Organic Farming Compost Experiments in Waimanalo, Hawaii 1993-1998

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I. Acknowledgements

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Nature Farming Compost Experiments in Waimanalo, Hawaii
Five Year Report, 1993-1998

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ABSTRACT

A long-term experimental plot was established at the UHM Waimanalo Experiment Station with the following overall goals:

1. Evaluate the long-term effects of following nature or organic farming techniques on soil quality, pest pressure, and crop productivity.
2. Develop recommendations (on composting, and techniques to grow specific crops) for the production of vegetables following nature-farming techniques.
3. Disseminate available information on nature farming, organic farming, and sustainable ag to farmers in Hawaii and other tropical areas.

The project, a cooperative effort between the University of Hawaii at Manoa College of Tropical Agriculture and Human Resources and the Mokichi Okada Association- Hawaii Branch, was initiated on early 1993. A 2 Acre plot of land, which had been fallow under a grassy cover for over 15 years was selected for this project. At the onset the soil was extremely compacted, due to the dry weather and needed to be ripped prior to soil preparation. Unfortunately, due to a lack of equipment only the top 6-9 inches of soil were properly ripped. On October 1993 random soil samples from all sections of the plot were collected to conduct soil fertility and nematode count evaluations. Since then similar surveys were conducted periodically. The entire experimental area was divided into three main sections:

1. A replicated experiment consisting of sixteen 30 x 4 -ft beds (4 treatments with 4 replications per treatment).
2. A demonstration plot (Section A) about 250 x 100 ft to grow a variety of vegetables following nature farming guidelines; and
3. A cover crop/fallow section (Section B) about 200 x 50 ft to demonstrate low-intensity field maintenance techniques and the use of several cover crops and green manures for improvement of soil quality and to minimize erosion.

From 1993 to 1998 over 50 vegetable species/varieties and over 40 cover crop or green manure species were evaluated on the cover crop and demonstration sections. On average a crop was being planted and harvested on a weekly basis. This provided the opportunity to evaluate the viability of growing a host of vegetable and cover crop species during the different

growing seasons. In 1998 an 8-year rotation experiment was begun on the demonstration plots. This experiment was established to evaluate the effect of rotations and green manures on the long-term productivity of vegetable crops. In the replicated plots, since 1993 seven consecutive experiments were conducted. In this experiment each bed has received the same treatment (control, compost alone, synthetic fertilizer alone, or a combination of composts and synthetic fertilizers) over these five years. In the replicated experiments specific cultural recommendations are being developed in terms of compost application rates, nutrient release rates from the compost applications, yield response from the compost treatments, crop nutrition, and effects of the long-term compost applications on soil quality, crop pests and diseases, and crop productivity. The following observations can be made from the work conducted to date in both the demonstration and replicated plots:

1. Commercially acceptable yields can be made from the application of composts alone. The addition of Nitrogen rich organic fertilizers may result beneficial to meet crop nutrient demands during particular growth stages when fast growth rates occur (such as fruiting in tomato, or heading in lettuce). The data collected from tissue nutrient contents and soil fertility will be helpful as baseline data to develop organic nutrient recommendations for Hawaii.
2. The modest application of composts (10 MT/Acre/year) resulted in a steady increase in the soil organic matter content in both the replicated and demonstration plots. The organic matter content also increased in the plots under cover crop/follow rotational study.
3. A trend was observed toward less nematode pressure in plots that received compost applications. In the demonstration plots nematode pests have not become a serious problem. Nematode infestations and reduced yields are typical in our conventional plots elsewhere at the Waimanalo station.
4. Recommendations can be made based on the work conducted to date on what crops are more amenable to nature farming, and recommendations can be made for the use of particular plant species or varieties than can be used as cover crops or green manures at low-elevations in Hawaii.

The results and conclusions made from the work conducted to date at the nature farming plots are by no means conclusive. Additional years of work, and further analysis of the data will be required before a better understanding is obtained concerning nature farming in the tropics and its effect on soil fertility, pest levels, and crop productivity.

1.0. Introduction

In May 1993 a 1.5 Acre plot at the UH Waimanalo Experiment Station was established to conduct pesticide-free compost experiments[1] . The land was divided in three sections: 1) Long-term replicated experiment to compare compost treatments and commercial synthetic fertilizers; 2) A demonstration plot showing the production of several crops under "nature" or "organic" farming techniques; and 3) Cover crop demonstration treatments for erosion control and to "build up" the soil. The purpose of these experiments has been to develop base-line information for the farmers of Hawaii in the area of Sustainable Agriculture.

A main component in the production of horticultural crops by those farmers who follow "nature farming," "organic," "biodynamic," "low-input" or more in general "sustainable agriculture" practices, is the importance of a healthy soil. A healthy soil, is proposed, will allow plants to grow healthier and to be more resistant to attack by pests and diseases. Therefore, the research in this project focused on the use of composts as nutrient sources, and to improve the quality of the soils for vegetable crop production. Information is being developed to evaluate what yields can be expected from several compost treatments, and how the composts affect other field related aspects such as nematode numbers and soil diseases.

Long term approach. Organic farmers know that it normally takes from 3 to 5 years to observe the full benefits of compost applications along with the practice of other organic farming techniques. This long-term response is explained because it normally takes a long time before natural microbial populations are re-established in the field, and before other major components of the agroecosystem (such as nutrient cycling and a balance between arthropod pests and their natural enemies) regain a balance. Since typical farming operations that rely on synthetic pesticides and fertilizers are "disturbed" systems (where high chemical and energy inputs are necessary to maintain crop production), it is thus reasonable to expect that it would take a few years before a "balanced" system is restored. Therefore, even though important information may be obtained from first or second year results, this information should be treated with caution, since data is being obtained from a system in "transition." This information will be valuable to those transitional farmers who decide to convert their systems from "conventional" to "sustainable." The need for this information is illustrated by the theme used for the WSAA Sustainable Agriculture Conference held in Hilo in November 1994: "Transition to Sustainable Lifestyles[2] ."

What follows is a description of the many experiments that were conducted in both the demonstration, cover crop, and replicated plots from 1993 to 1998. Because so much data was collected, here we place an emphasis on summarizing the data, which was collected, and to highlight some of the major results which were obtained. Additional work will be required to further synthesize the data to explain the many interesting results which were observed. It is hoped that the information obtained to date will provide some practical data which will be of use to nature or organic farmers in Hawaii and other tropical regions. It is also hoped that this research will serve as a spring board that will lead to further long-term research in critical areas needed to further the understanding of agroecological principles which will further stimulate the growth of nature and organic farming in tropical regions.

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[1] This work is sponsored by the World Sustainable Agriculture Association, Mokichi Okada Association (MOA), and by the University of Hawaii College of Tropical Agriculture and Human Resources.

[2] WSSA Sustainable Agriculture Conference, Hilo, Hawaii. 11-12 Nov. 1994

2.0. Lettuce Compost Experiments, Nov. 1993 to Feb. 1994.

2.1. Materials and Methods

Location. The experiments were conducted at the University of Hawaii Waimanalo Experiment Station in Oahu. The site is located at 70 ft elevation above sea level. The soils are classified as Wailua (Waimanalo) silt clay (Vertic Haplustolls) with 45 in. (1150 mm) median annual rainfall. Soil at the Waimanalo branch station is predominantly a montmorilonitic clay. The first soil samples were obtained in October of 1993, after the field had been tilled, but prior to experiment initiation. Analyses of the soil samples are listed in Table O-3.

◊ Mean Annual Temperature: 75 F (24.6C), monthly range 70-80F (22-27C)

◊ Mean annual rainfall 55 in (1380 mm). Annual Range= 500-1800 mm

◊ Soil type- Vertic Haplustolls, derived from lava and coral,

◊ pH about 6.5, good base status, low organic matter

Treatments. One month old 'Manoa' (semi-head) and 'El Toro' (head) lettuce seedlings were transplanted on 24 Nov. 1993. The treatments were:

1) 100 lbs / Acre of nitrogen (N), applied as Urea;
2) Home made compost at 10 MT / Ac alone;
3) Commercial compost, Amend (Kellogg Supply Inc., Carson City, CA) at 10 MT / Ac alone;
4) Amend compost at 10 MT / A plus 100 lbs / Ac N as urea;
5) Amend compost at 10 MT / A plus 200 lbs / Ac N as urea; and
6) Amend compost at 10 MT / Ac plus 300 lbs / Ac N as urea, and
7) Control.

Each treatment was established on a 30 by 4 feet raised bed. Each treatment (bed) was replicated 4 times, for a total of 16 beds. The experimental design is a Complete Randomized Block. Soil analysis before fertilizer applications showed small counts (10-30 per pint) of spiral nematodes (*Helicotylenchus* sp.). The plots were blocked due to an erosion and nutrient gradient that occurs from West (high) to East (lower fertility). Soil pH in this part of the field ranged from 6.6 to 7.0. Soil solution nutrient ranges were P= 109-487 ppm; K=360-520 ppm; Ca= 4400-7100; and Mg= 1300-1500 ppm. Soil percent organic carbon ranged from 1.3-1.6. Manoa lettuce was picked and weighed on 7 Jan. 'El Toro' was harvested on February 3, 1994. Analysis of the raw compost materials used is listed in Table O-1.

2.2. Results and discussion- Lettuce trials

Manoa Lettuce yields. In the experiment with 'Manoa' lettuce the best yields were obtained with all the treatments that received the Amend compost at 10 tons / Acre plus some nitrogen fertilizer in the form of urea. The highest yields of almost 12,000 lbs / Acre were obtained with the Amend compost plus 100 lbs / Acre of N as urea (Table L-1 and Table L-2). Higher applications of N as urea did not increase yields any further and for the grower this would have meant wasted money from the excess added fertilizer. Yields between treatments receiving either commercial fertilizer alone or homemade compost alone were not statistically different but yields from the commercial fertilizer tended to be greater (Table L-1 and Table L-2). It should be noted that composts act as slow-release fertilizers. It would be expected that nutrients from the composts would not be released fast enough to meet the demands of a fast growing crop such as lettuce. Therefore, as expected, yields of plants that received commercial nitrogen fertilizer (urea) tended to be greater than those which received compost alone. *Head Lettuce*. yields A different picture emerged from the harvest about a month later of the 'El Toro' head lettuce. In this trial plants that received Amend compost at 10 tons / Acre plus 100 lbs of N as urea also had a trend toward the greatest yields. However no statistical significance occurred on yields between all treatments, all ranging around 20,000 lbs / Acre (Table L-1). The treatment with the lowest yield was the one that received commercial N fertilizer alone. The plants in the fertilizer treatment may have been more susceptible to nematode damage (see Table Nem-1) but the nematode numbers for the plants receiving commercial N were not higher than for the other treatments. The reasons for the relative low yields for plants receiving synthetic N alone, and for the control treatments yielding almost as well as plants receiving both compost and synthetic N, thus remain undetermined. However yields here were almost double the average yields or 11,000 lbs/Acre reported for commercial lettuce production in Hawaii (DOA data).

Soil Analysis and Nematode Counts. The soil analysis taken after completion of the lettuce trials is listed in Table O-4, and the nematode counts in Table Nem-1. The soil pH remained unchanged for all treatments at around 7.0. The soil salinity increased at above 0.10 mmhos for treatments that received a compost application but not for the one that received synthetic N alone. The increased salinity of the compost treatments is explained by the high nutrient content of the raw composts. As an example both composts had a content of over 1500 parts per million in potassium levels alone (Table O-4). Soil levels of the other nutrients (potassium, calcium, and magnesium) did not vary significantly between treatments, but the numbers are valuable as records for the long-term planned experiments on the same site. The lowest organic matter (or percent organic carbon) content was found on the control plots (1.2%) compared to a mean of 1.7% for all treatments that received a compost treatment (Table O-3). Furthermore, note that the demonstration plots, located nearby, and which received more frequent compost doses, already had by this time an organic carbon content greater than 2%. Therefore, in the long run, the benefits from increased organic matter in the soil (improved root growth resulting from improved aeration, water drainage, and nutrient availability) would be expected from those plots receiving on-going compost applications. Also notice that the treatments that received synthetic fertilizer alone had lower organic matter content than treatments which received compost applications (Table O-3).

Tissue Analysis. Tissue samples were collected from wrapper leaves at the heading stage for the 'El Toro' iceberg variety. In general nutrient levels were above the levels recommended for commercial head lettuce production (Table L-3). These data points out the high native fertility of some agricultural soils in Hawaii, such as the ones in the Waimanalo area (Dr. Ike Ikawa, personal communication, October 1993). The tissue content levels for the control treatments, which received no fertilizers nor compost, were also adequate for lettuce production. These data indicates that, since the head lettuce was in the field for a longer period than the leafy lettuce (planted on same date but head lettuce harvested about a month later), the control plants were able to develop an extensive root system that was able to uptake the needed nutrients to obtain yields similar to the treatments which received compost or N fertilizer (Table L-3). Plants which received composts plus synthetic N fertilizer did show a slight increase in tissue nitrogen (N) content, while plants which received compost alone, or urea alone had similar N tissue levels as the controls. Plants which received compost treatments also had higher Magnesium (Mg), Sodium (Na), Manganese (Mn), Zinc (Zn), and Boron (B) than the controls. All of this data will be useful for development of fertilizer recommendations, and for the use of composts for vegetable production in Hawaii.

Table L-1. Effects of composts treatments on yields of lettuce, Waimanalo, 1994.

Treatment	Yield (lbs/Acre) Manoa Lettuce	Head Lettuce
Control	4833 a	22,134a
Home made at 10 MT/Ac)	5251 ab	21,266a
Synthetic fertilizer 150 lbs/Acre	6062 b	18,445a
Amend plus 0 lbs/Acre Nitrogen	10,073 c	21,049a
Amend plus 300 lbs/A N	11,577 cd	21,700a
Amend plus 200 lbs/A N	11,619 cd	20,181a
Amend plus 100 lbs/A N	11,887d	23,219a

◊ Numbers in the column followed by the same letter are not significantly different according to Duncans New Multiple Range test at 5% probability. Each number is the mean of 28 (for Amend compost) or 61 measurements (other treatments). Each treatment was blocked (replicated) four times based on erosion rates in the field.
◊ Yields are based on estimated field populations of 21,780 plants per acre (2 ft between rows and 1 ft between plants in the row.)

Table L-2. Effect of compost treatments on mean lettuce head size (ounces), 1994.

Treatment	Yield (oz per head of 'Manoa' lettuce)
Control	3.15 a
MOA compost (home made at 10 MT/Ac)	3.89 ab
Synthetic fertilizer 150 lbs/Acre	4.52 b
Amend plus 0 lbs/Acre Nitrogen	7.46 c
Amend plus 300 lbs/A N	8.57 cd
Amend plus 200 lbs/A N	8.61 cd
Amend plus 100 lbs/A N	8.79 d

Numbers in the column followed by the same letter are not significantly different according to Duncans New Multiple Range test at 5% probability. Each number is the mean of 28 (for Amend compost) or 61 measurements (other treatments). Each treatment was blocked (replicated) four times based on erosion rates in the field.

Table L-3. Effect of compost and synthetic nitrogen fertilizer treatments on the nutrient tissue content of head lettuce, January 1994.

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Mn	Fe (ppm)	Zn	B
Control	3.3	0.48	7.5	1.5	0.40	0.14	64	154	42	27
Home-made	3.4	0.46	8.2	1.7	0.44	0.14	72	119	34	27
Comp-0	3.3	0.44	8.32	1.7	0.52	0.35	73	167	55	32
Comp-100	3.5	0.46	7.04	1.3	0.43	0.30	77	149	52	31
Comp-200	3.8	0.40	7.5	1.4	0.46	0.25	84	122	45	32
Comp-300	3.8	0.48	7.2	1.3	0.44	0.27	77	144	49	32
Urea	3.3	0.43	7.4	1.3	0.37	0.16	99	146	31	27
Recommended levels	2.8	0.48	4.2	0.9	0.32	NA	51	128	38	19

Note: Tissue samples collected from most recently matured wrapper leaves at the heading stage of cultivar 'El Toro.' Recommended levels are to obtain yields of over 15 MT per Acre (Fox and Valenzuela, 1992

3.0. Sweet basil Experiment, April to Dec. 1994.

3.1. Materials and Methods

The experiments were conducted at the University of Hawaii Waimanalo Experiment Station in Oahu. Site descriptions are as outlined in section 2.0. Analyses of the soil plots are listed in Table O-3, O-4, O-5, & O-6). The green sweet basil cultivar Italian Large Leaf (Alf Christianson Seed Co.) was seeded on 12 January and transplanted on 8 April 1994. Compost treatments were placed each on a 30 by 4 feet raised bed. One planting row was used per bed with a 2-ft distance between plants in the row. See Section 2 for additional details on the experimental design.

The treatments were:

1) 150 lbs/Acre of nitrogen (N), applied as Urea;
2) Home made compost at 10 MT/Ac alone;
3) Commercial compost, Amend (Kellogg Supply Inc., Carson City, CA) at 10 MT/Ac alone;
4) Amend at 10 MT/A plus 100 lbs/Ac N as urea;
5) Amend at 10 MT/A plus 200 lbs/Ac N as urea;
6) Amend at 10 MT/Ac plus 300 lbs/Ac N as urea, and
7) Control.

Soil analysis before fertilizer applications showed small counts (10-30 per pint) of spiral nematodes (*Helicotylenchus* sp.). The plots were blocked due to an erosion and nutrient gradient. Soil pH in this part of the field ranged from 6.6 to 7.0. Soil solution nutrient ranges were P= 109-487 ppm; K=360-520 ppm; Ca= 4400-7100; and Mg= 1300-1500 ppm. Soil percent organic carbon ranged from 1.3-1.6. For harvest, 4-6 inch tips of basil were hand picked and fresh weight per plant was recorded. In addition, at each harvest date individual canopy height and diameter was determined. Chemical analysis of the raw compost product used is listed in Table O-2.

3.2. Results and discussion- Basil Trials

Yields and Canopy Growth. The yields obtained in all treatments were quite impressive. By the last harvest of the year, yields ranged from 30 to 64 MT per acre or 6 to 12 pounds per plant for a 5-month harvesting period. Yields up to August 1994 (see Table B-2, and Fig. B-1 to B-3) were significantly lower for the controls. However, all treatments that received a compost treatment plus synthetic nitrogen (N) fertilizer, or synthetic N fertilizer alone yielded similarly at a range of 30-34 MT per acre after about two and a half months of harvests. By this time, in August, the greatest yields were obtained for plants that received compost plus 100 lbs / Acre of N as synthetic fertilizer. By the last harvest period, however, plants that received compost at 10 MT / acre plus 300 lbs of N as urea showed a trend toward the greatest yields at 65.6 MT / acre but were close to those obtained by compost plus 100 lbs N as urea, at 63.7 MT / acre. To evaluate the benefits provided by the compost applications alone, note that yields of the controls were about 60% of the yields obtained with applications of the home made compost alone, and 70% of the yields obtained with the Amend commercial compost alone.

Canopy height and diameter (Table B- and Figures B-1 to B-3) followed a similar trend as yields. By September 21, plant height was similar for all treatments, ranging between 30-35 inches (80-90 cm), with the control having the shortest plants, and with plants receiving synthetic N alone, or compost plus 100 lbs N having the tallest plants (Table B-2). Canopy diameter or width showed more marked differences between treatments. By 21 September canopy width was about 27 inches for controls and about 35 inches for plants that received compost plus either 100 or 300 lbs N / acre. This information will be useful for growers when planning their nutrient management practices because particular canopy structures simplify manual harvesting operations. All measurements taken (yields per plant, and canopy dimensions, see Fig. B-1 to B-3) show a similar growth pattern over time.

Soil Analysis. Soil analysis and nematode counts were conducted twice before starting the basil experiment. The first samples were taken in October 1993 (Table O-3), and the second one in February 1994 (Table O-4) after harvesting the lettuce but prior to transplanting the basil. Soil samples for nutrient analysis and nematode counts were again collected in 15 July 1994 (Table O-6). With the exception of Organic Matter content no significant differences were found in soil analysis between treatments. This indicates that, as is well known, it takes a long time, and high levels of amendments for small changes to occur in soil fertility. Still, compared to initial fertility levels in October 1993, by July 1994 the pH and the soil salinity (EC in mmhos) increased, especially in soils that received the commercial Amend compost. However all the salinity levels determined in July 1994 are still considered excellent for vegetable production. Among all the parameters tested the organic matter (OM) content underwent the major changes from 1993 to 1994. In October 1993 OM was 1.4%; in the controls; synthetic fertilizer treatments OM remained at about 1.6% during 1994, but increased to 1.9% OM for treatments which received a compost application (an increase of 35% compared to initial soil levels in Oct. 1993).

Due to the slight slope in the experimental plots, and higher erosion in the lower sections, the treatment plots could be divided into a high fertility (Blocks I and II), and a low fertility section (Blocks III and IV). As indicated in Table O-6, these differences in fertility are reflected by the higher salinity (EC), organic matter, Phosphorus (P), Potassium (K), and Calcium (Ca) levels in blocks I and II, compared to the lower levels in Blocks III and IV. This data illustrates the need for commercial growers to take into consideration the different fertility conditions in the farm when conducting fertilizer or compost applications.

