Kidneys happen to be my least favorite bean, because they are large and starchy. The small beans, which include all the Costa Ricans, and blacks, are in my opinion, a higher quality food. The cooking time tends to be shorter also. The small Costa Rican beans are tender in one hour, whereas the large kidneys may take three hours. So, although yields for small beans may be lower and shelling time longer, one saves fuel and can have cooked beans in a shorter time. We include recipes and suggestions for cooking dried beans in *The Cook Book of the New Alchemists* and further recommend *The Bean Book* by Crescent Dragonwagon from Workman Publishing Company. When eaten in combination with other protein-providing foods, beans add a high quality protein to the diet, as the amino acids which they lack are available in grains and some seeds and nuts. A cup and one-half of beans on their own provide usable protein equivalent to six and one-quarter ounces of steak; four cups of rice alone provide protein equivalent to seven ounces of steak. But the rice and beans together provide usable protein equivalent to nineteen ounces of steak, a 43% increase over the two eaten separately. (*Diet for a Small Planet,* Frances Moore Lappé, pp. 156-157, Ballantine). American Indians and Mexicans combine beans with corn, and the Caribbean and South American cultures combine beans and rice. Lentils and rice are combined in India, and soy and rice in China. Legumes have been a beneficial source of protein for many peoples for many thousands of years without upsetting the balance between the needs of the human population and the immediate ecosystem.

TABLE 1 - Bean Varieties and Yields

	Name of Variety	*Yield per two 25' rows*
1.	Dark Red Kidney	3 lb.
2.	Lt. Red Kidney	8 lb.
3.	Charlevoix Kidney	3¾ lb.
4.	Trout	5¾ lb.
5.	Soldier	1¼ lb.
6.	Maine Yellow Eye	6½ lb.
7.	Navy	2¼ lb. (one 25' row)
8.	Mexican Black	4 lb.
9.	Local Black	5 lb.
10.	Adzuki	Not mature at frost
11.	Mung	3 lb. (one 25' row)
12.	Costa Rican Black	1 3/8 lb.
13.	Costa Rican Colorado	1¼ lb.
14.	Costa Rican Coloradito	1¼ lb.
15.	Costa Rican Mantequilla	4¼ lb.
16.	Costa Rican Tigre	2¾ lb.

Photo by Hilde Maingay

The Effects of Mulching with "Seaweed" and Azoll on Lettuce Productivity

— *Susan Ervin*

Mulching is a common gardening practice, used to control weeds, retain soil moisture and add organic matter to the soil. We have used it extensively in the New Alchemy gardens. In 1976 we conducted an experiment comparing the productivity of unmulched lettuce to that of lettuce mulched with "seaweed" (actually a mixture of eel grass and codium) and of lettuce mulched with azolla (probably *Azolla pinnata*). Azolla is a small aquatic fern on which grows the nitrogen-fixing blue-green algae, *Anabaena* sp. In experiments conducted in Denmark, it was found that the symbiotic algae on the azolla fix up to 95 kg/ha of nitrogen in small ponds in one season's growth.[1] Azolla is commonly grown in rice paddies in Vietnam, resulting in 50% to 100% greater yields.[2] We thought that the excess azolla from our fish ponds, used as mulch, might be a rich source of nitrogen for the garden plants. Seaweed was chosen for the trials because it is plentiful here and has been our primary mulching material at New Alchemy, as well as having been used traditionally on Cape Cod.

The 15' by 10' experimental plot was divided into six sections. On June 14, three 3' rows, consisting of fifteen (Bibb lettuce, Ferry-Morse) plants each, were set in each section and mulched. The seaweed mulch was approximately 4" thick but settled to a thin covering and had to be renewed several times to maintain a depth of about 1" to 1½". The plot was watered as needed, with each section receiving an equal amount of tap water. Plants were harvested and edible portions weighed on July 15 and 16. Contrary to our expectations, the unmulched plants gave higher yields than those receiving either of the two mulches (Table 1).

Table 1: Mean weights of lettuces — unmulched, mulched with azolla, and mulched with seaweed — Trial I.

	No. Plants	Total Wt.	Mean Wt.
Plot A (azolla)	45	941 g	20.9 g
Plot B (seaweed)	43	690 g	16.05 g
Plot C (seaweed)	44	836 g	19 g
Plot D (no mulch)	43	1125 g	26.6 g
Plot E (no mulch)	43	1217 g	27.66 g
Plot F (azolla)	45	805 g	17.89 g

The following pairs were compared using a Wilcoxon signed rank test:[3]

A (azolla) vs. B (seaweed)
C (seaweed) vs. D (no mulch)
E (no mulch) vs. F (azolla)

The respective values of T were 281.5, 216 and 105.5. In each case, there was a difference between the treatment effects significant at the 5% level or better.

On July 20 the rows were re-seeded with Great Lakes lettuce (Burpee) and on August 6 thinned to fifteen plants per row, again giving a total of forty-five plants per section. Mulching was done with seaweed and azolla as described in the first trial; however, as azolla was scarce at this time, the mulch was not as thick as before until a second application was made on September 2. To offset any possible inherent natural advantage in any particular section, treatment was rotated between the first and the second trials.