Tissue Levels. To match fertilizer applications with crop nutrient demands it is necessary to have a good understanding of soil fertility and of nutrient levels in the plant tissue, to develop what are called 'calibration' curves. A nutrient budget analysis accounts for nutrient levels already present in the soil, for desired nutrient contents in the plant, and the balance not present in the soil is applied through organic or synthetic fertilizers. Tissue lab nutrient analyses were conducted for basil in 15 May, 15 June, and 15 July (Table B-1). As observed in the lettuce experiments (Table L-3), nutrient levels found for basil were above those required for optimum crop growth, but not yet reaching toxic levels. This again indicates the high native fertility of the Waimanalo soils. However, the "dilution" effect of nutrients should be taken into consideration when evaluating tissue content levels. For example the controls had nitrogen (N) tissue levels of 3.2%, which is only about 10% less than levels found in plants that received N fertilizer alone, and 20% less than levels found in plants that received Amend compost plus 300 lbs N / acre. However both Amend plus 300 lbs N / Acre and N alone treatments yielded about twice as much as controls (208 and 178% yield increases compared to control, respectively (Table B-2). Therefore the basil plants which received no compost nor N fertilizer were able to obtain sufficient nutrient levels within a canopy of limited dimensions and with slow growth rates, compared to the much faster growth rates (as indicated by yields and canopy growth over time, Figures B-1 to 3) of plants that received compost and / or N fertilizer applications. This trend may also explain for the higher potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), and zinc (Zn) levels found in controls than in the other treatments. On the other hand the relatively high levels of manganese (Mn), sodium (Na), nitrogen (N), and iron (Fe) on plants that received a compost treatment, may be explained in part by the high levels of these nutrients found in the raw compost products (Table B-1). Future plantings will thus require no additional fertilizer applications other than N, in the form of organic or synthetic fertilizers.

Table B-1. Effect of compost and synthetic nitrogen fertilizer treatments on the nutrient tissue content of basil, Waimanalo 1994[z].

Treatment	N	P	K	Ca	Mg	Na	S	Mn	Fe	Cu	Zn	B
			(%)							(ppm)		
Control	3.2a [y]	0.47a	4.2a	2.6a	0.63a	0.04a	0.31a	56b	253a	20a	63a	29a
Home-made	3.1a	0.45ab	4.0ab	2.5a	0.61a	0.04b	0.29a	56b	224a	20a	61ab	30a
Comp-0	3.3a	0.39bc	3.8ab	2.5a	0.61a	0.05ab	0.31a	57b	197a	20a	53ab	28a
Comp-100	3.5a	0.34c	3.5b	2.6a	0.60a	0.04a	0.31a	68ab	197a	20a	46ab	30a
Comp-200	3.5a	0.34c	3.7ab	2.3a	0.54a	0.05a	0.30a	82a	190a	19a	47ab	29a
Comp-300	3.7a	0.35c	3.7ab	2.5a	0.58a	0.05ab	0.31a	84a	199a	20a	49ab	30a
Urea	3.4a	0.35c	4.0ab	2.4a	0.56a	0.04ab	0.29a	80a	188a	16a	44b	28a
Recommended levels (lettuce)	2.8	0.48	4.2	0.9	0.32	NA	NA	51	128	NA	38	19

[z] Tissue samples collected from most recently matured leaves. Data shown are means from samples collected in 15 May, 15 June, and 15 July 1994.
[y] Within each column numbers followed by the same letter are not significantly different according to Duncan's New Multiple Range test, $P<0.05$.

Table B-2. Effect of compost and nitrogen fertilizer treatments on mean canopy dimensions and yields of basil after seven harvests from June to November 1994.

Treatment	N rate (lbs / A)	Canopy Width (cm)	Canopy Height (cm)	Yields by Aug. 94 (lb / Acre)	Yields by Dec. 94 (lb / Acre)
Control	0	61.0c	65.1b	16,370c	31,494
Home-made	0	66.7b	70.4ab	24,556b	55,969
Amend Compost	0	67.3ab	69.0ab	24,554b	43,762
Amend Compost	200	71.0ab	69.8ab	31,004ab	53,456
Fertilizer	150	69.2ab	72.9a	29,396ab	55,969
Amend Compost	300	70.5ab	70.2ab	32,608a	65,643
Amend Compost	100	72.2a	71.2a	34,223a	63,702

Figure B-1

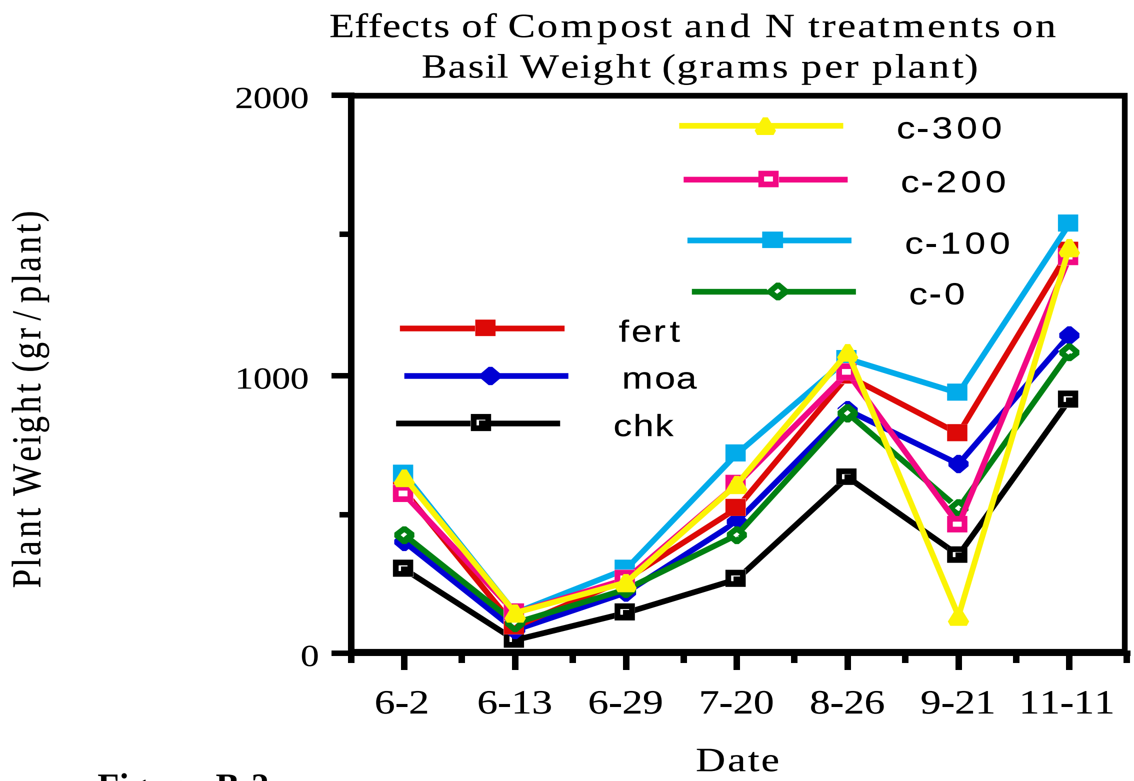


Figure B-2

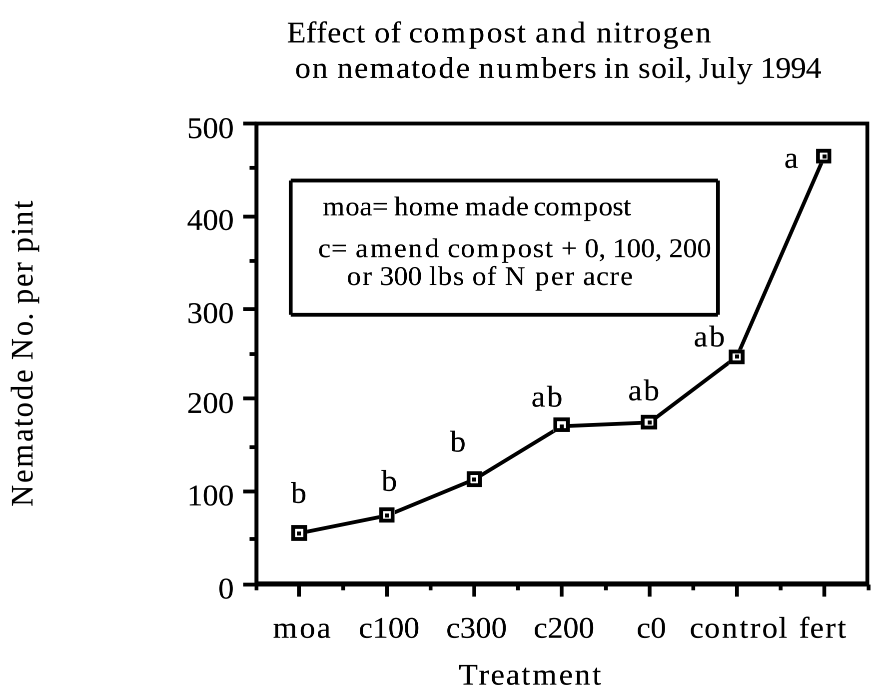


Figure B-3

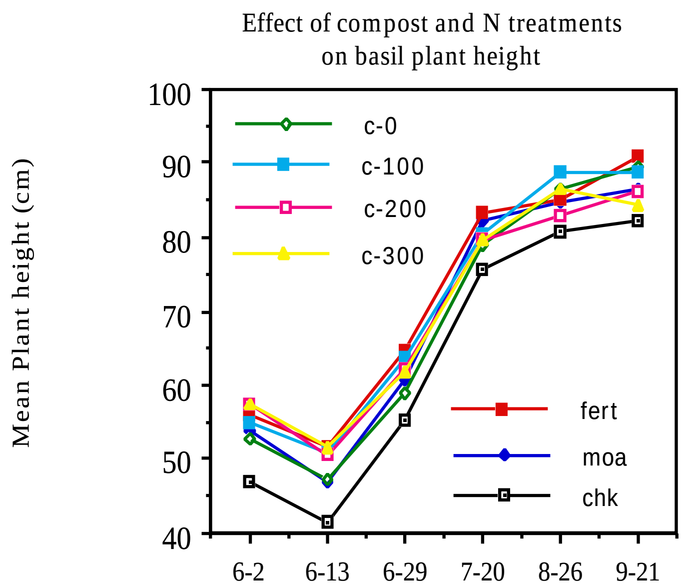
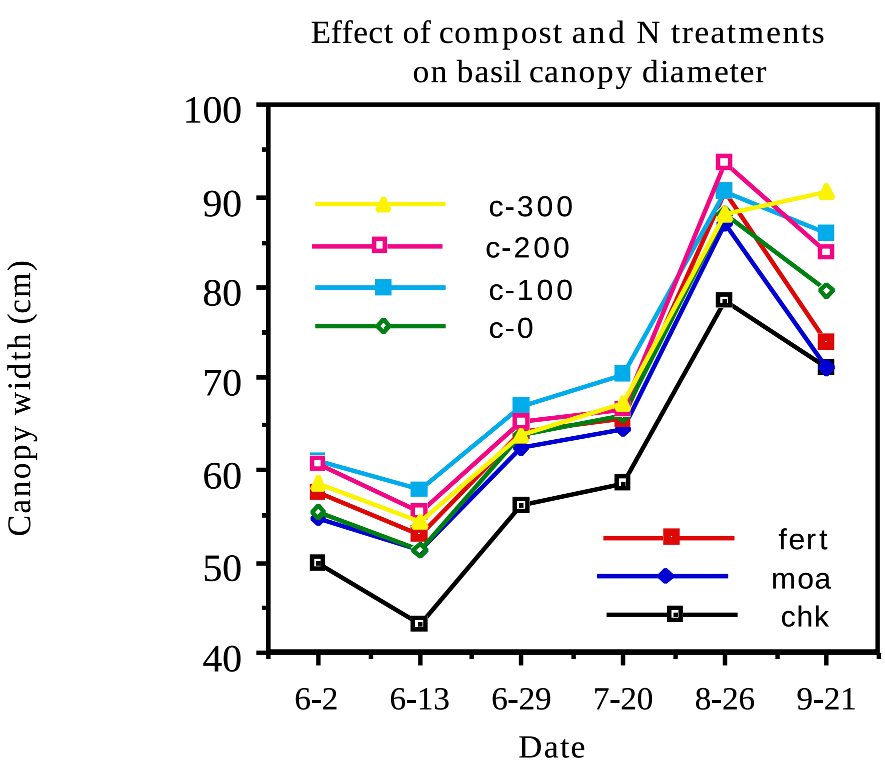


Figure B-4



4.0. Nature Farming Demonstration Plots 1993 & 1994

The demonstration nature farming plots consist of over 40 beds 100 ft long (Fig. D-1, Section A). Several crops and cover crops were grown successfully beginning in the Fall 1993, and continuing till 1997 (Fig. D-2). These crops included (with their yields per 100 ft of row): soybeans (20 lbs/100 ft of row); Manoa lettuce (50 lbs/100 ft); Chinese daikon (270 lbs/100 ft); carrots (50 lbs); beets (90 lbs); green onions (used as nursery crop); mustard cabbage (130 lbs); hybrid daikon (150 lbs); long daikon (180 lbs); okra (15 lbs); green onion (60 lbs); choi sum (30 lbs); red leaf lettuce (30 lbs); cilantro (50 lbs); and spinach (55 lbs). Crop failures occurred due to the wet weather in the winter or to pests with the following crops: sweet corn; won bok (aphids, leaf hopper); oriental cucumber (aphids, vine borer); string beans (rust); bulb onion; and carrots. Insect pests included rose beetles, aphids, mites, and whiteflies, and a thrips species in beets which was previously never reported to infest sugar beets (Dr. Dick Tsuda, personal communication). Diseases included bacterial black rot (Xanthomonas campestris) in Chinese cabbage and choi sum, perhaps due to contaminated seed. Tissue samples of some of these vegetables was collected on 30 April, and 12 December 1994 (Table D-1). Surprisingly (for plants grown free of synthetic fertilizers), the tissues had relatively high nutrient levels, especially for nitrogen (N); levels above those recommended for optimum growth of vegetable crops, but not yet reaching toxicity. Leaf lettuce for example had 3.6% N, while recommended rates range from 2.5% and above. Swiss chard also had a very high 4% N content; recommended levels for cabbage, another brassica, are about 3%. Soil analysis was also conducted prior and after plantings (Table O-4). Phosphorus (P), Potassium (K), and Calcium (Ca) levels were increased, as well as soil organic carbon content. This indicates that the high rates of composts applications contributed to the high yields and to improved soil fertility. The higher organic matter levels in the soils would be expected to contribute toward improved soil aeration, and improved root access to water and nutrients. In our future studies we will continue to monitor the effects of continuous compost applications on soil quality, as well as on nematode and soil disease populations.

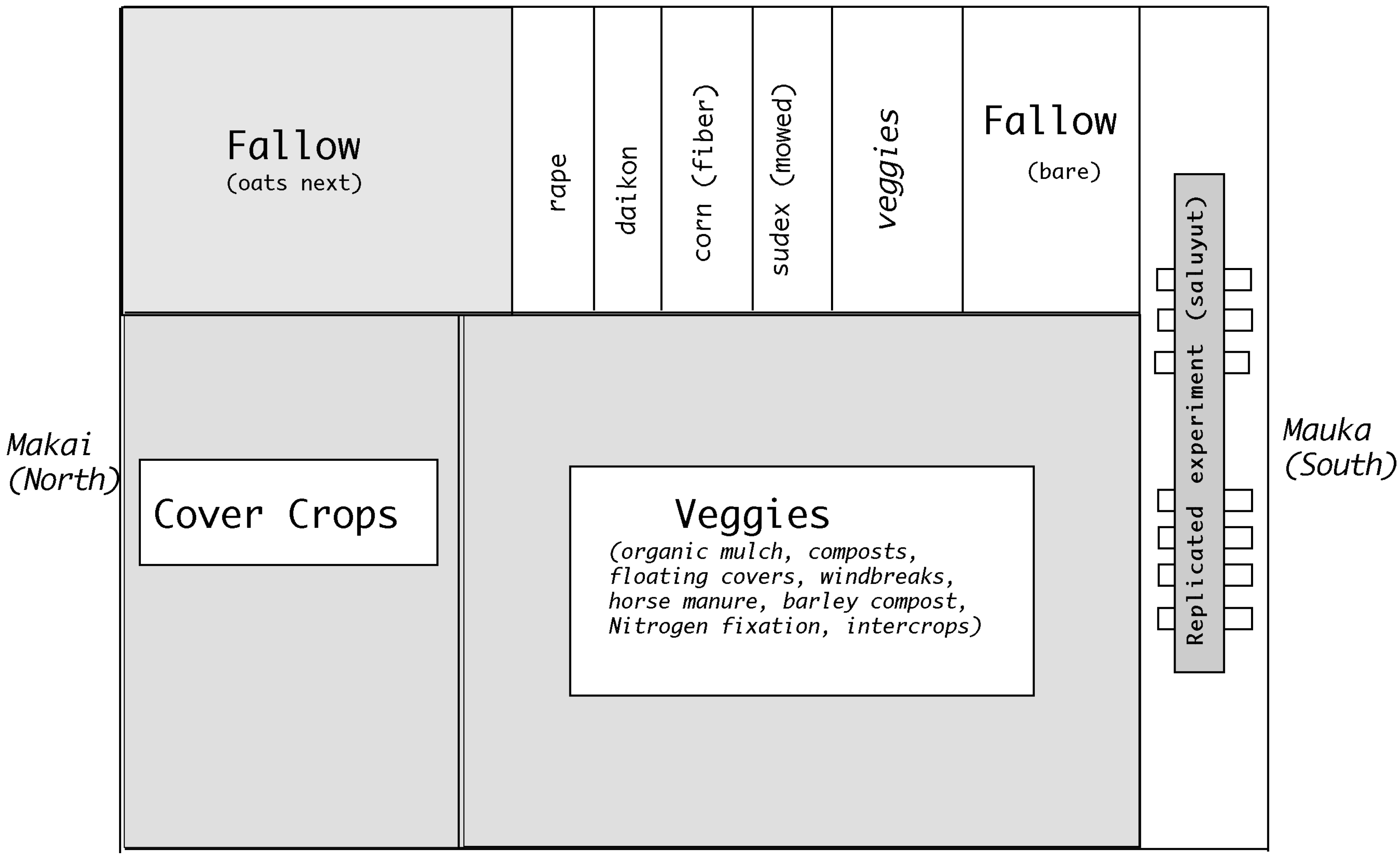

Fallow
(oats next)
rape
daikon
corn (fiber)
sudex (mowed)
veggies
Fallow
(bare)
Replicated experiment (saluyut)
Makai
(North)
Cover Crops
Veggies
(organic mulch, composts,
floating covers, windbreaks,
horse manure, barley compost,
Nitrogen fixation, intercrops)
Mauka
(South)

Table D-1. Tissue nutrient content levels for vegetable crops grown in the nature farming demonstration plots at the UH Waiamanlo Experiment Station. Samples collected on 30 March 1994 (except Ch. cabbage and choi sum, collected on 12. Dec. 1994).

Crop	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm
Beet	3.5	0.45	7.3	1.3	1.26	2.76	186	778	14	43	28
Carrot	2.6	0.46	5.0	1.7	0.31	0.42	61	615	9	32	45
Chinese cabbage	2.8	0.57	5.9	3.2	0.54	NA	31	81	7	29	34
Choi sum	4.6	0.51	5.6	2.0	0.52	NA	37	132	7	35	32
Daikon	3.8	0.54	3.7	3.1	0.58	0.74	33	166	6	28	45
Lettuce leaf	3.6	0.61	7.4	1.3	0.36	0.23	147	827	20	44	30
Onion, bulb	3.8	0.71	3.6	1.5	0.33	0.25	67	149	9	19	27
Swpotato, green	2.7	0.5	4.8	0.80	0.44	0.11	98	132	16	23	43
Swiss chard	4.1	0.51	6.4	0.81	0.93	3.23	136	1085	17	44	31

Table D-1a. Soil samples from the demonstration plots, collected before and after compost treatments.

Date taken	pH	OC	P	K	Ca	Mg
		%	ppm	ppm	ppm	ppm
Before (10-93)	6.8	1.8	310	400	6000	1450
After (2-94)	6.9	2.0	430	540	6800	1100

5.0 Overall Results for 1993-1994

5.1. Yields: The compost applications resulted in commercially acceptable yields. Yields of leaf and head lettuce treated with compost were about 12,000 and 23,000 lbs/Acre, respectively. Yields of basil after continuous harvest for 8 months were >63 MT/Acre with a combination of compost plus 100 lbs N/Acre.

5.2. Soil quality: Nematode counts were lower and organic matter content was greater in plots that received compost than in compost-free treatments (controls and plots that received N fertilizer alone) (See section: 20.0, Overall Results).

5.3. Nutrient tissue content: Nutrient tissue content in all treatments was at or above the nutrient sufficiency range for leafy vegetable crops, which indicates the high native soil fertility. Basil controls had relatively high tissue nutrient content levels but had overall 50% lower biomass production than plants which received a combination of composts and N fertilizers.

5.4. Conclusions for 1994.

Preliminary results indicate that compost applications contribute toward commercially acceptable yields of vegetable crops, and toward reduced nematode populations. For commercial growers the best treatment combination for high consisted of 10 tons/acre of compost plus 100 lbs of Nitrogen (N) as synthetic fertilizer. However, an organic source of N can be substituted for the synthetic fertilizer (such as chicken manure) to obtain similar high yields. Pest problems included rose beetles, mites, and spittle bugs which were the likely cause of general plant chlorosis in December 1994.

6.0. Organic Amendment experiments with Daikon-Roy Shiraki's Farm, 1995 & 1996

An organic amendment experiment was conducted on Roy Shiraki's commercial organic farm in Central Oahu. The main crop on this farm is organic taro for lua leaf production. The experiment consisted in evaluating 4 different organic amendments in daikon, compared to the application of synthetic fertilizer (16-16-16). Each treatment consisted of one plot 27 by 27 ft in size. The compost was applied 3 months prior to direct seeding the daikon. The greatest yields were obtained with the application of a mixture of composted vegetables and pig manure, followed by an application of chicken manure alone. Mid-range yields were obtained with the application of chicken manure and synthetic fertilizer. The lowest yields were obtained with the application of a mix of guinea grass and chicken manure. The nitrate sap analysis indicated that higher petiole nitrate levels were found in the pig manure and vegetable compost treatments, compared to the levels observed for the guinea grass and synthetic fertilizer treatments. Growers using rapid sap analysis kits would thus target to have nitrate petiole levels to be greater than 3500 to reach high daikon yields. The laboratory tissue analysis results also reflect the higher tissue nutrient levels in the treatments that received vegetable composts, and chicken and pig manures than the treatments that received guinea grass applications or the controls.

Daikon Compost experimental details

Direct seeded: Oct 9, 1995
Harvest Nov. 27, 1995
Plots= 27 by 27 ft (9 by 9 m)
Compost applied 3 months prior to planting
Daikon was direct seeded variety 'Aoguki' (Green neck, Japanese type)

Table DA-1. Effect of several organic amendments on daikon yields, 1995.

Treatment (10 tons/Acre)	Yield (lbs/plot)	Yield (lbs/Acre)
Guinea grass & chicken manure	68	4,063
Pig manure, aged	119	7,100
Fertilizer, 16-16-16	83	4,959
Chicken manure, aged	84	5,019
Compost veg & chick manure	144	8,604

Table DA-2. Effect of several organic amendments on the petiole nitrate sap nitrate content of daikon, 1995.

Daikon nitrate levels at Roy Shiraki's, 11/3/95 with rapid sap analyser, whole leaf mid-rib

Treatment	Nitrate (ppm)	K+ (ppm)
Guinea grass	3200	1200
Chicken manure	3800	2400
Pig manure	3600	1900
Vegetable compost	3600	1100
Fertilizer 16-16-16	2500	960

Table DA-3. Effect of several organic amendments on the nutrient tissue content of Daikon on two experiments conducted in Central Oahu, 1995 and 1996.

Daikon Tissue levels- sampled 11-3-95

Treatment	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
Check	5.6	0.34	4.6	4.3	0.53	0.81	60	805	28	34	30
Guinea grass mulch	4.4	0.28	3.9	10.4	0.67	0.36	62	942	24	37	43
Pig manure	6.5	0.63	6.8	3.2	0.49	1.01	75	1033	68	41	39
Fertilizer	6.4	0.53	5.2	4.9	0.55	1.32	75	661	28	22	29
Veg compost & chicken manure	6.8	0.52	7.4	3.6	0.51	0.9	99	562	20	36	38
Chicken manure	7.2	0.61	6.4	2.6	0.53	1.14	187	775	26	51	40

Expt. 2

Samples from 3-1-96

Treatment	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
Check	2.9	0.21	1.9	4.9	0.58	0.30	45	607	10	29	42
Guinea grass	3.2	0.17	1.6	4.1	0.40	0.27	34	266	6	26	34
Pig manure	4.9	0.47	3.4	2.4	0.46	0.47	75	364	11	43	36
Fertilizer	4.7	0.36	3.0	2.8	0.35	0.28	35	718	9	18	32
Vegetable comp	5.1	0.45	4.8	2.0	0.25	0.38	32	439	13	42	38
Chicken	5.1	0.46	4.7	2.2	0.34	0.51	62	539	19	43	39
Chick & guinea	5.0	0.49	4.9	1.8	0.27	0.43	58	386	15	39	38

Table DA-4. Nutrient tissue content of commercially grown organic dryland taro, grown in Central Oahu, 1995.

Tissue samples- collected 5-9-95 at Roy Shiraki's farm in Wahiawa

N	P	K	Ca	Mg	Na	S	Mn	Fe	Cu	Zn	B
4.6	0.54	5.4	1.3	0.29	0.03	0.38	145	78	14	31	24

Table DA-5. The effect of several organic amendments on the soil nutrient content of organically grown daikon in Central Oahu, March 1, 1996, collected 1 wk prior to harvest.

Treatment	pH	EC mmhos	OM (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
Control	6.5	0.09	1.0	60	60	1560	60
Guinea grass alone	7.3	0.08	1.0	21	100	2100	60
Fert commercial	7.0	0.10	1.0	75	100	1900	60
Veg compost	6.7	0.28	1.8	497	500	2200	220
Chicken manure	6.6	0.18	1.7	264	340	1460	160
Ch. man& guinea gr.	6.7	0.34	1.8	605	480	2400	220
Pig manure	7.2	0.12	1.3	58	240	2400	220
Taro fields organic	5.4	1.54	2.5	402	720	1300	300

Table DA-6. Soil fertility of commercially grown taro (old organic plot) and daikon (newly established field) in Central Oahu, August 1996.

Treatment	Date	pH	OM (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	EC (mmhos)
Taro	8/29/96	5.4	5.17	1183	1300	2900	540	2.8
Daikon	8/29/96	6.5	2.1	616	680	2300	260	1.3

Table DA-7. Soil fertility of organically grown daikon at the MOA nature farming demonstration plots, Waimanalo, 1994. Tissue samples taken= March 30, 1994

Crop	N %	P %	K %	Ca %	Mg %	Na %	Mn ppm	Fe ppm	Cu ppm	Zn ppm	B ppm
Daikon	3.8	0.54	3.7	3.1	0.58	0.74	33	166	6	28	45

7.0. Saluyut Trials, 1996-1997

First Saluyut Experiment: 1995-1996.

As part of the long-term replicated compost experiments at the Waimanalo Nature Farming plots, saluyut, or Filipino spinach (Corchorus olitorius L., Tiliaceae Family), was planted on October 10, 1995. The treatments, as for the previous experiments were: control, synthetic fertilizer at the rate of 150 lbs/Acre, compost alone at a rate of 10 MT/Acre, and compost at 10 MT/Acre plus 0, 100, 200, or 300 lbs/Acre of synthetic N fertilizer.

Seeded: Oct. 10, 1996

Synthetic fertilizer treatments: Oct. 26= apply 50 lbs/Acre N and 100 lbs/Acre N (for comp-200 and comp-300). On Nov. 17, 1995, apply a second 50 lb/Acre rate, and the last 50 lb/Ac N application was conducted on Dec. 8, 1995.

Harvest dates= Nov. 29, 1995, and Jan. 18, 1996.

Second Saluyut experiment, 1997

A second saluyut experiment was conducted in the Fall 1997. Compost treatments were applied on August 14, 1997. The treatments were conducted as follows:

1) Control
2) Synthetic fertilizer (urea)
3) MOA= compost made out of 50% straw compost (50% chicken manure & 50% straw) plus 50% bayodo. The bayodo compost was made from 60% soil & 40% rice hulls.
4) Comp compost made out of 50% chips compost (50% chips and 50% chicken manure) plus 50% bayodo.

The saluyut was direct seeded (broadcasted on a 2 ft wide strip, for a total planting area of 2 by 30 ft) on August 28, 1997. The fertilizer and comp & fert plots were fertilized with urea on September 4, 1997. A second synthetic N application was made on October 13, 1997. A count of number of plants per plot was conducted on September 30, 1997. The saluyut was harvested on October 9 & 27th, 1997, and on Jan. 6, 1997. Plant stands obtained for this experiment was as follows: Mean number of plants counted per bed were for control (260), fertilizer (231), MOA-compost (413), and compost beds (471).

Results.

In the 1996 experiment no significant difference was found between treatments with respect to overall yields (Table S-1). However a trend was shown for higher yields (over 15% greater yields) than the controls for the synthetic fertilizer, MOA compost, Compost plus 100, and Compost plus 200 lbs/Acre of synthetic fertilizer. The compost plus 300 lbs/Acre of synthetic N actually showed suppressed yields compared to the lower N application rates (Table S-1). In the 1997 experiments significant differences were found between treatments with respect to yield. Lowest yields in 1997 were obtained by the controls while greatest yields were obtained by the compost treatments receiving either 0, 200, or 300 lbs / Acre of synthetic Nitrogen (Table S-2). By the second harvest in 1997 treatments that received compost had yields that were over 50% greater than the controls (Table S-2). Also by second harvest the treatments that received compost alone had greater yields than the synthetic fertilizer treatments. By the last harvest, treatments that received compost alone performed similarly to the synthetic N treatment (Table S-3). The greatest yields, by the last harvest, were obtained by the compost plus 0, 200, or 300 lbs of synthetic N. The nutrient tissue contents of the most recently matured leaves (Table S-4) showed a similar trend as that observed in the yield data. Tissue N levels were equal for the plants that only received either compost or synthetic fertilizer. Further increases in the tissue N content was found for plants that received compost plus 100, 200 or 300 lbs of synthetic N. A similar pattern was observed with respect to the other nutrients (Table S-4). The nutrient tissue levels of the compost plus synthetic N treatments found in this experiment were similar to those levels found in a highly fertilizer commercial farm in Mahaka (Table S-5).

The compost treatments had an effect on the final plant stands of saluyut. This indicates that the compost applications improved the soil tilth which resulted in improved seed germination and seedling growth. The mean total number of plants (N=4 per treatment) found per 30-ft bed section was control, 260; synthetic fertilizer, 231; MOA-compost 413, and compost beds, 471.

Table S-1. Effect of compost treatments on saluyut yields (2 harvests) in the long-term organic replicated plots, Waimanalo, 1996.

Treatment	Yield per plant (lbs)	Yield per acre (lbs)	% Increase (from control)
Control	0.94a	10,199a	0
Fertilizer N	1.10a	11,935a	17
MOA compost	1.08a	11,718a	15
Comp-0	0.96a	10,416a	2
Comp-100	1.10a	11,935a	17
Comp-200	1.08a	11,718a	15
Comp-300	1.00a	10,850a	6

Note: MOA= straw -based compost (25% by volume); Comp= chip-based compost (25% by volume). Comp-0, 100, 200, or 300 equals chip based compost plus 0, 100, 200 or 300 lb / Acre rate of synthetic Nitrogen applied as urea. Fert N= treatments received 150 lb / Acre of synthetic N (as urea).

Table S-2. Effect of compost treatments on saluyut yields (2 harvests) on the long-term organic replicated plots, Waimanalo, 1997.

Treatment	Yield per linear ft (lb)	Yield per acre (lb)	% increase from control	Approx. N contribution (lbs / Acre)
Control	1.14b	12,369b	0	101.4
Fertilizer N	1.68ab	18,228ab	47	150.0
MOA comp alone	1.76ab	19,096ab	54	156.6
Comp-0	1.98ab	21,483ab	74	176.2
Comp-100	1.82ab	19,747ab	60	161.9
Comp-200	2.03a	22,047a	78	180.8
Comp-300	2.03a	22,047a	78	180.8

Note: MOA= straw -based compost (25% by volume); Comp= chip-based compost (25% by volume). Comp-0, 100, 200, or 300 equals chip based compost plus 0, 100, 200 or 300 lb / Acre rate of synthetic Nitrogen applied as urea. Fert N= treatments received 150 lb / Acre of synthetic N (as urea).

Table S-3. Effect of compost treatments on saluyut yields (3 harvests) in the long-term organic replicated plots, Waimanalo, 1997.

Treatment	Mean Yield (lb / ft)	Mean Yield (lb / Acre)	Biomass (lb / Ac)	% Increase over control	Approx. N contribution (lbs / Ac)
Check	0.53	34,503	3,450.3	0	110.4
Fertilizer N	0.72	46,872	4,687.2	35	150.0
MOA compost	0.70	45,570	4,557.0	32	145.8
Comp-0	0.80	52,080	5,208.0	50	167.0
Comp-100	0.66	42,966	4,296.6	24	137.5
Comp-200	0.80	52,080	5,208.0	51	166.6
Comp-300	0.83	54,033	5,403.3	57	173.0

Note: MOA= straw -based compost (25% by volume); Comp= chip-based compost (25% by volume). Comp-0, 100, 200, or 300 equals chip based compost plus 0, 100, 200 or 300 lb / Acre rate of synthetic Nitrogen applied as urea. Fert N= treatments received 150 lb / Acre of synthetic N (as urea).

Table S-4. Effect of compost treatments on saluyut, Filipino spinach, nutrient tissue levels, Waimanalo, October 28, 1997.

Treatment	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
			(%)					ppm			
Control	4.5	0.37	2.8	1.6	0.3	0	65	102	16	25	37
Fert	4.8	0.36	2.8	1.7	0.3	0.1	72	97	15	26	39
Moa	4.8	0.38	2.9	1.8	0.3	0	79	98	17	25	41
Comp-0	4.8	0.38	2.8	1.8	0.3	0.1	81	98	18	24	44
Comp-100	4.9	0.38	2.9	1.8	0.3	0.1	80	100	21	25	45
Comp-200	5.0	0.40	3.1	1.9	0.3	0.1	93	109	23	27	46
Comp-300	5.2	0.43	2.9	1.7	0.3	0.1	94	107	24	28	44

Table S-5. Saluyut samples collected from a commercial farm on Makaha Oahu, Sept. 8, 1995

a. **Soil Fertility**

Crop	pH	Salinity	P	K			
Ca	Mg	Org. C					
Saluyut	7.1	1.41	98	400	6400	2500	1.66
Cowpea	6.5	1.37	538	460	5700	3000	1.37

b. **Nutrient Tissue levels**

Crop	N	P	K	Ca	Mg	Na	S	Mn	Fe	Cu	Zn	B
Saluyut	5.2	0.44	3.11	1.33	0.45	0.02	0.31	135	562	21	27	32

8. Zucchini Trials, 1998

Zucchini 'Ambassador' was planted in a 2 row staggered pattern on February 13, 1998 on the replicated compost plots to evaluate the effect of the different compost treatments on compost yields. The crop was harvested 8 times (3 times per week) from March 18 until April 3, 1998. The treatments were as follows:

MOA= 10 MT / Ac of compost made of 50% compost [1 / 2 straw & 1 / 2 chicken manure] + 50% bayodo (60% soil & 40% rice hulls)

COMP= 10 MT / Ac of compost made of 50% compost [1 / 2 chips & 1 / 2 chicken manure] + 50% bayodo (60% soil & 40% rice hulls)

Fert= 200 lbs N / Acre (urea split in 2 applications at 1 and 4 weeks after planting).

Comp-100, 200, and 300 (chips compost plus 0, 100, 200 or 300 lbs N / Acre as Urea).

Results

The greatest yields were obtained with the split applications of synthetic N fertilizer alone at the rate of 200 lbs acre of Nitrogen. In the synthetic N treatment zucchini yields were about 60% greater than in the controls. Yields for plants receiving compost plus 100 or 300 lbs / Acre N were 30-40% greater than the controls. This indicates that the compost treatments alone provided negligible (0 to 80 lbs of Nitrogen) amounts of N to the zucchini plants which resulted in yields that were similar to those obtained by the untreated controls. The greater yields obtained by the plants in the MOA (straw compost) than in the Compost (chips) treatments reflect the greater N content in the straw compost (1.46%) than in the chips compost (0.93%). The yield reduction obtained in the plots that received the chips compost alone (comp-0) indicate that the available N was fixed by microbial activity, due to the high C to N ratio. The addition of synthetic N to the chips compost, as would be predicted with the lower C:N ratios, indeed increased the zucchini yields by 30 to 40% as compared to the controls. The comp-100 treatment (compost plus 100 lbs synthethic N) thus provided a total of about 180 lbs N / Acre, compared to the 200 lbs / Acre N which were applied to the fert (synthetic N) treatments. The 10 MT / Acre of chips compost thus provided about 80 lbs of N. Plants stands were evaluated about 2 weeks after planting. The compost treatments had no effect on plant stands as compared to the controls or the synthetic N treatments. The level of viral infection also was similar among all treatments (about 25% of all plants infected among all treatments).

Table Z-1. Effect of compost treatment on the yield of zucchini, in the long-term replicated organic plots, Waimanalo, Spring 1998.

Treatment	Yield (lbs / Acre)	Biomass (lb / Ac dry wt)	% increase over check
Check	21,005.6	2,100.6	0
Fertilizer N	33,206.0	3,320.6	58
MOA compost	22,617.3	2,261.7	8
Comp-0	19,327.8	1,932.8	-8
Comp-100	29,279.6	2,927.9	39
Comp-200	24,661.1	2,466.1	17
Comp-300	27,582.8	2,758.3	31

Note: MOA= straw -based compost (25% by volume); Comp= chip-based compost (25% by volume). Comp-0, 100, 200, or 300 equals chip based compost plus 0, 100, 200 or 300 lb / Acre rate of synthetic Nitrogen applied as urea. Fert N= treatments received 200 lb / Acre of synthetic N (as urea).

Table Z-2. Nutrient content of the compost materials used on zucchini, Spring 1998.

Compost analysis as tissue, 8/25/97

Compost	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
Straw-mulch	1.5	2.5	2.6	14.8	1.0	0.59	1779	28300	107	487	83
Bayodo	0.64	0.49	0.62	0.38	0.53	0.06	3689	95170	142	144	251
Chips compost	0.93	0.95	0.94	5.5	0.66	0.24	2715	76090	130	270	183

NOTE:

Straw-mulch= compost made from 50% straw, 50% chicken manure

Chips comp= compost made from 50% chips (legume, Leuceana trees), 50% chicken manure

Bayodo= compost made from 60% soil and 40% rice hulls

9. Basil Trials, Summer 1998

Introduction

Basil is an important crop in Hawaii and there has been increasing interest by farmers in growing it organically. Application of organic matter as the sole source of nutrients for basil has been observed by both farmers and researchers in Hawaii to support yields similar to plants fertilized with synthetic nutrients. Additions of organic matter have also been observed to reduce pest populations and disease incidence. Experiments to determine whether it is possible to obtain commercially acceptable yields in basil and other vegetable have been conducted over the past several years at the University of Hawaii's agricultural experiment station in Waimanalo (See sections 2 & 3). Another experiment is currently under way at the same location to observe yield response of basil to two rates of compost application compared to a synthetic fertilizer treatment. Any observed difference in pest populations, disease incidence and basil quality between treatments will also be recorded. The experiment reported here was conducted to build up pest populations for these future trials, as well as to observe the plant's response to an application of chicken manure estimated to release a total of 100 lbs of nitrogen to the crop.

Materials and Methods

Sixteen beds had been previously arranged into four replications of four beds, each bed representing a treatment. The treatments were:

Control- No application of fertilizer or organic matter. These beds have never received fertilizer or compost applications

Fertilizer- 100 pounds N / acre applied as urea in two applications of 50lbsN / acre each, 11 days and 41 days after transplanting respectively. These beds have received applications of urea over the past 4 years

Compost- Chicken manure applied at the rate of approximately two tons per acre, which was predicted to supply100 lbs N / acre to the current crop. Over the past 4 years these beds received annual compost and urea applications.

MOA Chicken manure applied at the same rate (lb / Acre) as the compost treatment. Over the past 4 years these beds received only compost applications and NO synthetic fertilizers.

Seeds of a *Fusarium* tolerant sweet type basil variety developed by the University of Hawaii were planted in trays in early March 1998. The seedlings were transplanted into the field seven weeks later at a spacing of 1.5 feet between plants. Five harvests were conducted beginning on 6 July 1998 and ending on 31 July 1998. Entire growing tips of 2-4 pairs of fully developed leaves were harvested and weighed. Tissue analysis for Nitrogen were conducted on all replications for each treatment immediately following the first urea application in the fertilizer treatment and again after the second application of urea. Soil analysis for organic carbon and nematode counts were conducted for all reps of each treatment immediately after removal of the plants the first week of August. Data were analysis with SAS.

Results

All treatments had leaf nitrogen contents suitable for commercial basil production.

Leaf nitrogen content in the control plots increased over the course of plant development without the addition of supplemental nitrogen. Tissue analysis showed plants grown in the compost treatments to have significantly higher leaf nitrogen levels over the course of the trial than the MOA and fertilizer treatments, which were not significantly different from each other. The leaf nitrogen content of plants grown in the control plots were significantly lower than all other treatments. After receiving 50 lbs / Acre N as urea, plants in the fertilizer treatments had leaf nitrogen levels significantly lower than the compost treatment. The levels were also lower than those in the MOA plots and higher than those in the controls, though the differences were not significant. After the second application of urea (100 lbs / Acre N cumulative total), tissue nitrogen levels in the fertilizer plots were significantly higher than those in the controls. They were lower than the compost plots and higher than the MOA plots, though the difference was not significant. Nitrogen tissue levels in the MOA plots were significantly higher than those in the control at that time

Total yield was greatest in the fertilizer treatment, though not significantly higher than the compost or MOA treatments. Total yield from the fertilizer, compost and MOA treatments were all significantly higher than the control. Yield from the compost treatment was significantly higher than yield from fertilizer and MOA treatments for the first two harvests when the fertilizer treatment received 50 lbs N / acre. Differences in yield between the fertilizer and MOA treatments were not significant at this rate. Yield from the fertilizer treatment was highest after receiving the second urea application, though not significantly higher than the compost or MOA treatments. Yield remained higher in the compost beds (previous history of synthetic N applications) than the MOA plots (no previous history of synthetic N treatments).

Table B-3. Effect of compost treatments on the yield of Basil on the nature farming long-term organic plots, Waimanalo, summer 1998.

Treatment	Total Yield per harvest (lb / acre)	Yield Increase Over the control (%)	N released approx. (lb / Ac)
Control	881.8	0	66
Fertilizer	1,327.0	51%	100
Compost	1,344.9	52%	100
MOA-comp	1,143.2	30%	80

Note: Yields per acre are based on estimates of 21,700 plants per Acre (following a planting density of 4 ft between beds, with double rows in each bed; 1 ft between plants in the row and 1ft between rows in the bed).

Table B-4. Effect of compost treatment on the yield of basil after the first urea (50 lbs / Acre N) application, Waimanalo, summer 1998.

Treatment	Yield / plant (grams)	Yield / Acre (lbs)	Increase over controls (%)	N equivalents (lbs / Acre)
Control	81.2	3,885 lbs	0%	25
Fertilizer	163.8	7,838 lbs	201%	50
Compost	257.9	12,297 lbs	316%	78
MOA	173.4	8,297 lbs	213%	53

Note: N equivalents, an estimate of the amount of N released to the basil plants (lbs / Acre) on each plot, was calculated relative to the yields obtained with the urea application rate (50 lbs / Acre N, assuming that all of the urea was effectively utilized by the plants). For example if yields for the controls were 50% of those obtained by the synthetic N (Fertilizer) treatment, it was estimated that the control treatments released 25 lb / Ac N (50% of 50 lbs of N applied as urea).