All plants were harvested on September 20 and the edible portions were weighed. In Plot E (azolla) nearly half the plants were damaged, with only roots and/or small leaves remaining so these were not considered in the analysis.

Table 2: Mean weights of lettuces — unmulched, mulched with azolla, and mulched with seaweed — Trial 2.

	No. Plants	Total Wt.	Mean Wt.
Plot A (seaweed)	44	1414 g	32.1 g
Plot B (azolla)	40	2496 g	62.4 g
Plot C (no mulch)	44	1963 g	44.6 g
Plot D (seaweed)	38	352 g	9.3 g
Plot F (no mulch)	44	603 g	13.7 g

Using the Wilcoxon signed rank test, the following pairs were compared:

A (seaweed) vs. B (azolla)
C (no mulch) vs. D (seaweed)

The respective values of T were 138.5 and 57, a difference, in each case, significant to the 5% level or better.

The results of the experiment are by no means clear. In the first trial, a lack of mulch of either type was advantageous for the plants. In the second trial, a light application of azolla resulted in the highest yields. The variability observed may have been due to the following variables: rainfall and water availability between the two trials, competition for oxygen and nitrogen between lettuce seedlings and mulches, particularly in Trial 1, and to the dynamics of soil and plant, mulch interactions which are as yet little understood.

Next summer we will continue our mulching trials, growing a root crop, a fruiting crop and a leafy crop. Unmulched plots will be compared to plots receiving several different mulches. Identical trials will be run with and without supplemental watering. We have observed that azolla can take root on the soil in the high humidity of the greenhouses, particularly in small planting boxes and pots. Perhaps further research should be done with these plants as a living mulch rather than a decomposing one.

Any observations from readers on the effects of mulches are invited.

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Fertile Fish Pond Water Irrigation Trials

—Susan Ervin

During the summers of 1973 and 1974, we conducted experiments comparing the productivity of plants irrigated with fertile water from fish ponds to that of plants watered with ordinary tap water. The most significant difference occurred with lettuce; collards showed some benefit from the fish pond water; beets, chard and zucchini showed no significan differences (the first and second *Journals of the New Alchemists*).

In 1976, we conducted further lettuce trials. Tomatoes were tested as a fruit crop. The lettuce trials were repeated not only in order to strengthen our findings by replication, but also because we planned to analyze and compare the ammonia content of the two types of water. Unfortunately, the water analysis equipment was defective on arrival and replacement arrived too late for adequate data collections. Water analysis results will be published next year.

The experimental plot was rectangular, 20' x 28', divided into four equal sections. Two sections were watered with tap water and two with water from aquaculture ponds. To prevent water run-off and mixing between sections, concave "nests" were dug for individual tomato plants and troughs made for the lettuce rows. A small amount of compost was mixed with the soil before planting. On June 6, each section was planted with ten tomato seedlings (Better Boy, Burpee) in two rows of five plants each, with thirty lettuces (Bibb, Ferry-Morse) planted in a single row. Watering was done at least once a week throughout the summer, more frequently when soil and weather conditions required. The 4' plots received equal amounts of water. At each watering, individual tomato plants received one gallon except during several very dry periods when they received two gallons each. At each watering, every lettuce trough received three gallons when the plants were small. This was later increased to four gallons, and to six gallons during dry periods.

The Bibb lettuce was harvested on July 6 and 7. Lettuce troughs were replanted with Prizehead lettuce (Northrup-King) on August 2 and harvested again on October 11. In both trials, raw weights of edible portions of the lettuce were recorded. Tomatoes were harvested and weighed individually when fully ripe until the first light frost when all remaining fruits were harvested.

Results of the experiments are show below (Tables 1 and 2).

Table 1. Mean weights of lettuces irrigated with fish pond and tap water

	No. Plants	Total Wt.	Mean Wt.
Trial 1			
-Bibb Lettuce			
Pond Water	56	1714 g	30.61 g
Tap Water	56	1184 g	21.24 g
Trial 2			
Prizehead Lettuce			
Pond Water	58	1823 g	31.43 g
Tap Water	58	1297 g	22.36 g

Statistical analysis of the data was carried out using a Wilcoxon signed rank test.[3] In the first lettuce trial, T = 367.5 indicating that the experimental plants were larger than the controls, significant at the 5% level. In the second trial, T = 559, which barely misses significance at the 5% level.

Even though the pond water produced larger fruits and the tap water a larger number and higher average yield per plant, there was no significant difference between the yields of tomatoes watered with pond water and those watered with tap water.

Table 2: Yields of tomatoes irrigated with fish pond water and tap water

	No. Plants	No. Fruits	Total Wt.	Mean Wt.	Aver. Yield per Plant
Pond Water	19	607	133.656 kg	220.9 g	7034.5 g
Tap Water	20	770	153.053 kg	198.77 g	7652.65 g

The results of these experiments are in accord with our earlier work. It appears that shallow rooted leafy crops are likely to benefit from irrigation with fertile fish pond water, whereas fruit crops are not as likely to benefit.

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