Table B-5. Effect of compost treatment on the yield of basil following the second urea (100 lbs cumulative total) application, Waimanalo, summer 1998.

Treatment	Yield / plant (grams)	Yield (lbs / Acre)	Increase over controls (%)	N equivalents (lbs / Acre)
Control	613.8	29,370	0	68
Fertilizer	896.06	42,878	46	100
Compost	846.9	40,524	38	94
MOA	750.63	35,917	22	83

Note: N equivalents, an estimate of the amount of N released to the basil plants (lbs / Acre) on each plot, was calculated relative to the yields obtained with the urea application rate (50 lbs / Acre N, assuming that all of the urea was effectively utilized by the plants). For example if yields for the controls were 50% of those obtained by the synthetic N (Fertilizer) treatment, it was estimated that the control treatments released 25 lb / Ac N (50% of 50 lbs of N applied as urea).

Table B-6. Effect of compost treatment on percent Nitrogen tissue content of the most recently matured leaf, conducted after two urea applications (50 lb / Acre N each).

After First Urea Application (50 lbs N / Acre)	
Treatment	N content (%)
Control	4.4
Fertilizer	4.6
Compost	4.8
MOA	4.7
After Second Urea application (50 lbs N / Acre)	
Control	4.5
Fertilizer	4.9
Compost	4.9
MOA	4.7

Table B-7. Effect of compost treatments on mean nematode counts found following basil harvest at the nature farming replicated plots in Waimanalo, July 31, 1998

Mean values	Org. Matter (%)	Root knot (no / pint)	Reniform (no / pint)	Total Nematode no. (no / pint)
Control	1.9	16.2	23	39.2
Fert	1.8	6.7	6.25	13.0
MOA	2.0	21.0	12.75	33.7
Compost	2.0	8.2	16.5	24.7

Table B-8. Effect of compost treatments on the tissue nutrient content of basil on trials conducted at the long-term organic replicated plots, Waimanalo Expt. Station

a. Conducted after first Urea application, Waimanalo, July 7, 1998

Treatment	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
Check	4.4	0.51	2.9	2.5	0.70	0.09	60	251	15	37	21
Fert	4.6	0.51	3.2	2.6	0.71	0.11	89	373	14	38	23
MOA	4.7	0.46	3.1	2.6	0.68	0.11	71	259	16	34	22
Comp	4.8	0.48	3.1	2.8	0.71	0.14	70	277	14	31	23

b. Conducted after Second Urea application, Waimanalo, July 22, 1998

Treatment	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
Check	4.5	0.53	2.3	2.4	0.71	.07	57	229	18	43	22
Fert	4.8	0.47	2.7	2.2	0.67	.001	67	268	19	41	22
MOA	4.7	0.54	2.5	2.4	0.66	0	67	252	17	41	24
Comp	4.9	0.48	2.9	2.6	0.72	.02	84	353	18	50	25

Discussion

Table B-3 indicates that application of chicken manure alone at 4 Tons per acre can improve basil productivity. The treatment with the lowest yield also had the lowest leaf nitrogen content. The compost and fertilizer treatments, which had the greatest yields, showed the highest leaf nitrogen content. In the fertilizer treatment, both leaf nitrogen content and yield increased after the second application of urea. This suggests that yield may increased with the addition of nitrogen if the average leaf nitrogen content is less than a minimum value (e.g.4.7%) at time of first harvest.

The increase of nitrogen content over time in tissues of plants that received no supplemental nitrogen suggests that basil increases its uptake of available nitrogen as the plant gets older. Although the compost and MOA beds received the same rate of chicken manure, the compost bed produced yields that were significantly greater than those from the MOA beds. This is attributed to a residual effect from the urea applications that the compost beds have received in the past. As a result of the probable residual effect of previous treatments on yield in the compost plot, yield from the MOA treatment was used in comparison with yield from the fertilizer treatment to determine the rate of nitrogen released from the chicken manure that was available to the crop. At 50 lbs nitrogen applied per acre, yields in the fertilizer treatment were similar to those achieved with chicken manure applied at a rate of 4 tons per acre. After the fertilizer treatment received the second application of urea, yields were significantly and dramatically higher than the MOA treatment. This suggests that rate of nitrogen available to the crop released by aged, partially composted chicken manure applied at a rate of 4 tons per acre is similar to the rate of available nitrogen released by urea applied at a rate of 104 lbs per acre, and that this rate is not sufficient for optimum yield.

Conclusion

Basil's requirement for nitrogen seems to increase as the plants get older and the leaf nitrogen content can be correlated with yield. An average leaf nitrogen content less than 4.7% at the early stage of growth may indicate a nitrogen deficiency and yields were observed to increase dramatically with the addition of nitrogen at this level. Applications of urea can affect yield of future crops grown in the same location without the application of additional urea. It was also observed that basil grown with chicken manure applied at the rate of 4 tons per acre produced the same yields as plants that received 104 pounds urea per acre, and doubling the amount of urea added significantly increased yield. These results were observed over a period of two months in the field, a much shorter time than most basil growers maintain their crop. Future studies should be conducted to last over the entire course of the plant's development.

10. Basil Trials, fall 1998

Effects of Compost on Organic Basil Production at the Waimanalo Nature Farming Plots

Introduction

There are an increasing number of growers interested in organic farming and other forms of sustainable agriculture. As a result there is a growing need for University organic fertilizer recommendations, which do not currently exist. University recommendations need to be based on multi-year, replicated studies. Such studies are currently being conducted in the Nature Farming plots of the UH Agriculture Experiment Station in Waimanalo, Hawaii.

This experiment was conducted to observe the effects of compost applications on the production of Basil (*Ocimum basilicum*), an important crop in Hawaii. The objectives of this experiment were:

1. To determine if, and at what rate, compost applications increase basil yields, and if these yields are comparable with those achieved using synthetic fertilizer
2. To determine if there is a difference in response among basil varieties to compost applications.
3. To determine if compost applications affect disease or pest incidence.
4. To determine if compost applications affect flavor or aroma intensity of basil.

Materials and Methods

This experiment was arranged in a randomized complete block design, with four treatments and four replications per treatment. The treatments were:

1) Compost at 20 Tons per acre.
2) Compost at 80 Tons per acre.
3) Synthetic nitrogen at 100 pounds per acre.
4) Control (no amendment).

Three basil varieties were grown for four months. The varieties were: 'Sweet Italian Large leaf', 'Thai Siam Queen', and 'UH', a *Fusarium* resistant sweet variety developed by the University of Hawaii . Harvests were conducted weekly over a period of 10 weeks, and marketable yields recorded. As Fusarium wilt disease became a problem, the number of affected plants was recorded. At harvest time root quality was scored on a scale of 1-5, where 1=100% decay and 5= 100% healthy roots. Root galling attributed to root-knot nematodes was scored on a scale of 1-5, with 1=0% galls and 5=100% galling. Sensory evaluation of 'Sweet Italian' was conducted at the University by 12 panel members to rate the flavor and aroma intensity of the Sweet Italian basil variety in each treatment, with a higher number representing and increased intensity.

Results

There was a differential response by variety to the treatments with respect to yield. There was also a difference in disease incidence among the varieties, which may help to explain the varied response to treatments. Sensory evaluation of the Sweet Italian variety showed an aroma intensity that was higher in plants receiving compost or synthetic fertilizer than in plants from the control.

Sweet Italian This variety exhibited no severe disease symptoms. Yields for this variety were similar among both rates compost and the synthetic fertilizer treatments, and these treatments were higher than the control (Table B-11).

Thai Siam Queen Many plants of this variety exhibited severe symptoms of *Fusarium oxysporum* infection and the pathogen was isolated from samples of those plants. The highest yields for this variety were obtained from the compost treatments, with yields being highest at the highest application rate (Table B-9). Yields were similar between the synthetic fertilizer treatment and the control. Table B-10 shows the mean percentage of plants per treatment exhibiting symptoms of the fungal disease.

UH Many plants from this variety showed symptoms of severe wilting and stunting that progressed with time. No plant pathogenic organisms were isolated from the vascular system of these plants. Roots of this variety showed severe galling and distortion typical of roots infected with root-knot nematodes, and exhibited rot associated with secondary infection as a result of the nematode damage. Root galling was more severe and the root system poorer in plants from this variety than from the other two varieties (Table

B-13). The highest yields were obtained from the Comp @20 MT / Ac treatment (Table B-9). Plants from this treatment also had better root health index rates than the other treatments (Table B-12).

Table B-9. Effect of compost treatments on mean Basil yield in grams per plant at the nature farming long-term replicated experiments, Fall 1998 (lbs per acre in parentheses).

Treatment	All Varieties	Thai Siam Queen	Sweet Italian	UH
Compost @ 80 tons	582a*	657a	700a	292b
	(27,848)	(26,231)	(33,495)	(13,972)
Compost @ 20 tons	597a	549b	687a	455a
	(28,566)	(26,269)	(32,873)	(21,771)
Synthetic fert.	494a	470c	651a	320b
	(23,637)	(22,489)	(31,150)	(15,312)
Control	468a	428c	532b	324b
	(22,393)	(20,479)	(25,456)	(15,503)

Table B-10. Effect of compost treatments on the mean percentage of 'Thai Siam Queen' plants exhibiting symptoms of *Fusarium* infection, Fall 1998.

Treatment	Symptomatic Plants
Synthetic fertilizer	27%
Control	22%
Compost 80 Tons	11%
Compost 20 Tons	7%

Table B-11. Effect of compost rates and treatment on the mean severity of root galls in basil. Damage index: 1=0% galls;-5= 100% galls

Treatment	All Varieties	UH	Thai Siam Queen	Sweet Italian
Compost 80 Tons	4.3a	4.7a	4.3a	3.7a
Compost 20 Tons	3.5a	3.8b	3.7b	3.1b
Synthetic Fert.	3.5a	4.3a	3.0c	3.5b
Control	2.7a	3.1b	2.7c	2.2c

Table B-12. Effect of compost rate and treatment on the mean root health index, as estimated by visual diagnosis. Root health index: 1= 100% decay; 5 = 100% healthy roots.

Treatment	All Varieties	UH	Thai Siam Queen	Sweet Italian
Compost 20 Tons	3.1a	3.0a	3.0a	3.1a
Synthetic Fert.	2.7a	2.5b	2.9a	2.9a
Check	2.9a	2.6b	3.0a	2.8a
Compost 80 Tons	2.7a	2.1c	3.1a	3.0a

Table B-13. Effect of basil variety on the mean root-knot nematode root gall damage index, and on the general mean root health index.

Variety Index	Mean Gall Index (1-5)	Mean Roots (1-5)
UH	3.9a	2.6b
Thai S.Q.	3.4b	3.0a
Sweet Italian	3.1c	3.0a

Note: root-knot nematode gall index: 1= no galls; 5= maximum gall no (100% of root). Gall number per root; Mean root index: 1= poor root growth (100% dead roots), 5= best root growth.

Table B-14. Effect of compost rate and treatment on the mean taste panel scores on 'Sweet Italian' aroma and taste intensity. Score Index: 1= weakest aroma and taste, 10= strongest aroma and taste, Fall 1998.

Treatment	Aroma Score	Taste Score
Compost 80 Tons	5.3a*	5.8a
Compost 20 Tons	5.0a	5.8a
Synthetic Fertilizer	5.3a	5.7a
Control	4.4b	5.3a

Discussion

Yields from both 'Sweet Italian' and 'Thai Siam Queen' strongly indicate that compost applications alone can improve basil productivity. Yields from 'Sweet Italian' suggest that, in the absence of disease, maximum short term benefits by compost to basil productivity may be reached at rates of or less than 20 tons per acre. With the Fusarium susceptible 'Thai Siam Queen', higher yields and lower numbers of symptomatic plants in the compost treatments suggests that compost applications in the field may partially suppress the pathogen. This would support observations by both researchers and farmers. While this variety may be much more susceptible to F. oxysporum than 'UH' or 'Sweet Italian', it is also possible that seed obtained for this variety was already contaminated with the pathogen. Yields from 'UH' corresponded to root quality. There is no ready explanation for highest yield and root quality obtained from the lowest rate of compost application, though these are the beds that showed some possible residual effect from previous urea treatments. It is likely that any treatment effect on this variety would be confounded by the nematode damage. The results shown on Tables B-11 & 13 indicate that 'UH' may be more susceptible to root knot nematodes than the other two varieties. With respect to basil postharvest quality the sensory evaluations indicate that sweet basil aroma and flavor intensifies with either synthetic N or organic amendment applications (Table B-14).

11. Cover Crop Studies from 1997 to 1999 (Section B).

From 1993 to 1997 section B (50 by 150 ft area total) was maintained under several cover crop and fallow treatments. Beginning on May 1997, Section B was divided into five (5) 30 by 50 ft plots (Figs. CC-1, and CC-2). Each plot was sowed with a different cover crop species, as indicated below. The purpose of this study was to evaluate several cover crop species, under the different climatic seasons, under a rotational system to evaluate cover crop adaptability to low elevations, including their competitiveness against weeds. Over time, we will be able to evaluate the trends toward levels of weed pressure on each plot, as affected by the different rotational schemes. Over time, we will also be able to evaluate the effect of the different cover crop rotations on the general fertility of the soil. Data collected for this purpose from 1997 to 1999 was 1 sq ft quandrant weed and cover crop counts. At each sampling date 3-4 quandrant counts were collected per plot.

Cover Crops Demonstration (Section B)
Planted on Section B, 30 by 50 ft blocks for each species
Order from makai to mauka was: Rhodes Grass, Mustard Dwarf Essex, Iron and Clay Cowpea, Sweet & Honey Sorghum, and Colt Canola
Planted on May 16, 1997 and drip irrigated
Harvested on Aug. 15, 1997
Soil samples collected on Sept. 1, 1997 (see Table O-11).
Spring / Summer 1997= 5 sampling dates for weed pressure
Winter / Spring 1998= 7 sampling dates for weed pressure

AHR Compost Demonstration Plots

UHM Waimanalo Experiment Station, June 1997

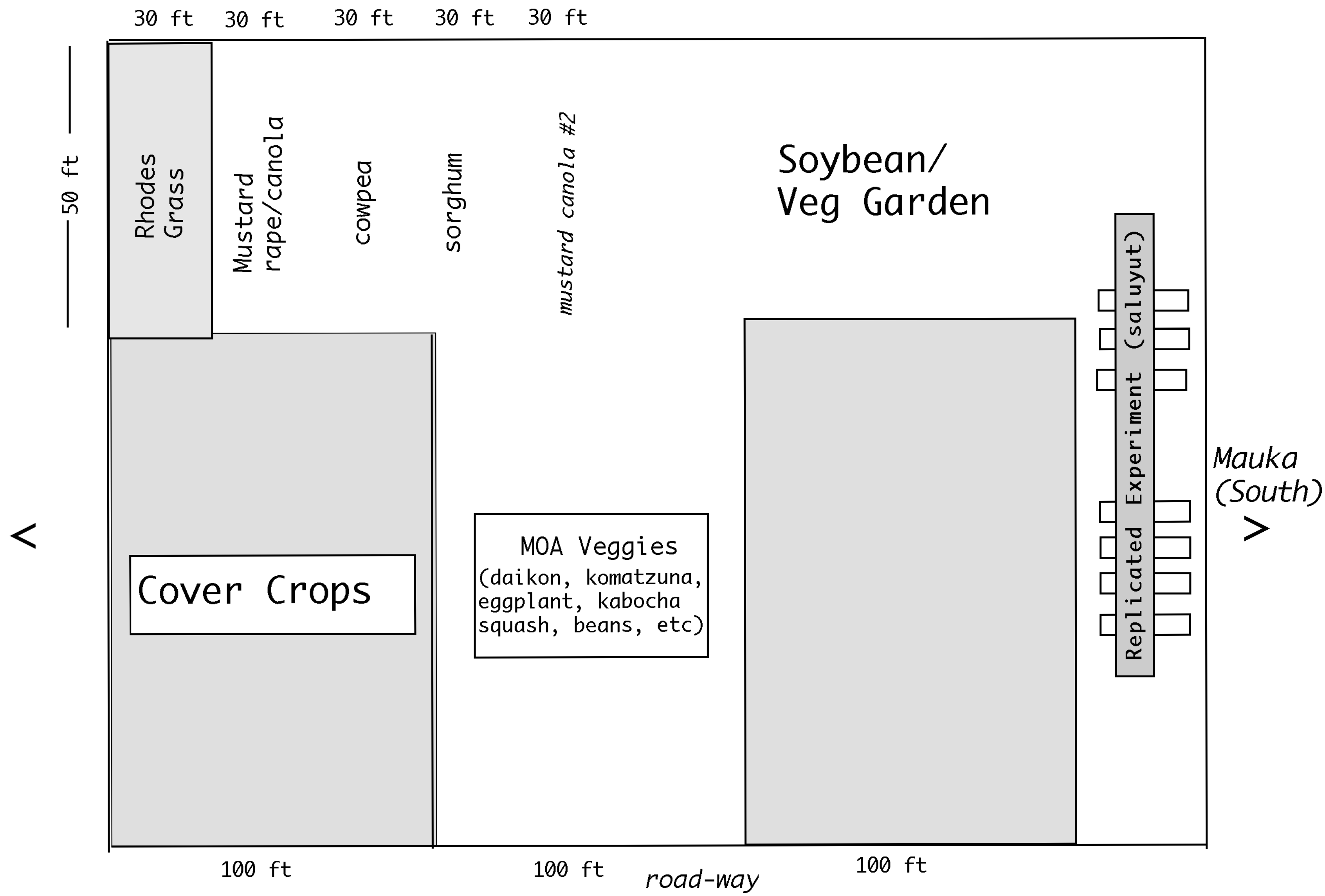


Figure CC-2. Section B. Cover Crop Rotational Study: Weed Competition and Soil Improvement Study

sow: 5-16-97	**B-1** Rhodes Grass	**B-2** Mustard 'Ohio'	**B-3** Cowpea 'Iron & Clay'	**B-4** Sudex 'Sw 'n Honey'	**B-5** Canola 'Colt'	mauka *(South)*
sow: 12-24-97	**B-1** Rhodes Grass	**B-2** Cowpea 'Red-ripper'	**B-3** Sudex 'Sw 'n Honey'	**B-4** Mustard 'Dwarf Essex'	**B-5** Faba bean 'Windsor'	
sow: 7-8-98 (2,4& 5)	**B-1** Rhodes Grass	**B-2** Mustard/Rape	**B-3** Sudex 'Sw 'n Honey'	**B-4** Cowpea 'Iron & Clay'	**B-5** Buckwheat 'PeacValley'	
sow: 8-98 (4) 11-98 (2&5)	**B-1** Rhodes Grass	**B-2** vetch/rye mix	**B-3** Sudex 'Sw 'n Honey'	**B-4** Basil Cultivar trial	**B-5** Rye/Buckwheat	
sow: 12-98 (B-5)	**B-1** Rhodes Grass	**B-2** vetch/rye mix	**B-3** Sudex 'Sw 'n Honey'	**B-4** Basil Cultivar trial	**B-5** Barley/buck-wheat	

Table CC-1 Treatment descriptions for cover crop plantings on May and December, 1997 (See Figs. CC-1 & 2)

Cover Crop Treatments sowed on 5/97			
Plot No.	Cover crop	Cultivar	Seeding rate (lbs/acre)
0	Bare ground	None	0
1	Rhodes grass	Katambora	100
2	Mustard	Dwarf essex	80
3	Cowpea	Iron & clay	180
4	Sorghum	Sweet & honey	150
5	Canola	Colt	80

Weeding pressure- area covered per 1 sq ft measurements, 144 squares per quadrant (1 sq ft).

Experiment 2- Follow-up on same plots
Date sowed= Dec. 24, 1998
Treatment= one rep, 30 by 50 ft per plot
sudex mowed= Feb, 19, cowpea mowed= Mar. 11
cowpea and faba bean developed foliar diseases (powdery mildew and anthracnose respectively).

Table CC-1, continued.
Cover Crop Treatments, sowed 12/24/97 (see Fig. CC-2).

Plot No.	Cover crop	Cultivar	Seding rate (lbs/acre)	Actual amount applied (lbs)
0	Bare ground		0	0
1	Rhodes grass	Katambora	100	4
2	Cowpea	Red riper	160	6
3	Sudex	Sweeter n'honey	100	4
4	Mustard	Dwarf essex	24	2
5	Faba bean	Windsor	350	10

Table CC-2. Effect of cover crop treatment on weed pressure. Mean values (out of a total possible of 144) from 5 sampling dates, Summer 1997 (N=15 quadrant samplings per treatment)

Cover Crop	Cover crop Area	Weed area	Bare ground area	% Weeds
Bare (2 dates only)	0	106a	38c	74a
Rhodes grass	72a	14c	58ab	10c
Mustard	71a	36b	36c	25b
Cowpeas	78a	19c	47bc	13c
Sorghum	74a	4c	65a	3c
Canola, colt	71a	20c	53abc	14c

Table CC-3. Effect of cover crop treatment on weed pressure 2 months after mowing the cover crop (data collected on Oct. 20, 1997).

Cover Crop	Weed Area	Bare area	% Weeds
Bare	90ab	54cd	63ab
Rhodes grass	27cd	117ab	19cd
Mustard	100a	44d	69a
Cowpea	56abc	88bcd	39abc
Sudex	3.5d	140a	2.5d
Canola, colt	44bcd	100abc	31bcd

COVER/CROP/WEED COUNTS

WAIMANALO NATURE FARMING PLOTS
JULY 1998-JANUARY 1999

The name of each cover crop is underlined with the date the count was taken in parentheses. This is followed by a description of the cover crop grown previously in that plot, any observations on weed pressure or cover crop growth, as well as dates planted/incorporated and seeding rate if known. A 12 by 12-in. quadrant was used to conduct vegetation counts (ground cover determination) in three random locations per date per plot.

Buckwheat, B-5(8-19-98)
This crop followed faba beans. Buckwheat stand was good along drip lines but relatively sparse in between lines. What weeds there were occurred primarily between drip lines. Primary weeds were: grasses, nutsedge and euphorbia, with some bidens, euphorbia and mimosa; there were only a couple of poorly growing amaranth and portulaca. Planted 7/7/98, tilled under 9/1/98.

	Quadrant (1)	(2)	(3)
COVER	17	76	57
WEED	11	19	12
BAREGROUND	116	49	71

Mean % weed level= 10%

Cowpea (8/19/98) *(B-4).*
This crop followed mustard 'Dwarf Essex'. Excellent cover. Only weed visible above canopy was grass (Chloris sp.?). Planted 7/8/98, removed 9/20/98. Basil variety trial followed the cowpea in this plot.

	Quadrant (1)	(2)	(3)
COVER	80	87	71
WEED	2	0	3
BAREGROUND	64	57	70

Mean % weed level= 1%

Rape (9/26/98) *(B-2).*
This cover crop followed cowpea 'Red Ripper' There was much whitefly and many cabbage butterflies in this plot. Main weeds were graminae, honohonograss, saluyut, and apple-of -Peru. I hadn't observed apple-of-peru in the plots before, so the rapeseed may be contaminated. Planted 7/9/98, turned under 11/7/98. Broadcast @ 871 lbs/acre.

	Quadrant		
	(1)	(2)	(3)
COVER	92	119	95
WEED	5	3	1
BAREGROUND	47	22	18
RAPE BIOMASS KG / SQ.METER (10/12/98)	2.95 (30,000 lbs / Ac)	1.88 (20,000 lbs / Ac)	2.74 (27,000 lbs / Ac)

Mean % weed level= 2%

Rye (11/21/98) (B-5)

This crop followed a buckwheat (Peaceful Valley) cover crop. Rye stand establishment was very poor. Buckwheat regenerated from previous crop's seed along drip lines. Once rains began to become more frequent, weeds came up heavily along with a few rye plants. Broadcast @ 350 lbs/acre.

	Quadrant		
	(1)	(2)	(3)
COVER (buckwheat)	2	15	7
COVER (rye)	0	0	4
WEED	132	0	30
BAREGROUND	10	129	103

Mean % weed level= 37%

Vetch/Rye (B-2)

This crop followed the rape cover crop. Half the plot (mauka) was planted with a common vetch/rye mixture and the other half (makai) with a hairy vetch/rye mixture. The same seeding rate and rye variety was used in both mixtures, and both vetch varieties came from the same supplier (Peaceful Valley). A first count was taken 13 DAP. A difference was observed between the two halves of the plots; the rye seemed heavier in the common vetch mixture, and on the other half the hairy vetch seemed heavier. The common vetch seemed less vigorous and more chlorotic than the hairy vetch. The hairy vetch was dense in areas that the rye was sparse, but this was not the case with the common vetch. A second count was taken in each half of the plot (three quadrants in the hairy vetch/rye and three quadrants in the common vetch/rye). Broadcast @ 40 lbs vetch + 100 lbs rye/acre. Planted 11/8/98.

11/21/98(first count)

	Quadrant		
	(1)	(2)	(3)
RYE	60	10	30
VETCH	23	25	30
WEED	5	6	5
BAREGROUND	56	103	79

Mean % weed level= 4%

1/3/99(second count)

COMMON			
VETCH	13	8	6
RYE	95	109	32
WEED	0	12	59
BAREGROUND	36	15	47

Mean % weed level= 16%

HAIRY			
VETCH	118	23	53
RYE	26	106	78
WEED	0	0	1
BAREGROUND	0	15	12

Mean % weed level= 0%

Sudex (1/3/99) (B3)

Note: cover count includes lodged and dead, undecomposed sudex plants. Most common weeds are other grasses, euphorbia, oxalis and emilia. Planted 12-24-97.

		Quadrant	
	(1)	**(2)**	**(3)**
COVER	104	125	125
WEED	42	11	16
BAREGROUND	0	8	3

Mean % weed level= 16%

Rhodesgrass (1/3/98) (B-1)

Excellent cover with moderate-heavy thatch. Planted 12-24-97

		Quadrant	
	(1)	**(2)**	**(3)**
COVER	144	142	144
WEED	0	2	0
BAREGROUND	0	0	0

Mean % weed level= 0%

Ryegrass A-4 (1/3/99)

Most common weeds are other grasses, euphorbia, oxalis and emilia. Planted 11/98.

		Quadrant	
	(1)	**(2)**	**(3)**
COVER	134	123	141
WEED	0	6	3
BAREGROUND	10	15	0

Mean % weed level= 2%

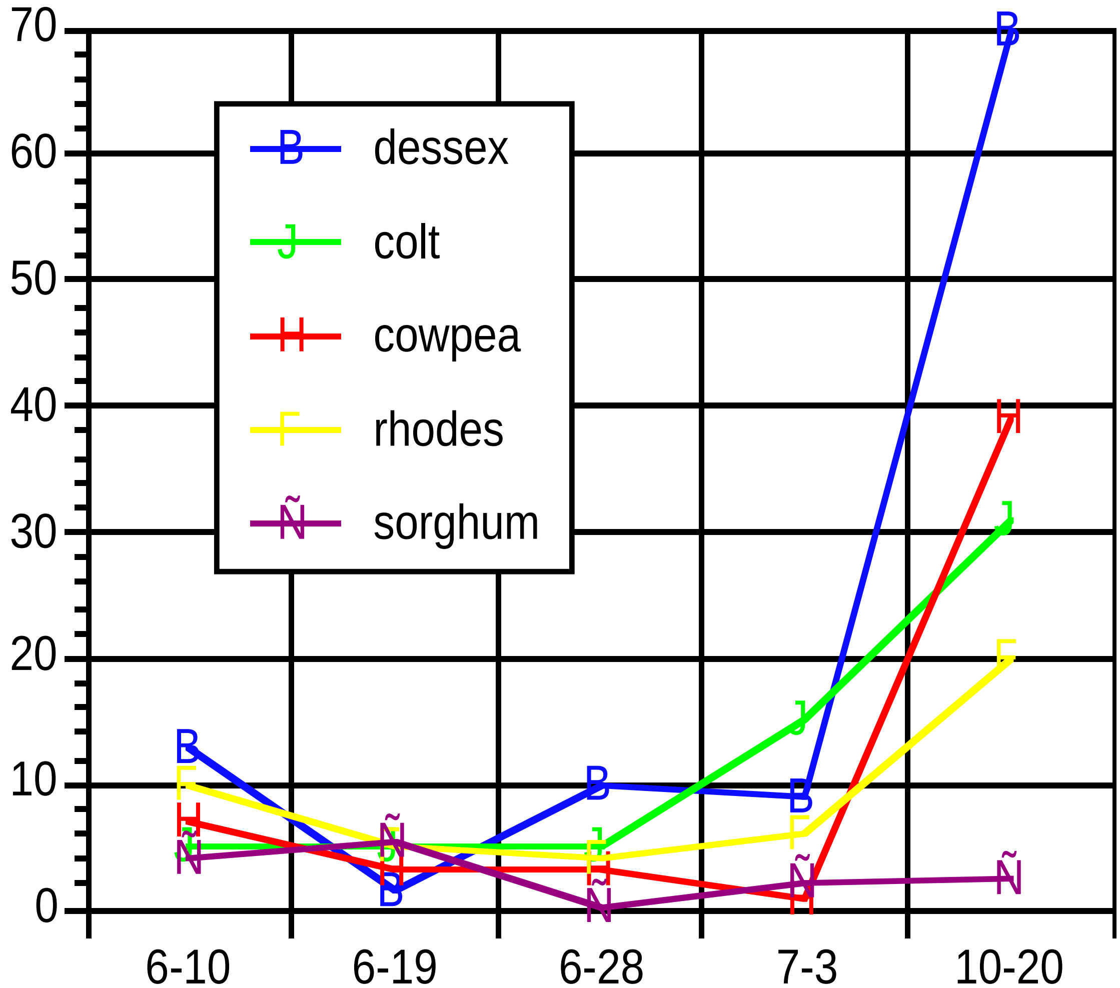


Fig. CC-3. Percent weed levels in cover crop experiment (Section B), 1997.
Note: Lowest weed levels were found in plants that provided close to a 100% ground cover such as sorghum, rhodes grass, and cowpeas.

Other Cover Crop Studies

Overall, from 1993 to 1998 we evaluated over 40 cover crop varieties for their adaptability for use as cover crops under low elevations in Hawaii (See Table CC-4). Growers will select cover crops for several possible reasons including: for N fixation (legumes), for biomass production, to break disease cycles, to build up populations of beneficial insects, for weed control, for erosion control, or for a combination of these and other reasons. Our cover crop database provides an indication of cover crop adaptability during the different growing seasons in Hawaii. However, specific research is required to further develop cover crop technology for Hawaii. This research would include: cultivar selection within cover crop species, cover crop and soil fertility interaction, planting densities, biomass production during the different growing seasons (summer vs. winter for example see Table CC-5), economics of cover crop use in Hawaii, and more specific data on weed suppression capabilities of the different growing species. To date the following cover crops have shown potential as for vegetable agroecosystems in Hawaii:

Legumes: sunhemp, pigeonpea, soybeans, cowpeas (also as potential insectary due to presence of extrafloral nectaries), hairy vetch, mucuna, and lablab bean.
Grasses: sudex, sorghum, ryegrass, rhodesgrass, oats, barley, millet, corn.
Others: buckwheat for rapid establishment and as potential insectary.

Table CC-4. List of cover crops grown at the nature farming plots, Waimanalo, 1993-1997.

Crop	Variety	Bed No.	Month (Harvest)	Year	
oats	feed oats	sec D	nov-mar	1994	
cowpea	sec d	sec d	mar-may	1994	
rhodes grass	3 rows		jun-nov	1995	
mustard	3 rows		jun-nov	1995	
crimson clover	3 rows		jun-nov	1995	
sudex	12 rows		jun-nov	1995	
austrian winter pea	2 rows		jun-nov	1995	
buck wheat	4 rows		jun-nov	1995	
fava beans	2 rows		jun-nov	1995	
sudex	14 rows		jun-nov	1995	
soybean			july	1995	weedy
sorghum			sep	1995	
oats			sep-nov	1995	California red
cowpea			sep-dec	1995	
lab lab bean	sec c		nov	1995	
soybean			nov	1995	
sudan grass	sec a		nov	1995	
rape	sec a		nov	1995	
sunhemp	sec a		nov	1995	
medic	sec a		nov	1995	
blando brome	sec a		nov	1995	
pigeon peas	sec a		nov	1995	
alfalfa Nitro	sec a		nov	1995	
berseem clover	1 bed		nov-feb	1995	
strawberry clover	1 bed		nov-feb	1995	
red clover	1 bed		nov-feb	1995	
buckwheat	1 bed		nov-feb	1995	
crimson clover	1 bed		nov-feb	1995	
bell beans	1 bed		nov-feb	1995	

Table CC-4. Continues

Crop	Variety	Bed No.	Month (Harvest)	Year	
oats	feed oats	sec D	nov-mar	1994	
austrian winter pea	1 bed		nov-feb	1995	
hykone rose clover	1 bed		nov-feb	1995	
white clover	1 bed		nov-feb	1995	
new zealand sw clover	1 bed		nov-feb	1995	
berseem & blando brome	1 bed		nov-feb	1995	
mustard yellow	1 bed		nov-feb	1995	
pigeon pea	sec b		may	1996	
sudex	4 beds	34-37	oct	1996	7-8 ft tall
pigeon pea	5 beds	38-42	oct	1996	7-8 ft tall
peanut perennial	1 bed	1	may-dec	1997	
sunhemp	2 beds	2-3	may-oct	1997	
bare	4 beds	4-7	may	1997	
sunhemp	2 beds	8-9	may-oct	1997	
bare	4 beds	10-13	may	1997	
pigeon pea	2 beds	14-15	apr-oct	1997	
bare ground	5 beds	16-20	may	1997	with mulch
pigeon pea	2 beds	21-22	may-oct	1997	
pigeon pea	2 beds	26-27	may-oct	1997	
pigeon pea	2 beds	32-33	may-oct	1997	
pigeon pea	1 bed	38	may-oct	1997	
rhodes grass	30 x 50 ft	sec d	may-jul	1997	
mustard dw essex	30 x 50 ft	sec d	may-jul	1997	
cowpea iron & clay	30 x 50 ft	sec d	may-jul	1997	
sorghum sw&honey	30 x 50 ft	sec d	may-jul	1997	
giant desmodium	20 ft	sec a	july-oct	1997	
habucha	20 ft	sec a	july-oct	1997	
desmodium nicaraguence	20 ft	sec a	july-oct	1997	
soybean	200 x 50	sec e	feb-nov	1997	
mustard colt	30 x 50 ft	sec d	may-jul	1997	
faba bean	1 bed	sec a	july	1997	didn’t do well
subt clover	1 bed	sec a	july	1997	didnt do well
vigna marina	1 bed	sec a	july-oct	1997	v/ well
buckwheat	1 bed	sec a	aug	1997	
sudex	1 bed	sec a	aug	1997	
cowpeas, vegetable	1 bed	sec a	aug	1997	
cowpeas iron & clay	1 bed	sec a	aug-oct	1997	
sunhemp	1 bed	sec a	aug-dec	1997	

Table CC-5. Dry weights (gr) per square foot of several cover crop species grown at the Waimanalo nature farming plots, Section A, 1998.

Cover crop	Date harvested	Fresh weight	Dry weight	% dry matter	Fresh wt. (lb / Acre)
Soybean green stem	7/17/98	184	44	24	17,682
Soybean green leaf	7/17/98	232	47	20	22,295
Soybean green pod	7/17/98	387	106	27	37,190
Corn leaf and stem	7/17/98	1059	318	30	101,769
Soybean pod north	7/27/98	515	135	26	49,491
Soybean leaf north	7/27/98	142	53	37	13,646
Soybean stem north	7/27/98	273	84	31	26,235
Oats	8/19/98	990	185	19	95,139
Sunflower	8/31/98	2325	370	16	223,432
Rhodes grass	8/26/98	1025	280	27	98,502
Barley	9/1/98	1005	220	22	96,580

12.0. No-till Experiment, 1998, Section B.

An Experiment was conducted to evaluate the effect of no-till production practices on the yield of vegetable crops. This demonstration experiment was conducted on a 100 by 50-ft plot section in the mauka side of Section B. The field was divided in two 50 by 50-ft plots. On March 1998 one plot was planted with rye and the second one was planted with an oats cover crop. At the flowering stage the cover crops were mowed. Several vegetables were then planted in both no-till plots. Results from this observational study are shown below.

Table NT-1. Effect of no-till treatment with oats and rye on the yield of several vegetable crops, long term nature farming plots, Waimanalo, summer 1998

Results of observation trial in MOA no-till plots June / July 1998
Kai Choi (harvested 6/26/98) 6.8 kg of kaichoi were harvested per row in the rye plot 2.5 kg of kai choi were harvested per row in the oats plot
Joi Choi (harvested 6/26/98) 10 kg of joi choi were harvested per row in the rye plot 8 kg of joi choi were harvested per row in the oats plot
Lettuce The lettuce performed poorly in both plots and was not harvested.
Pumpkin (harvested 7/29/98) 16.4 kg of pumpkins were harvested in the rye plots 22.4 kg of pumpkins were harvested in the oats plots

Table NT-2. Effect of no-till treatment with oats and rye on the yield of several bush bean cultivars grown at the long-term organic plots in Waimanalo, summer 1998.

Beans (harvested 7/17 through 7/29/98)

Oats plot (grams per plant total harvest)

Cultivar	yields (grams total)	lbs/Acre
Rushmore	75g	10,777 lb/Acre
Mirada	61.3g	8,808
Ex-344	55.0g	7,903
Magnum	53.5g	7,688
Mean Pooled Yields (all cvrs)		8,794

Rye plot (grams per plant total harvest)

Cultivar	Yield (grams)	
Magnum	101g	15,513 lb/Acre
Rushmore	93.3g	13,407
Mirada	46.2g	6,639
Ex-344	34.4g	4,943
Mean Pooled Yields (all cvrs)		10,125

Table NT-3. Effect of no-till treatment with oats and rye on the weed pressure about 1 month after mowing the cover crops, summer 1998.

On 6/26/98 three areas in each plot (oats and rye) were surveyed for the area of ground covered by weeds and cover crop with a one foot by one-foot quadrant. The numbers below are the numbers of square inches covered per square foot.

Rye

Area #1; 80 weeds, 36 cover, 28 bare ground

Area #2; 13 weeds, 84 cover, 47 bare ground

Area #3; 60 weeds, 50 cover, 34 bareground

Mean % weed pressure= 35%

Oats

Area #1; 30 weed, 104 cover, 10 bareground

Area #2; 115 weed, 20 cover, 9 bareground

Area #3; 38 weed, 106, 0 bareground

Mean % weed pressure= 42%%

Discussion

At the time of crop planting both covers had been mowed; the rye was dead, but the oats were living and re-growing. The cover provided by the rye was extremely light; after it was mowed there were few weeds present, but much bare ground was exposed and weeds eventually became extremely heavy. The oats grew well from the time of crop planting, and weeds never became a problem as they did in the rye plot; however, the oats were in competition with the crop from the time of transplanting. The early maturing crops (kai choi, joi choi) probably did better in the rye plot because they were able to develop before weeds became too heavy and without the constant competition from the oats. All pumpkins were un-marketable due to extensive melon fly damage. The beans had very little insect/bird damage in either plot. By the third harvest (7/20) all reps of the bean varieties EX-344 and Mirada were very chlorotic in the rye plot, though not in the oats. These reps produced relatively constant yields over the harvest period. All other reps, including with 'EX-344' and 'Mirada' in the oats plot, produced the heaviest yields on the first two harvests. If a similar trial were to be conducted in the future, increasing the seeding rate of the rye and taking care to kill the oats before crop planting is recommended. (Note: Christine has noticed in her experiment that the oats were difficult to kill- even after mowing and round-up she observed some of the oats growing back.)

13. Basil variety trial following cover crop treatments

Basil Variety Trial
Waimanalo Nature Farming Cover Crop Plots
September 1998-January 1999

Introduction
A basil variety trial was conducted at the Waimanalo experiment station's Nature Farming plots (Section B) to evaluate the varieties' performance under organic growing conditions. The different basil varieties were grouped into Market 'types'. Basil varieties within a Market type share similar characteristics and uses. The following types were used in this trial:

Sweet- The Italian types used for pesto. This is one of the two major types grown in Hawaii.
Purple- An Ornamental and culinary type that tends to be more pungent than sweet types.
Specialty- Used for teas, popurri, etc.
Thai- Popular in South East Asian cuisine. Half of the basil grown in Hawaii is of this type.
Citrus- Includes lemon and lime basils.
Holy- A non-culinary species known for it's fungicidal and medicinal properties.

Methods
Each of the twenty two varieties were grown in a 5 foot bed following cowpea in a plot where basil had not been grown previously. The following cover crop sequence was followed prior to planting basil: Sudex was grown from May to Aug. 1997; Mustard 'Dwarf Essex' was grown from April 1 until July 1998; and cowpea was grown from July 8 until September 20, 1998. Chicken manure was applied at 10 tons per acre. Plants were harvested weekly over a period of 8 weeks. Plants were then taken given a 'rest period' of four weeks before two more harvests were conducted.

Results

Table B-15. Total plant yields and average plant height and width for several basil varieties grown organically in a cover crop rotation experiment, Waimanalo, 1998

Variety	Total Yield (grams per plant) & (lb / Acre in parentheses)	Mean Canopy Height (in.)	Mean Canopy Width (in)
Sweet Types			
Napoletano	930 (44,500)	24	35
Greek Mini	890 (42,586)	18	25
Select Green	770 (36,844)	26	38
Perfume	750 (35,887)	26	33
Valentino	640 (30,624)	17	27
Purple Types			
Red Rubin	460 (22,011)	21	27
Dark Opal	400 (19,140)	17	24
Purple Passion	370 (17,704)	17	24
Thai Types			
Thai Siam Queen	580 (27,753)	21	32
Specialty Types			
Thai	1050 (50,242)	29	45
Mexican Cinnamon	900 (43,065)	28	40
Cinnamon	870 (41,629)	29	43
Licorice	730 (34,930)	28	37
Citrus Types			
Thai Lemon	1090 (52,156)	25	37
Lime (Southern Exp.)	970 (46,414)	22	37
Lemon	790 (37,801)	22	33
Sweet Dani	680 (42,538)	28	40
Lime (Johnny's)	570 (27,274)	20	38
Holy (O. sanctum)			
Holy (Johnny's)	300 (14,355)	24	35
Holy (Southern Exp.)	261 (12,488)	25	38
Sacred Purple	225 (10,766)	27	31
Holy Red / Green	171 (8,182)	25	25

Note: Yields per acre are based on estimates of 21,700 plants per Acre (following a planting density of 2 ft between rows and 1 ft between plants)

Variety Descriptions

Select Green Shepherd, Large leaf green basil with sweet, slightly anise aroma and flavor that is less intense than 'Perfume'.

Genova Profumatissima Perfume Shepherd, The glossy. long, pointed, deep green leaves of this variety are typical of 'Genovese' type sweet basils, distinguished by their intense, almost perfumed flavor.

Napoletano Ornamental Edibles, The very large, light green, rounded and deeply crinkled leaves form a dense, heavy canopy. Stems are thicker and succulent. Napoletano has a light fragrance and mellow flavor.

Valentino Park, Leaves are very similar to 'Napoletano'. Plant structure is compact and shorter than other sweet types. Flavor and aroma are slightly stronger than 'Napoletano' and similar to that of 'Select Green'.

Greek Mini Shepherd, This bush basil (O. *basilicum minimum*) is ideal for container growing. Its tiny bright green leaves form a compact umbrella shaped canopy. The intense scent and flavor are similar to 'Genovese' types. Bush basils tend to be very susceptible to *Fusarium*.

Dark Opal Park, This purple basil has medium sized, dark purple leaves. Aroma is spicy, with hints of cinnamon and clove. The flavor is strong, almost pungent.

Purple Passion Ornamental Edibles; This variety is similar in growth habit, aroma and flavor to 'Dark Opal'. The color is an intense scarlet purple.

Red Rubin Shepherd, Red Rubin resembles a purple version of the sweet basil types. Leaf color is a medium reddish purple, and is not completely uniform. Leaves are larger than 'Dark Opal and 'Purple Passion', and the flavor is more mild.

Mexican Cinnamon Spice Nichol's Garden, Tall bush plants have purple stems and medium sized, dark green, serrated leaves. Flavor and aroma spicy sweet, with the hints of camphor and anise in the scent.

Cinnamon Ornamental Edibles, Identical in appearance to 'Mexican Cinnamon'. The fragrance is slightly heavier and more complex.

Licorice Ferry Morse, Identical in appearance to 'Mexican Cinnamon'. The fragrance of 'Licorice' is sweet, almost cloying.

Thai Companion, Listed by the seed company as a different species, 'Thai' is almost identical to 'Licorice' in appearance, aroma and flavor. It bears little resemblance to 'Thai Siam Queen' or other Thai basils. According to one Hawaii grower, cinnamon type basils are substituted for Thai in Europe, which may be the source of this variety's name.

Thai Siam Queen Park, This heavy bearing variety has dark green leaves and an unusual branching inflorescence. Similar to the local Thai type, 'Thai Siam Queen' has a very intense anise flavor and aroma. This variety is very susceptible to *Fusarium*.

Maenglak Thai Lemon Shepherd, The very intense complex scent and flavor of this variety is a combination of lemon and sweet basil. This variety is similar in habit and appearance to other lemon basils. Bushy plants have small, narrow pointed leaves.

Sweet Dani lemon Park, This is a new lemon basil with larger leaves, more erect growth habit, and a higher essential oil content than other lemon basils. The strong lemon fragrance is less complex than 'Lime' and 'Maeglak Thai Lemon'.

Lemon Southern Exposure, Bushy, plants with small leaves and a strong lemon scent.

Lime (O. americanum*) Johnny's/Southern Exposure*, Plants were very similar in appearance, flavor and aroma to 'Maenglak Thai Lemon'. The complex citrus aroma is reminiscent of lime

Holy (O. sanctum) Johnny's, / Southern Exposure, This basil species reportedly has strong insecticidal, fungicidal and medicinal properties. Large oval leaves are green and pubescent. Scent is a blend of spice and citrus.

Red and Green Holy (O. sanctum) Johnny's, Same as 'Holy', with purple stems and purple and green leave

Sacred Purple Holy Shepherd Identical in appearance to 'Red and Green'.

14. Overall Results 1993-1998

14.1. Biomass 1993-1998

Table O-1. Effect of compost treatments on the total biomass (dry weight) produced from 1993 to 1998 in the replicated compost plots at the Waimanalo Experiment Station (assuming 10% dry matter in the harvested crop).

Treatment	93-95	Saluyut '97	Zucchini '98	Basil '98	Total biomass[1] (93-98)
		(lbs / Acre dry weight)			
Control	3433	3450	2100	5176	14,159
Fert	4618	4687	3320	6652	19,277 (36%)
MOA	4709	4557	2261	6376	17,903 (26%)
Comp-0	4265	5208	1932	6909	18,314 (29%)
Comp-100	5444	4296	2927	6909	19,576 (38%)
Comp-200	4848	5208	2466	6909	19,431 (37%)
Comp-300	5579	5403	2758	6909	20,649 (46%)

[1]Percent yield increase over yields obtained by the controls, in parentheses.

Table O-2. Nutrient analysis of the compost materials used in the replicated compost plots at the Waimanalo Experiment Station nature farming plots (1994, 1995, 1996, 1997 & 1998).

February 1994

Treatment	N (%)	pH	Salinity mmhos	P	K ppm	Ca	Mg	Org. C (%)
MOA demo soil	0	6.9	0.09	430	540	6800	1100	2.03
Amend, raw	1.03%	6.6	0	3824	2900	22000	1500	15.93
Home made, raw	0.72%	7.6	0	357	1500	7800	1700	4.7

Compost analysis 10/18/95

Compost	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn
Amend	1.06	0.49	2.41	0.38	0.46	274	30410	205	462
Moa compost	0.93	0.62	3.46	0.7	0.17	3028	60885	99	210

Compost Analysis provided by Randy Hamasaki, Sept. 26, 1996

Compost	pH	N	P	K	Ca	Mg	C (%)	C:N	EC
Amend	7.3	1.3	213	3200	19000	1600	23.22	18	
Dyn Lfter	7.6	2.2	2174	26000	6300	1900	18.31	8	
Unisyn	7.7	3.4	158	3800	9100	1500	17.94	5	5.4
Mpod	7.3	2.1	505	2400	4600	3600	40.93	20	

N,C=%
P,K,Ca,Mg=ppm
Amend= Kellogs Amend, sewage sludge and composted rice hulls

Dyn. Lft= Dynamic lifter (pelleted chicken manure)
Unisyn= Unisyn compost (delivered to Nalo Farms)
Mpod= well composted monkeypod leaves (Pearl City Garden Ctr)

Table O-2. cont.

Compost analysis, 8/25/97

Compost	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
Straw-mulch	1.46	2.52	2.63	14.8	1.00	0.59	1779	28300	107	487	83
Bayodo	0.64	0.49	0.62	0.38	0.53	0.06	3689	95170	142	144	251
Chips compost	0.93	0.95	0.94	5.51	0.66	0.24	2715	76090	130	270	183

Straw-mulch= compost made from 50% straw, 50% chicken manure
Chips comp= compost made from 50% chips (legume, Leuceana trees), 50% chicken manure
Bayodo= compost made from 60% soil and 40% rice hulls

Compost analysis, 6, 1998

Material	pH	P	K	Ca	Mg	OC
Chicken manure aged	8.1	3498	24420	6330	2258	11.51
Compost, home-made	7.2	141	1316	8174	1166	3.99

Table O-3. Initial soil nutrient levels and nematode counts[z] from the Waimanalo compost plots, October 1993:

Sample No.	pH	OC	P	K	Ca	Mg
1	6.5	1.7673	380	4000	1300	
2	6.8	1.81274	380	6000	1400	
3	6.8	1.2765	300	4000	1300	
4	6.9	1.79346	420	6000	1500	
5	6.6	1.27109	360	4400	1300	
6	6.6	1.28221	440	5600	1500	
7	7.0	1.63487	520	7100	1300	

[z]Samples No. 1 and 2 (lower field, makai)- few numbers (5 and 0) of Spiral nematode (Helicotylenchus sp) per pint of soil ; Samples 3 and 4 (middle field); Few (5 and 0) numbers of reniform (Rotylenchus sp) nematode per pint of soil; Samples 5-7 (upper field, mauka) few (28, 9, and 14) numbers of spiral nematode per pint of soil.

Table O-4. The effect of several compost treatments on soil nutrient content (ppm) and chemical characteristics, February 1994.

Treatment	N Rate (lbs/Ac)	pH	Salinity mmhos	P	K	Ca	Mg	Org. C (%)
Initial analysis (Oct. 1993)	**0**	**6.7**	**NA**	**272**	**440**	**5700**	**1366**	**1.39**
Control	0	7.2	0.06	37	440	5900	1300	1.24
Fert	150	7.1	0.06	43	420	6000	1300	1.37
MOA	0	7	0.11	51	460	6200	1300	1.67
Comp-0	0	7	0.28	60	400	6100	1300	1.84
Comp-100	100	7.2	0.17	60	420	7100	1200	1.97
Comp-200	200	7.1	0.27	53	400	5700	1200	1.44
Comp-300	300	6.9	0.19	342	400	6000	1300	1.52
MOA demo soil	0	6.9	0.09	430	540	6800	1100	2.03
Amend raw	1.03%	6.6	0	3824	2900	22000	1500	15.93
Home made raw	0.72%	7.6	0	357	1500	7800	1700	4.7

Note: MOA demo soils= soil samples from the demonstration plots, outside of the experimental site. These plots received higher rates of home-made compost for the production of several vegetable crops. A nutrient analysis was run for the raw Amend and home made composts, and is shown in the bottom section of the table, including percent Nitrogen contents.

Table O-5. Effect of Compost Treatment and Nitrogen rates on Nematode counts and Soil Organic Matter content determined after Lettuce Winter production[z] March, 1994.

Treatment[y]	Compost (MT/Ac)	Urea-N (lbs/Acre)	Reniform Nematodes (No. per pint)	Soil Organic Matter (%)
Prior to Planting			14-30	1.39
Control	0	0	286	1.24
Home-made	10	0	277	1.67
Amend	10	0	155	1.84
Amend	10	100	193	1.97
Amend	10	200	263	1.44
Amend	10	300	564	1.52
Urea	0	0	277	1.37

[z] Nematode counts taken on October 28, 1993 prior to experiment initiation found a range of 9-28 spiral nematodes (Helicothylenchus sp.) per pint, and 0 reniform nematodes (Rotylenchulus sp.) per pint. After harvest soil samples were taken on 30 March 1994.

[y] Composts, home-made and Amend (Kellogg Corp), applied at 10 MT/Acre. The 10-20-20 fertilizer applied at 1,500 lbs/Acre (150 lbs/Acre of Nitrogen).

Table O-6. Effect of compost and synthetic nitrogen fertilizer treatments on soil analysis determinations for basil production, Waimanalo, July 15, 1994

Treatment	pH	EC	OC	P	K	Ca	Mg
Mean Levels Oct. 1993	6.7	NA	1.39	272	440	5700	1366
Mean Levels Feb. 1994	7.05	0.15	1.63	134	435	6225	1250
Control	6.9	0.08	1.47	57	370	6875	1250
Fert Chemical	7.1	0.13	1.51	65	370	7075	1190
MOA compost	7.2	0.14	1.70	69	340	7575	1200
Comp & 0 N	6.7	0.24	1.71	69	360	6400	1250
Comp & 100 N	7.2	0.23	1.93	73	350	7450	1150
Comp & 200 N	6.8	0.25	2.40	79	370	7100	1150
Comp & 300 N	6.8	0.27	1.90	74	385	6825	1150
Significance	NS	NS	10%	NS	NS	NS	NS
Average Values for Each Block (Block I and II= higher fertility; III & IV= lower fertility)							
Treatment	pH	EC	OC	P	K	Ca	Mg
Block I & II	7.1	0.22	1.90	83	356	8014	1111
Block III & IV	6.8	0.16	1.71	56	318	6071	1271

Table O-7. Effect of compost treatments on the soil fertility of the replicated compost plots of the long-term organic experiments at the Waimanalo Experiment Station, May 26, 1995.

Treatment	pH	OM	P	K	Ca	Mg
Control	7.03	1.5	185	280	6000	950
Fert	6.98	1.6	133	280	6125	970
MOA	7.30	1.7	60.5	260	6175	925
Comp-0	7.00	2.0	271	305	5625	1010
Comp-100	7.03	2.2	301	325	5750	1000
Comp-200	6.78	2.0	142	270	5375	925
Comp-300	6.73	1.9	231	265	5400	900

Table O-8. Soil nutrient levels from the MOA Compost demonstration and replicated plots taken on March 21, 1996

Data shown prior (Oct 93) and after (3-96) compost treatments

Cover crop/Fallow Section: Lower Side (makai)- Section D

Date	pH	OM	P	K	Ca	Mg	EC
3/21/96	6.3	1.53	37	420	3700	1200	0.099
Oct-93	6.5	1.76	73	380	4000	1300	
Increase	-0.2	-0.23	-36	40	-300	-100	

MOA compost demo plots: Lower Side (makai)- right side -Section A

Date	pH	OM	P	K	Ca	Mg	EC
3/21/96	7.3	2.47	65	720	6500	1200	0.335
Oct-93	6.8	1.81	274	380	6000	1400	
Increase	0.5	0.66	-209	340	500	-200	

Cover crop/Fallow: Middle Side- left side- Section E

Date	pH	OM	P	K	Ca	Mg	EC
3/21/96	6.6	1.65	72	420	4300	1100	0.165
Oct-93	6.8	1.27	65	300	4000	1300	
Increase	-0.2	0.38	7	120	300	-200	

MOA compost demo plots: Middle Side- right side- Section B

Date	pH	OM	P	K	Ca	Mg	EC
3/21/96	7.3	1.88	60	440	6300	1300	0.13
Oct-93	6.9	1.79	346	420	6000	1500	
Increase	0.4	0.09	-286	20	300	-200	

Average increase between plots from Oct. 93 to March 96

Section	pH	OM	P	K	Ca	Mg
Cover crop	-0.2	0.075	-14.5	80	0	-150
MOA comp	0.45	0.375	-248	180	400	-200

Experimental Plots after (3-96) compost treatments

Treatment	Date	pH	OM	P	K	Ca	Mg
Control	3/21/96	6.8	1.69	372	420	7100	1200
Fert	3/21/96	6.6	1.14	523	440	5900	1600
MOA	3/21/96	6.8	1.82	523	440	7300	1300
Comp-0	3/21/96	6.6	2.32	663	420	7700	1100
Comp-100	3/21/96	7	2.85	125	460	6900	1100
Comp-200	3/21/96	6.5	2.21	579	480	6500	1100
Comp-300	3/21/96	6.1	2.22	505	420	6500	1000

Table 7. Experimental Plots prior to (10-93) compost treatments

Upper field (mauka)- left side (toward guava plots)- Replicated compost plots

Treatment	Date	pH	OM	P	K	Ca	Mg
Fallow	Oct-93	6.6	1.27	109	360	4400	1300

Upper field (mauka)- middle)- Replicated compost plots

Treatment	Date	pH	OM	P	K	Ca	Mg
Fallow	Oct-93	6.6	1.28	221	440	5600	1500

Upper field (mauka)- right side (toward road)- Replicated compost plots

Treatment	Date	pH	OM	P	K	Ca	Mg
Fallow	Oct-93	7	1.63	487	520	7100	1300

Table 7, cont. Compost Trials with lettuce

Soil Samples taken after experiment completion on Feb. 1994

Treatment	N Rate (lbs/Ac)	pH	Salinity mmhos	P	K ppm	Ca	Mg
Initial analysis (Oct. 1993)	0	6.7	NA	272	440	5700	1366
Control	0	7.2	0.06	37	440	5900	1300
Fert	150	7.1	0.06	43	420	6000	1300
MOA	0	7	0.11	51	460	6200	1300
Comp-0	0	7	0.28	60	400	6100	1300
Comp-100	100	7.2	0.17	60	420	7100	1200
Comp-200	200	7.1	0.27	53	400	5700	1200
Comp-300	300	6.9	0.19	342	400	6000	1300
MOA demo soil	0	6.9	0.09	430	540	6800	1100
Amend	1.03%	6.6	0	3824	2900	22000	1500
MOA compost	0.72%	7.6	0	357	1500	7800	1700

Table 0-9. Soil fertility levels from the MOA nature farming plots in Waimanalo following several rotation, green manure, and organic amendment application treatments. Also, as comparison, fertility levels from soil samples collected from a taro and vegetable organic farm in Wahiawa, Oahu on August 1996.

Treatment	Date	pH	OM	P	K	Ca	Mg	EC
MOA-1	8/29/96	7.1	2.4	76	520	5900	1200	0.28
MOA-2	8/29/96	7.4	2.6	104	570	6600	1300	0.41
MOA-3	8/29/96	7.3	2.1	95	310	6500	1300	0.38
MOA-4	8/29/96	6.5	1.9	56	420	3800	1200	0.15
Control	8/29/96	7	1.5	321	360	5700	1300	0.15
Samples from an Organic Farm in Wahiawa, Oahu.								
Taro garden	8/29/96	5.4	5.2	1183	1300	2900	540	2.8
daikon garden	8/29/96	6.5	2.1	616	680	2300	260	1.3

NOTE: OM= Percent Organic Matter Content; EC= salinity (mmhos/cm)

Description of Samples, August 1996

Sample	description
MOA-1	makai, demo plots section, compost/rotations (drip)
MOA-2	middle, demo plots section, green manure (pigeon pea), rotation, drip
MOA-3	mauka, demo plots section, chips (3 yr ago), rotations, compost, drip
MOA-4	makai, cover crops section by Guava field
Control	controls from replicated trials
Taro garden	organic taro farm Wahiawa, Oahu
daikon garden	organic vegetable farm, Wahiawa, Oahu

Table. O-10. Soil Analysis collected prior to compost treatment applications and prior to planting saluyut on August 1997,

Treatment	Date	pH	OM	P	K	Ca	Mg	EC
Control	8/20/97	6.8	2.88	326	440	5200	1200	0.475
Fert	8/20/97	6.8	2.28	561	360	5500	1100	0.425
MOA	8/20/97	7	2.39	476	380	5300	1200	0.49
Comp	8/20/97	6.6	2.37	340	400	4200	1200	0.438

Table. O-11. Soil fertility of Section B plots, after planting, and turning over 5 different cover crop treatments, including two grasses, one legume, and two mustard species, Sept. 1997

Treatment	Date	pH	OM	P	K	Ca	Mg	N
Cover Crop Demonstration trial, Section B								
Rhodesgrass	9/4/97	6.3	2.24	38	420	3000	1400	0.16
Control, bare	9/4/97	6.3	2.38	38	460	3200	1500	0.17
Colt-canola	9/4/97	6.4	2.24	73	320	3600	1400	0.18
Dwessex	9/4/97	6.4	2.29	70	420	3400	1400	0.19
Cowpea	9/4/97	6.3	2.61	108	540	3700	1400	0.2
Sorghum	9/4/97	6.4	2.27	101	340	3700	1300	0.19

Cover Crops Demonstration (Section B)

Planted on Section B, 30 by 50 ft blocks for each species
Order from makai to mauka was: Rhodes Grass, Mustard Dwarf Essex, Iron and Clay Cowpea, Sweet & Honey Sorghum, and Colt Canola
Planted on May 16, 1997 and drip irrigated
Harvested on Aug. 15, 1997
Soil samples collected on Sept. 1, 1997

Table O-12. Soil fertility levels from sub-plots in Section A (sub-plots A, B, and C) following several organic amendment applications, September 1997

Treatment	Date	pH	OM	P	K	Ca	Mg	N
Demo Sections								
Sect A-A	9/4/97	6.9	2.63	266	460	5100	1400	0.2
A-B-16-19	9/4/97	7.0	2.49	603	620	5600	1300	0.21
A-C-11-14	9/4/97	7.0	2.36	733	420	5500	1500	0.19
A-C-17-22	9/4/97	7.4	2.47	82	620	5500	1400	0.2

Note: OM= organic matter (%), nutrient levels= ppm; N=%

Demonstration Section A (sub Sections A-C from makai to Mauka)
Sub-Section A- devoted for miscellaneous green manures in 1997
Sub-sec-B-16-19 (Section B, Beds no. 16-19, from mauka to makai)-
Sub-sec-B-16-19= in June 97 applid 800 lb compost- chicken manure& cut grass, plus 1000 lb grass compost
Sub-sec-C-11-14= in Aug 97 applied compost- wood chips & chicken manure, about 1000 lb on 2000 sq ft
Sub-sec-C-17-22= applied 10 tons of vegetable produce in April 97 in area of 2500 sq ft

Table O-13. Effect of several compost treatments and compost demonstration and rotation treatments on the soil fertility of the long-term nature farming plots at the Waimanalo Experiment Station, Jan. and March, 1998.

Soil Analysis MOA compost plots, Waimanalo Station
Date collected: Jan 15, 1998 and March 1998

Treatment	Date	pH	OM	P	K	Ca	Mg	EC
Outside-soil	1/15/98	6.7	2.05	520	520	4000	1300	0.056
Control	1/15/98	7	2.32	319	420	4700	1100	0.074
Fert	1/15/98	6.8	2.37	395	540	4600	1100	0.112
MOA	1/15/98	7.4	2.31	91	460	4700	1200	0.152
Comp-0	1/15/98	7.1	2.43	78	380	4700	1100	0.114
Comp-100	1/15/98	7.1	2.29	116	540	4800	1100	0.156
Comp-200	1/15/98	6.3	2.08	364	400	4300	1200	0.118
Comp-300	1/15/98	6.1	2.3	402	520	4300	1100	0.199
Rotation Experiment 1998-2002								
A-1	3/1/98	6.8	2.01	22	604	5658	1262	0.38
A-2	3/1/98	6.8	1.91	441	558	5462	1292	0.22
A-3	3/1/98	7.5	2.11	75	582	6658	1158	0.26
A-4	3/1/98	6.9	1.93	490	470	5674	1190	0.26
A-5	3/1/98	6.9	1.88	506	472	5406	1262	0.34
A-6	3/1/98	7	1.87	77	590	5658	1188	0.36
A-7	3/1/98	7	1.85	69	450	5804	1280	0.5
A-8	3/1/98	7.1	1.82	77	490	5718	1306	0.28
Conventional Plot fertility in Waimanalo and Poamoho								
Crosby-Nalo	3/15/98	6.1	1.4	294	476	4788	1544	0.23
Bean-Nalo	3/10/98	7.2	1.35	55	234	4904	952	0.29
Cux-Poa	3/15/98	6.1	1.19	368	372	1670	188	0.19

NOTE: recommended levels for heavy soils: P= 35-50; K=200-300; Ca=1500-2000; Mg=300-400.
OM= organic matter (%), N= %; other nutrients= ppm (parts per million)

Treatment Code Descriptions

Note: A1-A8= 8 year rotation plots in MOA demonstration plots in Waimanalo, following 5 years of organic amendment applications (no chemicals)
Crosby-Nalo= no-till experiment in a conventional plot in Waimanalo
Bean-Nalo= bean cultivar trial in a conventional plot in Waimanalo
Cux-Poamoho= cucumber cultivar trial in a conventional plot in Waimanalo outside soil= conventional plot, mauka of MOA plots in Waimanalo

Comp= replicated plots that received compost treatments from 1993-1998

Fert- replicated treatment that received only synthetic nutrients from 93-98

MOA- replicated plots that received compost treatments from 93-98
Control- control replicated plots, no amendments from 93-98

Table O-14. Fertility of control treatments at the replicated long-term compost experiments of the Waimanalo Nature Farming plots. Data collected on June, 1998.

Treatment	pH	P	K	Ca	Mg	OM (%)
Chk-block 1	7.4	95	592	8212	1316	1.73
Chk-block 2	7.0	382	548	6834	1484	1.71
Chk-block 3	7.0	283	862	6424	1622	1.90
Chk-block 4	6.8	134	366	4316	1338	1.41

Note: The location of Block 3 was inadvertently moved on 1995 to build an alleyway in the long-term plots. High Organic matter (OM) show on this plot because of previous chip mulch applications conducted on 1994.

Table 0-14.1. Effect of compost treatments on the soil strength, as determined by a soil penetrometer, at the Waimanalo long-term replicated nature-farming experiment, 6 April 1998.

Treatment	Pressure to reach 6 inches (psi)	Depth to Hard-pan at >250 psi (inches)
Control	139.6b	10.6ab
Fertilizer	201.7a	9.7bc
MOA-compost	158.3b	11.9a
Compost	210.4a	7.9c

Note: A soil penetrometer was used to determine the soil strength (compaction level) of the different treatments. Soil compaction is shown by a shallow hard pan. Soil penetrometer data was collected on 3 locations per bed (N=12 for each treatment). The data shows that the fertilizer and compost treatments had the greatest soil compaction or soil strength. Thus for the MOA and controls the hard pan was found at about 11 inches depth, while for the compost it was 8 inches and for the fertilizer treatment it was about 10 inches deep. It may be possible that root growth was deeper for the controls and for the MOA plots (no previous history of synthetic N treatments) to acquire the necessary nutrients, while root growth for the compost (previous history or synthetic N) and synthetic fertilizer (Fert) treatments was shallower because most needed nutrients (especially N) were readily available within the top 6-8 inches below the soil line.

Overall Results: Organic Matter levels

Organic matter (organic carbon) levels were collected annually from 1993 to 1998. The trend in OM content on the demonstration and replicated plots over that period of time is shown on Table O-15. For the controls, soil OM levels remained fairly constant ranging between 1.4 and 1.7. The high OM levels shown for the controls, and for the other treatments in the Aug. 1997 and Jan. 1998 sampling dates may be due to mixing of the soil between treatments, due to an artifact of the laboratory OM analyses, or to an as yet undetermined factor. The OM levels for the demonstration plots increased by 38% from 1993 to 1997. The lower (1.9%) OM levels shown for the demonstration plots by Jan. 1998 may be an artifact of the lab OM analysis, or could be a result of the reduced levels of organic amendment applications, beginning in early 1997. The OM for the synthetic fertilizer treatments remained low, and even declined below baseline levels, by March 1996. On the other hand, plots receiving organic amendment applications showed a steady increase in the soil OM content. From 1993 to 1996 the OM levels in the compost plots increased by 57-100%, compared to the 1993 baseline levels (Table O-15), while for the fertilizer plots OM actually decreased by 21% in that period of time (see discussion on C system exports below). Similarly between 1993 and Jan. 1998, soil OM levels increased by 50-64% in the compost plots. The respective OM rate of increase from 1993 to July 1998 was 34% for the controls, 28% for the fertilizer treatment, and 42% for all compost treatments. The increase in OM for plots receiving organic amendments occurred despite a greater export of carbon from the system, through the crop harvests. Carbon export (Table O-15) was 36% greater in the fertilizer treatments, and ranged from 26-46% greater in the compost plots, compared to C exports in the controls. A more detailed C nutrient budget of this experiment would indicate the portion of the applied composts that is exported with the crop harvests, that portion which remains in the system contributing toward a greater soil OM content, and that portion which is lost through respiration and oxidation (probably >50-60% of biomass productivity, including both plant and rhizosphere microbial respiration). A more detailed C budget may provide insights into the amount of annual C inputs (in the form of composts, green manures, or other organic amendments) that are required to maintain crop productivity, and to increase the soil OM content to an optimum (and as yet undetermined level). This information may be critical for the design and implementation of large-scale organic or nature farming production systems in Hawaii and other tropical regions.

Table 0-15. Overall trend in soil organic matter (% organic carbon) content from 1993 to 1998 at the long-term nature farming plots, Waimanalo.

	Treatment							
Date	Control	Fert	MOA	Demo	C-0	C-100	C-200	C-300
Oct 93	1.4	1.4	1.4	1.8	1.4	1.4	1.4	1.4
Mar 94	1.2	1.4	1.7	2.0	1.7	2.0	1.4	1.5
July 94	1.5	1.5	1.7	NA	1.7	1.9	2.4	1.9
May 95	1.5	1.6	1.7	NA	2.0	2.2	2.0	1.9
Mar 96	1.7	1.1	1.8	NA	2.3	2.8	2.2	2.2
Aug 96	1.5	NA	NA	2.4	NA	NA	NA	NA
Aug 97	2.9	2.3	2.4	2.5	2.4	NA	NA	NA
Jan 98	2.3	2.4	2.3	1.9	2.4	2.2	2.1	2.3
June 98	1.7	NA	NA	NA	NA	NA	NA	NA
July 98	1.9	1.8	2.0	NA	2.0	2.0	2.0	2.0
Percent Increase over Oct. 1993 baseline data								
1993 to 96	20%	-21%	28%	33%	64%	100%	57%	57%
1993 to 7-98	34%	28%	42%	5%	42%	42	42%	42%
Carbon Output (Harvested biomass, from Table O-1, multiplied column 6 x 0.9)								
93-98	12,743	17,349	16,112	NA	16,482	17,618	17,488	18,584
Biomass yield increase over control	0%	36%	26%	NA	29%	38%	37%	46%

Table 0-15. Overall trend in soil organic matter (% organic carbon) content from 1993 to 1997 on the cover crop / fallow section (Section B) at the long-term nature farming plots, Waimanalo.

Date	Organic Matter Content (%)
Oct. 1993	1.5
March 1996	1.6
August 1996	1.9
Sept. 1997	2.4

Overall Results Nematode Counts 1993-1998

A baseline count of nematode numbers was conducted in the Waimanalo nature farming plots on October 1993, prior to the initiation of the replicated and demonstration experiments. Initially negligible nematode numbers were found in all sites (Table O-3). Nematode counts were then collected periodically in the replicated plots. Casual inspections of the root of the many vegetables grown in the demonstration plots has found no gall formation and in general healthy root growth which indicates that nematode pests have not been a serious problem in the demonstration plots. Nematode pest pressure evaluations in the replicated plots have shown mixed results and are discussed below.

1994. Lettuce and Basil Experiments: Soil analysis prior to starting the experiment showed small counts (10-30 per pint of soil) of spiral nematodes (*Helicotylenchus* sp.). By March 1994 nematode counts increased to a range of 155 for soil that received Amend compost alone to 564 per pint for soils that received Amend plus 300 lbs N / acre. In the March, 1994 samples, nematode counts increased successively, as nitrogen rates were increased in the compost plus N plots. Thus soil samples that received Amend compost had nematode counts of 155, 193, 263, and 564, as N rates increased by 0, 100, 200, and 300 lbs / acre, respectively (Table Nem-1). At this time, in March 1994, Amend compost plus 0 lbs N / acre thus had 27% as many nematodes as Amend plus 300 lbs N / acre. Final yields of Amend alone were 67% of the final yields for Amend plus 300 lbs N / Acre so differences in plant growth do not seem to account alone, for the difference in nematode counts between treatments.

By the sampling date on July 15, 1994, soils from the home-made compost had the lowest nematode counts, at 55 per pint of soil (Table Nem-2), while plants that received synthetic fertilizer alone had the highest nematode counts. Also by July, the soils that received Amend compost had a mean count of 134 nematodes per pint which was about half the amount obtained for the controls, and about a third (29%) of that obtained by the synthetic N applications alone. On the other hand, mean yields of all plants that received an Amend compost treatment were almost double those obtained by the controls. These data indicates that the compost treatments may have contributed toward a decrease in the nematode populations in the soil. For example, plant pathologists normally expect higher nematode counts on susceptible plants as growth rate increases because this results in more root tissue available for the nematodes to develop (Dr. Brent Sipes, personal communication), but in our case even though yields of plants that received Amend compost were almost *twice* as great the controls, nematode counts for Amend were about *half* of those in the controls.

1995. Nematode counts were conducted on February 1995 following the 1994 eight-month basil planting. By this time, several nematode species were found in the replicated compost plots. No root-knot nematodes were found on the controls or on the compost treatments that also received either 200 or 300 lb / Ac of synthetic Nitrogen. Of the treatments that had root-knot nematodes the synthetic N plots had the greatest nematode numbers, while the lowest numbers were found in the compost plots (Comp-0) that received no synthetic N (see Table Nem-3). The control plots had the greatest Reniform numbers, while the MOA (home-made compost) and synthetic N treatments had the lowest Reniform counts. The synthetic N treatment had the greatest lesion nematode numbers. Concerning total nematode counts, the greatest overall numbers were found in the synthetic N, controls, and homemade (MOA) compost treatments (Table Nem-3). It was surprising to find that the compost treatments that received some levels of synthetic N had lower nematode counts than the plots that received the compost treatment alone (comp-0). A follow-up nematode sampling conducted in May 1995 found high root-knot numbers in the synthetic N fertilizer treatments, low levels in the home-made (MOA) compost treatment and none in the controls (Table Nem-4). On the same sampling date highest reniform counts were found in the controls, medium levels in the MOA (homemade), and none in synthetic N treatment. Total nematode counts were greatest in the controls, followed by the synthetic N treatment, and lowest in the homemade compost plots (Table Nem-4).

1998. A nematode sampling was conducted in January 1998, following the four-month fall saluyut planting. Root-knot counts were greatest in the MOA plots (straw compost) with negligible numbers in the other treatments (Table Nem-5). Reniform numbers were greatest in the controls followed by Comp-100, MOA, and negligible numbers in the other treatments. Concerning total nematode counts, the greatest numbers were found in the MOA treatments. Because the yield data (Table Nem-10) suggests that plants under the MOA plots were under some stress (depressed yields were observed, likely caused by the high C:N ratio of the straw-based compost), it is plausible that nematode numbers were able to reproduced faster with the plants under stress, than in the other treatments. Low to negligible total nematode counts were observed in the synthetic N treatment (fert) and in the compost plots that received low N rates (Table Nem-5).
During the summer 1998, following a short basil crop, generally low nematode counts were found throughout (Table B-7). In the July 1998 sampling, greatest nematode numbers were found in the controls, and the lowest levels were found in the synthetic N treatment. Following a second basil crop, in the Fall of 1998, an index rating of root gall damage on the roots of basil found greater galling in the treatments with a high compost application rate (80 MT / Ha), and lowest galling rates in the controls. As observed in Table B-9, basil yields were depressed with the highest compost application rate, indicating that the plants may

have been subjected to stress (plausibly due to high soluble salt levels under the high composting application rates), making the plants more susceptible to nematode attack.

Overall Results for Nematode Counts. Overall, the compost treatments seemed to have provided some level of suppression against nematode pest population buildup (Fig. Nem-1), but the results are far from conclusive. Several factors may be confounding the possible suppressive characteristics of the compost materials. In general nematode numbers tend to increase faster in plants that are growing rapidly than in slower-growing plants due to the greater root biomass growth which provide more sites for infection and a richer food supply. Because all compost treatments (both compost and MOA plots) in general resulted in greater crop growth, it is likely that nematode reproduction rates would tend to be faster in these treatments. Also, several nematode species appeared in the experiment (root-knots, reniforms, spiral), further complicating the picture, because the particular nematode species may respond differently to the soil fertility, to the crop being grown at the time, and to the rates of crop growth.

To try to isolate or separate the effect of the greater root growth (and corresponding greater yields and nematode numbers) from the possible nematode suppressive characteristics of the compost treatments, a determination was made of the nematode counts obtained in each experiment in relation to the final yields obtained in that experiment (See Tables Nem-6 to 11). When calculating nematode populations per 1000 lbs of harvested produce (fresh weight) the data looks as follows: In the lettuce experiments (Table Nem-6) the compost treatments with low N rates (0 or 100 lbs / Acre) had about 40% less nematodes per pound of harvested produce, than the controls. In the 1994 basil experiment, during the first three months of crop growth the compost treatments (MOA plots not included) had a range of 50-85% less nematodes per pound of harvested produce than the controls (Table Nem-7). By the end of the 8-month crop cycle, all compost treatments (MOA included) had a range of 35-70% less nematodes per pound of harvested produce than the controls (Table Nem-8), a level of reduction that remained by 30-50% by May 1995 (Table Nem-9). Similarly, following a 4-month saluyut crop, the compost treatments that received low N rates (MOA not included), had 40-80% less nematodes per pound of harvested produce, than the controls. A similar trend was observed with basil in 1998, showing a 40-50% nematode reduction per pound of harvested produce, in the compost plots, compared to the controls. When all sampling dates are pooled together (Tables Nem-6 to 11) the mean levels of nematode reduction (per pound of harvested produce) for the different treatments was: synthetic fertilizer, 38%; compost alone, 52%; compost plus 100 lbs / Ac N, 55%; and compost plus 300 lbs N, 21% nematode level reduction as compared to the controls. This indicates that the compost plots may be providing a relative level of nematode pest suppression, perhaps due to a greater level of soil biological control activity resulting from the organic amendment applications.

Table Nem-1. Effect of Compost Treatment and Nitrogen rates on Nematode counts found after Lettuce Winter production, Waimanalo Station, April 1994[z].

Treatment[y]	Compost (MT / Ha)	Urea-N (lbs / Acre)	Reniforn Nematodes (No. per pint)
Control	0	0	286
Fert	0	0	277
MOA	10	0	277
Comp-0	10	0	155
Comp-100	10	100	193
Comp-200	10	200	263
Comp-300	10	300	564

[z] Nematode counts taken on October 28, 1993 prior to experiment initiation found a range of 9-28 spiral nematodes (Helicothylenchus sp.) per pint, and 0 reniform nematodes (Rotylenchulus sp.) per pint. After harvest soil samples were taken on 30 March 1994.

[y] Composts, homemade and Amend (Kellog Corp), applied at 10 MT / Acre. The 10-20-20 fertilizer applied at 1,500 lbs / Acre (150 lbs / Acre of Nitrogen).

Table Nem-2. Effect of compost treatment on Reniform nematode level counts (no. per pint of soil) conducted at the replicated nature farming plots, Waimanalo, July 1994

Treatment	Reniform No.	Levels
Control	246.7	abundant
Fert	349.0	abundant
MOA	55.0	low
Comp-0	175.0	moderate
Comp-100	75.5	moderate
Comp-200	172.7	moderate
Comp-300	114.0	moderate

Reniform nematode numbers by block, Waimanalo, July 1994

Block-1	88.7
Block -2	194.5
Block -3	202.1
Block -4	193.4

Table Nem-3. Effect of compost treatment on nematode counts (no. per pint of soil) at the long-term replicated nature farming plots, Waimanalo, Feb. 1995.

Treatment	Root Knot	Reniforms	Spiral	Lesion	Total
Control	0	554.25	39.33	14	587.25
Fert	2040	270.25	301.00	118	885.00
MOA	592	211.50	188.00	0	648.50
Comp-0	42	404.00	113.00	0	520.50
Comp-100	28	363.00	42.50	28	398.25
Comp-200	0	321.75	239.50	0	441.50
Comp-300	0	434.75	18.50	0	444.00

MOA demonstration Plots- Nematode Counts 3-94

MOA demonstration plots March 30, 1994	0 nematodes found
MOA demo. plots October 28, 1993	0-5 reniforms per pint

Table Nem-4. Effect of compost treatment on nematode levels (no. per pint of soil) at the replicated nature farming plots, Waimanalo, May 1995.

Treatment	Root-knot	Reniform	Spiral	Lesion	Total	Total
		(no. / pint)				(% of control)
Control	0	992	33	0	1025	100%
MOA	75	357	99	0	531	52%
Fert	832	33	0	0	865	84%

Table Nem-5. Effect of compost treatments on nematode counts following the last saluyut (Filipino spinach) harvest, Jan. 15, 1998.

Treatment	Root-knot	Reniform	Spiral	Total
Control	0	126	0	126
Fert	28	16	0	44
MOA	526	71	0	597
Comp-0	0	38	0	38
Comp-100	0	99	0	99
Comp-200	0	0	59	59
Comp-300	80	0	85	165
Outside-mauka	0	0	0	0

Note: MOA= straw-based compost treatment (25% by volume); Comp= wood-chips based compost (25% chips by volume). Outside-Mauka= soil samples collected from a field plot located Mauka (South in this case) of the compost plots. This plot had been fallow for over 6 months prior to sample collection.

Basil Expt. 1998. *See Sections 9 and 10:*

Table Nem-6. Effect of compost treatment on the Nematode number to yield ratio obtained in lettuce, Waimanalo, March 1994.

Treatment	Total Nematode Numbers (no./pint)	Percent of Control	Total yield (lbs/Acre)	No. Nematodes per 1000 lb yield	Percent of Control
Control	286	100%	22,134	12.9	100
Fert	277	97	18,445	15.0	116
MOA comp	277	97	21,266	13.0	101
Comp-0	155	54	21,049	7.36	57
Comp-100	193	67	23,219	8.3	64
Comp-200	263	92	20,181	13.0	101
Comp-300	564	197	21,700	26.0	201

Table Nem-7. Effect of compost treatment on the Nematode number to yield ratio obtained in basil, Waimanalo, July 1994.

Treatment	Total Nematode Numbers (no./pint)	Percent of Control	Total yield (lbs/Acre)	No. Nematodes per 1000 lb yield	Percent of Control
Control	246.7	100%	16,370	15.1	100%
Fert	349.0	141	29,396	11.9	79
MOA	55	22	24,556	22.4	148
Comp-0	175	71	24,554	7.1	47
Comp-100	75.5	30	34,223	2.2	15
Comp-200	172.7	69	31,004	5.6	37
Comp-300	114	46	32,608	3.5	23

Table Nem-8. Effect of compost treatment on the Nematode number to yield ratio obtained in basil, Waimanalo, February 1995.

Treatment	Total Nematode Numbers (no./pint)	Percent of Control	Total yield (lbs/Acre)	No. Nematodes per 1000 lb yield	Percent of Control
Control	587.2	100%	31,494	18.6	100
Fert	885.0	151	55,969	15.8	85
MOA	648.5	110	55,969	11.6	62
Comp-0	520,5	89	43,762	11.9	64
Comp-100	398.2	68	63,702	6.2	33
Comp-200	441.5	75	43,762	10.1	54
Comp-300	440	76	65,643	6.7	36

Table Nem-9. Effect of compost treatment on the Nematode number to yield ratio obtained in basil, Waimanalo, May 1995.

Treatment	Total Nematode Numbers (no./pint)	Percent of Control	Total yield (lbs/Acre)	No. Nematodes per 1000 lb yield	Percent of Control
Control	1025	100%	31,494	32.5	100%
MOA	531	51	55,969	9.5	29
Fert	865	84	55,969	15.4	47

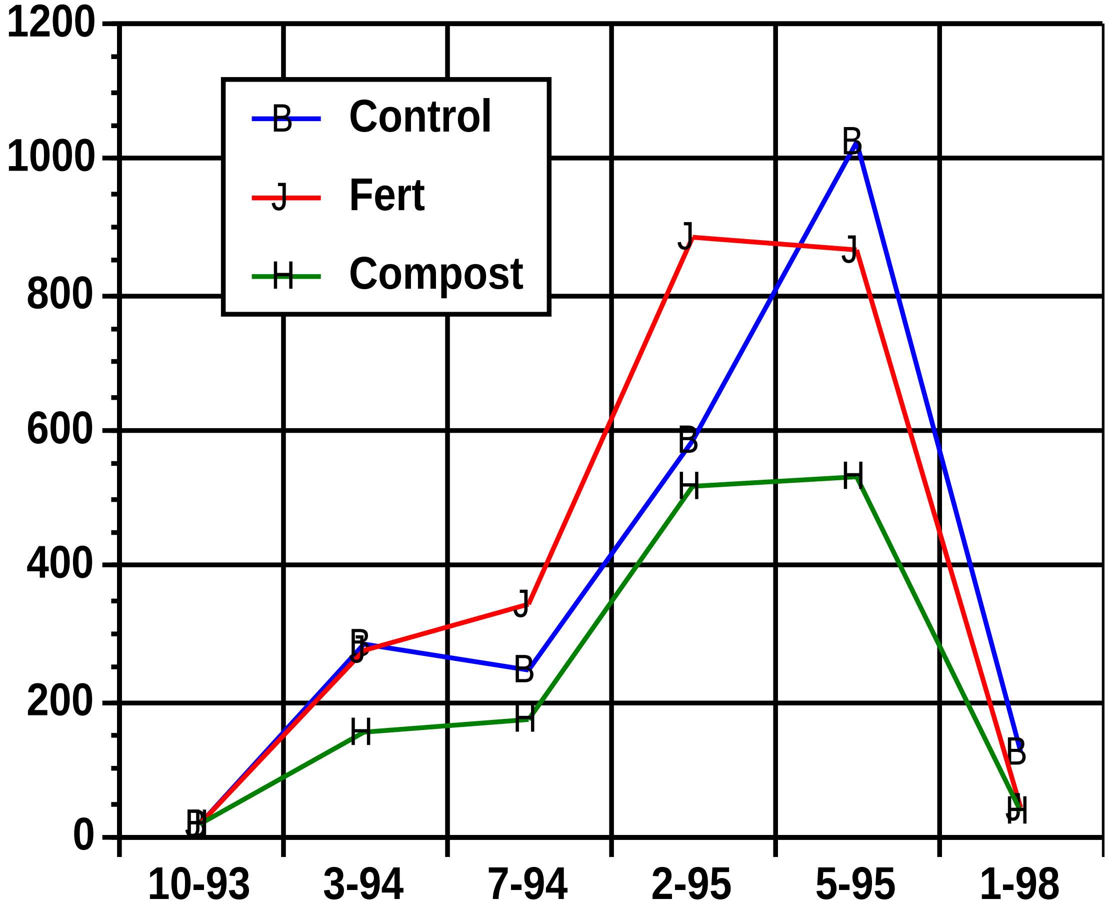
Table Nem-10. Effect of compost treatment on the Nematode number to yield ratio obtained in saluyut, Filipino spinach, Waimanalo, January 1998.

Treatment	Total Nematode Numbers (no./pint)	Percent of Control	Total yield (lbs/Acre)	No. Nematodes per 1000 lb yield	Percent of Control
Control	126	100%	34,503	3.6	100%
Fert	44	35	46,872	0.94	26
MOA	597	474	45,570	13.1	359
Comp-0	38	30	52,080	0.73	20
Comp-100	99	78	42,966	2.3	63
Comp-200	59	47	52,080	1.1	30
Comp-300	165	130	54,033	3.0	83

Table Nem-11. Effect of compost treatment on the Nematode number to yield ratio obtained in basil, Waimanalo, July 1998

Treatment	Total Nematode Numbers (no./pint)	Percent of Control	Total yield (lbs/Acre)	No. Nematodes per 1000 lb yield	Percent of Control
Control	39.2	100%	29,370	1.3	100%
Fertilizer	13.0	33	42,878	0.30	22
MOA	33.7	85	40,524	0.83	62
Comp	24.7	63	35,917	0.69	51

Fig N-1. Effect of compost treatments on nematode counts from 1993 to 1998 at the replicated farming plots, Waimanalo.



15. Overall Results Demonstration plots, 1993-1998

Overall over 50 different vegetable crops were grown and evaluated at the Waimanalo MOA nature farming plots (see: Table D-2) This large experimental data base provides an indication of the crops that can be grown organically in Hawaii, during the different growing seasons. This initial database will provide the groundwork to begin to develop detailed technological packages for the production of specific vegetables in tropical regions, following nature-farming guidelines. However, additional and more detailed research will be required to develop these production guidelines for specific crops. The fertility studies conducted in the replicated plots with lettuce, basil, saluyut, and zucchini (See sections: 2,3, 8, 9, 10, 11 & 14) provide an indication of the type of research that is necessary to develop the appropriate location-specific production packages for specific crops. In addition to crop nutrition research will be needed in other aspects of crop production such as irrigation, planting and crop establishment, pest management (see Table D-4)

Table D-2. List of several crops grown on the demonstration plots (Sect. A), Waimanalo 1993-1997.

71 beds total from Mauka to Makai in demo plots

bed no= from mauka to makai

Crop	Variety	Bed No.	Month (Harvest)	Year	planted	harvest	yield (lbs)	harvest area (feet row)	compost (tons/Acre)	comments
bare	3 beds	48-50	oct	1996						
bare	4 beds	57-60	oct	1996						
bare	4 beds	4-7	may	1997						
bare	4 beds	10-13	may	1997						
bare	1 bed	23	may	1997						
bare	4 beds	39-42	may	1997						
bare	15 beds	60	may	1997						
bare	7 beds	sec e	may	1997						
bare beds	4 beds		jan	1995						
bare ground	25 beds	8-33	oct	1996						
bare ground	5 beds	16-20	may	1997						with produce layed down
bean pole	HI wonder	1 bed	oct-nov	1995	8/28/95	10/30/95	77	200		organic mulch
bean pole			nov	1995						
beans bush	1 bed	sec c	july	1997						
beans bush	1 bed	sec b	aug	1997						intercrop with corn
beans red	trellis 1 bed	sec e	aug	1997						
beans string		11	lost	1993	9/15/93			20		lost, fungus, rust
beet sugar		7	nov	1993	9/13/93	11/19/93	17.4	20		with tops
beet sugar		3 rows	april	1994				20		
beet sugar	1 bed	sec e	aug	1997						
beets		3 beds	march	1994						weedy
beets	3 rw/bed		feb-mar	1995						
beets			nov	1995						
beets			may	1996						
beets	1 bed	43	may	1997						weedy

Table D-2, cont. List of several crops grown on the demonstration plots (Sect. A), Waimanalo 1993-1997.

beets sugar		28	feb	1994	12/4/93	2/13/94	15.8	20	
beets sugar		46	feb	1994	12/14/93	2/13/94	13.9	20	
beets sugar		2 beds	aug-oct	1995	8/18/95	10/30/95	260	400	organic mulch
broccoli			nov	1995					
broccoli			may	1996					
broccoli	1 bed	45	may	1997					weedy
cabbage	4 beds	34-37	may-jun	1997					v/weedy
cabbage chinese	3 rw/bed	1 bed	jan-feb	1997					
cabbage head			nov	1995					
cabbage mustard		13	nov	1993	9/20/93	11/15/93	27.8	20	
cabbage mustard		45	feb	1994	12/14/93	2/9/94	23.4	20	bolting, hoppers after 4 wks
carrot		1 bed	april	1994				20	
carrot		1 bed	june	1994					
carrot	2 beds	43-44	oct-jan	1996					seedlings
carrot	1 bed		jan-feb	1997					
carrot	2 beds	sec b	aug	1997					
carrots		6	nov	1993	9/10/93	11/29/93	10.4	20	15.7 lb with tops
carrots		23	feb	1994	11/5/93	2/5/94	11.5	20	16.4 lb with tops
carrots		31	march	1994	12/4/93			20	
carrots		44	march	1994	12/14/93			20	
carrots	6 beds		jan	1995					
carrots			jun	1995					
carrots	3 rw/bed	2 beds	aug-nov	1995	8/16/95	11/17/95	400	200	organic mulch
Chinese cabbage			dec	1994				20	
choi sum		24	dec	1993	11/10/93	12/27/93	6.1	20	early flowering
choi sum		48	jan	1994	12/14/93	1/28/94	5.7	20	
choi sum			march	1994					
choi sum			dec	1994				20	
choi sum	1 bed		jan	1995	flowering, insectary?				flowering, insectary?
choi sum	2 beds		jan	1995					
choi sum			nov	1995					
choi sum	2 beds	6-7	oct	1996					flowering, insectary?
cilantro		38	jan	1994	12/11/93	1/25/94	9.9	20	oversized

Table D-2, cont. List of several crops grown on the demonstration plots (Sect. A), Waimanalo 1993-1997.

cilantro			march	1994					
collards	1 bed	sec c	july-nov	1997					
cucumber	oriental	9	lost	1993	9/15/93			20	losts, aphids, vine borer
daikon	chinese	5	oct	1993	9/8/93	10/11/93	57.4	20	
daikon	chinese	20	nov	1993	10/20/93	11/24/93	56.9	20	with tops
daikon	hybrid	26	jan	1994	12/4/93	1/24/94	30.8	20	
daikon	long	27	feb	1994	12/4/93	2/3/94	39.2	20	
daikon			march	1994					
daikon	hybrid	47	feb	1994	12/14/93		31.2	20	
daikon			april	1994				20	
daikon	4 beds		jan	1995					
daikon	chinese	4 beds	aug-sep	1995	8/9/95	9/19/95	983	800	organic mulch
daikon	japanese	1 bed	nov	1995	10/1/95	11/17/95	214	200	no mulch
daikon			june-aug	1995					mulch
daikon	2 beds	2-3	oct-dec	1996					
daikon	2 beds	51-52	oct	1996					
daikon	2 rw/bed	11 bed	jan-mar	1997					
daikon	2 beds	28-29	may-july	1997					
daikon	2 beds	30-31	may-july	1997					weedy
daikon	1 bed	sec b	aug	1997					
daikon	1 bed	sec e	aug	1997					grass compost
daikon	hybrid	14	nov	1993	9/22/93	11/5/93	29.7	20	
daikon	chinese	1 bed	oct-nov	1995	10/6/95	11/22/95	183	200	no mulch
daikon chinese		25	jan	1994	12/4/93	1/11/94	58.6	20	
daikon hybrid		21	dec	1993	10/20/93	12/1/93	31.2	20	with tops
daikon long		15	nov	1993	9/20/93	11/24/93	37.6	20	
daikon long	long	22	dec	1993	10/10/93	12/16/93	38.4	20	with tops
eggplant	2 beds		mar	1995					
eggplant			sep-dec	1995					
eggplant			may	1996					
eggplant	1 bed	66	oct	1996					
eggplant	1 bed	44	may	1997					weedy
gobo	1 bed, 2 rws	sec c	july	1997					didnt make it

Table D-2, cont. List of several crops grown on the demonstration plots (Sect. A), Waimanalo 1993-1997.

gobo salad Masume	1 bed, Takii		dec	1996					
hibiscus edible	1 bed		sept-dec	1995	10/3/95	1/27/96	300	200	no mulch
joi choi	1 bed	sec b	aug	1997					
katuk	1 bed		sept-dec	1995					
kay choi	4 beds	61-64	oct	1996					
kay choy	2 beds	4-5	oct-dec	1996					
komatzuna	4 rw/bed	1 bed	dec-feb	1996					
komatzuna	3 rw/bed		jan-feb	1997					
komatzuna	2 beds	24-25	may-jun	1997					weedy
leaf lettuce			april	1994				20	
lemon grass	1 bed		may-dec	1997					
lettuce	manoa	4	oct	1993	9/8/93	10/15/93	10.2	20	
lettuce	manoa	19	dec	1993	10/6/93	12/10/93	11.7	20	
lettuce	manoa	33	jan	1994	12/4/93	1/19/94	9.6	20	
lettuce	red leaf	34	jan	1994	12/4/93	1/20/94	2.8	10	
lettuce		4 beds	march	1994					seedlings
lettuce	4 rw/bed		feb	1995					
lettuce manoa	3 beds	45-47	oct	1996					
melon winter			nov	1995					
mizuna	2 beds		jan-feb	1995					
mizuna			nov	1995					
mizuna			dec-feb	1996					weedy
okra		17	dec	1993	9/29/93	12/8/93	1.5	20	lf curl, fungal growth
okra	1 bed		dec-mar	1995					
okra			jun	1995					
okra			sep	1995					
okra			may	1996					
okra	1 bed	53	oct-dec	1996					4-5 ft tall
okra	3 beds	54-56	oct-mar	1996					seedlings
okra	1 bed	sec b	aug	1997					grass compost
okra large	1 bed	65	oct	1996					
onion	bulb	32	may	1994	12/4/93			20	
onion bulb		30	may	1994	12/4/93			20	

Table D-2, cont. List of several crops grown on the demonstration plots (Sect. A), Waimanalo 1993-1997.

onion bulb			april	1994				20		
onion bulb		29	may	1994				20		
onion bulb	1 bed		jan	1995	bolting					bolting
onion green		18	dec	1993	9/29/93	12/15/93	12.7	20		
onion green		43	march	1994	12/14/93			20		
onion green			nov	1995						intercropped with eggplant
onion green			may	1996						
onion green	1 bed	sec b	aug	1997						
onions green		8	nov	1993	9/13/93			20		nursery to increase stock
onions green	1 bed	sec c	july	1997						
papaya	6 beds		aug	1995						
papaya	1 bed		may-dec	1997						
peanut			nov	1995						
peanut perennial	1 bed	1	may-dec	1997						
peas chinese	1 bed	sec b	aug	1997						
pigeon pea	5 beds	38-42	oct	1996						7-8 ft tall
pigeon pea	2 beds	14-15	may-oct	1997						
pigeon pea	2 beds	21-22	may-oct	1997						
pigeon pea	2 beds	26-27	may-oct	1997						
pigeon pea	2 beds	32-33	may-oct	1997						
pigeon pea	1 bed	38	may-oct	1997						
pumpkin	1 bed	sec b	aug	1997						grass compost
soybean			march	1994						poor stand, birds ate seed
soybean		2 beds	may	1994	poor stand					poor stand
soybean		1 bed	june	1994	n fixation study					n fixation study
soybean	1 bed		jun	1995						N fixation study
soybean			may	1996						
soybean	9 beds	sec e	may	1997						rose-beetle damage
soybean	5 beds, 2 r/bed	sec e	may	1997						plastic mulch, with grass alleys, look OK
soybeans		1	nov	1993	9/6/93	11/24/93	2	20	10	
soybeans		10	lost	1993	9/15/93			20		lost, poor germination
soybeans	kahala	1 bed	may-aug	1995	5/28/95	8/21/95	49	200		122 lb all plant; no mulch
soybeans	kahala	1 bed	jun-sep	1995	6/17/95	9/10/95	52	200		130 lb all plant; no mulch

Table D-2, cont. List of several crops grown on the demonstration plots (Sect. A), Waimanalo 1993-1997.

soybeans	kahala	1 bed	jul-oct	1995	7/16/95	10/8/95	67	200	167 lb all plant; mulch
soybeans	7 beds	sec e	may	1997					just planted
spinach		42	feb	1994	12/8/93	2/2/94	11.4	20	
spinach		1 bed	dec-jan	1996					
spinach	1 bed	sec b	aug	1997					grass compost
spinach	1 bed	sec e	aug	1997					
squash	kabocha		may	1996					
squash	1 bed	1	sep-dec	1996					organic mulch
sudex	4 beds	34-37	oct	1996					7-8 ft tall
sunhemp	2 beds	2-3	may-oct	1997					
sunhemp	2 beds	8-9	may-oct	1997					
sw corn		2	lost	1993	9/6/93			20	lost, leafhoppers
sw corn			jun	1995					chlorotic
sw corn	1 bed	sec b	aug	1997					intercrop with beans
swcorn			june	1994					
sweetcorn	waimanalo	12	nov	1993	9/15/93	11/19/93	2.1	20	stunted growth, hoppers
swiss chard			april	1994				20	
swiss chard		1 bed	oct-feb	1995	8/16/95	10/30/95	86	200	organic mulch
swpotato		35-37	june	1994	12/11/93			20	
swpotato		39-41	june	1994	12/11/93			20	
swpotato			april	1994				20	
taro	bung long		nov	1995					
togan			nov	1995					
weedy	9 beds		jan	1995					
won bok		3	lost	1993	9/6/93			20	lost, aphids, leafhoppers
won bok		16	lost	1993	9/27/93			20	lost aphids 5th wk
yama imo			nov	1995					
zucchini			nov	1995					floating cover trial

Table D-3. Description of some pests attacking vegetable crops grown at the nature farming demonstration plots in Waimanalo, summer 1998. (Information provided by Randall Hamasaki, CES extension agent, Kaneohe, pers. Comm. June 5, 1998).

Bell pepper

* Broad mites (Polyphagotarsonemus latus)- It's feeding causes bronzing and distortion of leaves, yellowing and withering of the growing shoot, and scarring and deformation of the fruit.
* Pepper weevil- None found but another common pest almost sure to become a problem. Watch for young pepper fruits falling off prematurely. Fruit has internal discoloration when opened.
* Bird damage (possibly bulbuls)

Eggplant

* Spider mites- Causes stippling (tiny whitish spots on leaves). High populations cause leaves to yellow and dry up prematurely. Problem usually gets worse as plants get older and weather gets hot and dry.
* Broad mites, Similar damage as w/ peppers
* Chinese rose beetle (Adoretus sinicus)- Chewing type damage causes holes in leaves.
* Eggplant wilt. Sample submitted to ADSC for analysis (JCN: 98-022795) June 5, Suspect that problem might be Phomopsis Blight or possibly Verticillium wilt. Hot water treatment of eggplant seeds (30 min. at 122 deg. F) suggested for Phomopsis blight prevention (from seeds).

Cowpea

* Powdery mildew (a fungal disease)
* Broad mites

Sweet Corn

* Corn delphacid (Peregrinus maidus)
* Flies/ants (not a pest problem) probably being attracted to honey dew secretion from hoppers

Dasheen (araimo)

* Probably Cladosporium leaf spot (Cladosporium colocasiae)—a relatively harmless fungal disease

Sweet potato

* A tortoise beetle (Cassida circumdata)

Was first collected in the State at the Waimanalo Experiment Station. Feeding causes small, circular holes in leaves.
* Sweetpotato flea beetle- Adult feeding on leaves causes whitish (tan) lines on leaves. Larvae might be feeding on roots.

Chinese Daikon

* The wet, smelling decay of roots is likely a bacterial soft rot.
* Imported cabbage webworm (Hellula undalis). Caterpillar feeds on growing point of daikon plant. In addition, this caterpillar might be feeding on the upper portion of the daikon root, which may be creating an entryway for the bacterial soft rot organism. Dimple like holes were noted on the upper to mid section of the daikon root.

16. Compost Project Educational Activities

Lectures and Presentations in which data/slides from the Waimanalo Compost Experiments were shown as an educational tool in the area of Composting, Nature Farming, and Sustainable Agriculture

Effect of Composts on Growth and Yields of Basil. Univ. Hawaii Horticulture Seminar. *Oct. 3, 1994*

Sustainable Agriculture. Guest Lecture with Ivan Kawamoto, MOA-Hawaii, for FSHN 250 class (Human Needs and Environmental Resources), 60 students. Instructor Dick Bowen, *6 Oct. 1994.*

Alternative Pest Control Methods in Veg Crops, presented with Dr. Kathleen Delate. 1994 Teleconference for Commercial Veg Growers (Video available). *Oct. 19,1994*

Attracting Beneficial Insects. at 4th WSSA Sustainable Agriculture Conference, Hilo, Hawaii. 11 Nov. 1994, Invited Speaker

Nature Farming Compost Experiments in Hawaii: First Year Results. Presented to WSAA representatives from around the world, *Jan. 14, 1995.*

Compost work at UH. Presented at Aiea Public Library as part of a Natural Gardening Workshop for home gardeners. Attendance= 120. *Feb. 25, 1995.*

Environmentally Friendly Vegetable Crops Production, Cable TV Presentation on Educational Channel, Focus in Agriculture presentation, (Video available) *March 16, 1995.*

Effects of composts on yields of vegetable crops, University of Hawaii, College of Tropical Agriculture and Human Resources First Horticulture Conference, *April 5, 1995*

On-Farm Research Strategies for Sustainable Agriculture. Sustainable Agriculture Train-the-Trainers Workshop, Kahului, Maui, June 28, 1995.

Valenzuela, H. and R. Hamasaki. 1995. Effect of composts and synthetic nitrogen fertilizer on growth and nematode infestations in lettuce and basil. Annual Meeting of the Amer. Soc. Hort. Sci. July 30-Aug. 3, 1995, Montreal, Canada.

Sustainable Agricultural Research in Hawaii. Sustainable Agriculture Workshop, Annual Meeting of the American Society for Horticultural Sciences, Montreal, Canada, August 1, 1995.

Train-the-Trainers Grant on Sustainable Agriculture, Was Awarded $89,000 to conduct three 1-week workshops in 1995 to train extension agents and soil specialists from the Pacific Region (Univ. Guam, American Samoa Community College, Northern Marianas College, College of Micronesia, U.S. Soil Conservation Service, and 7 faculty from Univ. Hawaii) in the area of sustainable agriculture.

Sustainable Vegetable Production, as part of the 3rd workshop on the Train-the-Trainers program on Sustainable Agriculture, Kona, Hawaii, *August 29, 1995.*

Sustainable Agriculture Research and Education Programs in Hawaii. Radio Interview in English / Japanese, Radio KZOO, Honolulu, June 18 and Nov. 5, 1995.

Panel Moderator: Techniques for building soil fertility through composts and Cover Crops. 5th WSSA Annual Sustainable Agriculture Conference, Honolulu, HI, Nov. 10, 1995. 400 attendants.

Tour of compost demonstration trials, 1995 WSSA Sustainable Agriculture Conference, tour of compost demonstration trials at the UH Waimanalo Experiment Station, *Nov. 11, 1995*

The use of Sewage sludge and composts for the production of diversified crops. In: Technology Transfer Workshop: Environmental Technologies for Hawaii (UHM Office of Technology Transfer & Economic Development- OTTED). Dec. 4, 1995.

Transition to Sustainable Vegetable Cropping Systems. In: Workshop on Transition to Sustainable Agriculture. Kauai, 6 January 1996.

Composts and Green Manure, 6th WSAA Sustainable Agriculture Conference, Kahului, Maui, 16-17 Nov. 1996.

Nature Farming Research at the Waimanalo Station MOA compost plots Presentation given at the WSAA Sustainable Ag Conference
Hector Valenzuela, Univ. Hawaii at Manoa, Kona Nov. 8, 1997

17. Publications, Research Reports, Field Day Brochures

1) Nature Farming Compost Experiment and Demonstrations. UH Waimanalo Research Station, Jan. 1994.
2) Nature farming compost Field Day and demonstrations. Waimanalo Research Station, June 24, 1994.
3) Valenzuela, H.R. 1994. Effect of composts on leafy lettuce yields. Vegetable Crops Update. 4(1).
4) Valenzuela, H.R., R. Hamasaki, and P.Y. Lai. 1995. Nature farming compost experiment and demonstration: First year results.
5) Valenzuela, H.R. 1995. Nature farming compost and cover crops field day. Nov. 10, 1995.
6) Display of Sustainable Agriculture Farms in Oahu, 3 Video Clips (VIDEO PUBLICATION).
7) Video Record of the Compost and Demonstration Experiments in Waimanalo, 1994-1996 (VIDEO PUBLICATION).

18. Industry Collaborators

Plastic mulch and irrigation supplies- Wisdom Industries
Fertilizer amendments- HGP
Fertilizer chemicals- Brewer Environmental.
Basil seed- Alf Christianson Seed, Mt. Vernon, Wash., Fukuda Seed, and others.