Table 1. Winter lettuce yield and quality results.

| Variety | Avg Plant Wt (oz) | Quality Rating[z] | Bitterness[y] Rating |
|---|---|---|---|
| Salina | 6.6 | 4 | 3 |
| Tango | 9.4 | 2 | 4 |
| Ermosa | 8.3 | 1 | 1 |
| Optima | 8.2 | 3 | 2 |

[z]Varieties were compared for quality (texture and taste), 1 being best and 4 being the least.
[y]Varieties were compared for bitterness starting with 1 being the least and 4 being the bitterest.

Table 2. Spring lettuce yield and quality results.

| Variety | Avg Plant Wt (oz) | Quality[z] Rating | Bitterness[y] Rating | Avg No. Plants Bolting |
|---|---|---|---|---|
| Salina | 4.7 | 5 | 5 | 0.0 |
| Tango | 6.0 | 4 | 6 | 1.1 |
| Ermosa | 9.7 | 1 | 1 | 2.4 |
| Optima | 10.5 | 3 | 3 | 2.8 |
| Nancy | 7.1 | 6 | 4 | 1.5 |
| Green Ice | 7.2 | 2 | 2 | 1.9 |

[z]Varieties were compared for quality (texture and taste), 1 being best and 6 being the least.
[y]Varieties were compared for bitterness starting with 1 being the least and 6 being the bitterest.

### Results and Discussion

This non-circulating hydroponic system proved to be a relatively simple and inexpensive system. It can be used on any level area in the production of short season lettuce crops by homeowners and market gardeners. Once set up the system has little to no maintenance during crop production. Monitoring of solution is not necessary due to the short length of the crop being grown.

All lettuce varieties tested developed an extensive root system that adapted to the change in water level. Results of both winter and spring variety trials (Table 1, Table 2) ranked 'Ermosa' highest in overall quality. Environmental factors that might contribute to bitterness were not monitored. However, varieties were different when compared in taste tests at the end of the trial. 'Salina' showed the best tolerance to bolting in the spring.

The system was shown to several homeowner groups that were touring the Discovery Gardens. Response was very favorable with many expressing interest in setting up similar systems on patios. Major points of interest was that the system had no moving parts, pumps, etc. to maintain.

The potential of this and similar systems for commercial use are being evaluated. Further work is needed to study the productivity of other varieties and longer season vegetable crops. Short season lettuce crops would work well in a market garden or u-pick situations based on the results of this trial.

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# YIELD RESPONSE OF HERBS TO N AND K RATES IN MULTIPLE HARVESTS ON SAND


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*Abstract.* **Italian parsley (parsley), *Petroselinum crispum*, Russian tarragon (tarragon), *Artemisia dracunculus*, sweet marjoram (marjoram), *Origanum majoranna*, and thyme, *Thymus vulgaris*, were evaluated for their yield potential in multiple harvest during fall-winter-spring (Oct.-Mar.) 1994-1995. The herbs were grown with the full-bed polyethylene mulch-seepage irrigation system at three N and K rates, 1×, 2×, and 3× (1× = 44 N and 36 K lb/acre). Phosphorous was applied at 30.5 lb P/ acre with all three N and K rates. Treatments were arranged in a randomized complete block and replicated four times. In the first three harvests, fresh weight of parsley, tarragon and thyme were similar with the 3 N and K rates. In the fourth and fifth harvests, parsley and tarragon yields increased with increasing N and K rates. Marjoram yields were best with the 2× (88 N and 72 K lb/ acre) N and K rate. Plant survival of marjoram and thyme were adversely affected by increasing soil total soluble salt (TSS) concentrations as the season progressed. Nitrogen and K rates had little or no effect on macroelement concentrations in herb shoots.**



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In the United States, herbs are the fastest growing segment of the specialty vegetables (Miller and Harper, 1990; Sit-

Table 1. Average monthly high and low temperatures and rainfall at GCREC-Bradenton from 1954-1995. (Stanley, 1996).

| Month | Temperature Max | Min | Average | Rainfall (in.) |
|---|---|---|---|---|
| | | (°F) | | |
| Jan. | 72 | 50 | 61 | 2.79 |
| Feb. | 74 | 52 | 63 | 3.01 |
| Mar. | 78 | 55 | 67 | 3.45 |
| Apr. | 82 | 60 | 71 | 1.83 |
| May | 87 | 64 | 76 | 2.86 |
| June | 89 | 70 | 80 | 7.96 |
| July | 91 | 72 | 82 | 9.20 |
| Aug. | 91 | 72 | 82 | 9.61 |
| Sep. | 90 | 71 | 81 | 7.76 |
| Oct. | 85 | 64 | 75 | 2.93 |
| Nov. | 79 | 58 | 69 | 1.94 |
| Dec. | 74 | 52 | 63 | 2.22 |

uation and Outlook Yearbook, 1997). For example, the domestic and imported shipments of miscellaneous herbs and parsley increased from 481 thousand cwt in 1993 to 690 thousand cwt in 1996. Import shipments alone increased from 227 thousand cwt in 1993 to 473 thousand cwt in 1996. The growing consumption of herbs is related to changes in the culinary habits in the USA. The greatest demand for herbs (fresh and dry) is during the Nov. to May market season (Calderin, 1989). Climatic condition in west central Florida should be favorable for herb production during this period (Table 1). In previous studies conducted in west central Florida, yields depended on the planting dates (Csizinszky, 1992; Csizinszky, 1993). for example, basil (*Ocimum basilicum* L.) had a higher yield in a Mar. than in a Jan. planting. On the other hand, Italian parsley (*Petroselinum crispum* L. *var. neapolitanum*), common marjoram (*Origanum majoranna.*), anise (*Pimpinella anisum* L.) and dill (*Anethum graveolens* L.) yields were better in a Dec. than in a March planting (Csizinsky, 1992; Csizinsky, 1993). There is little information available on the optimum fertilizer rates for herbs, therefore, a study was conducted to evaluate several herbs for their yield potential at various N and K rates with the full-bed polyethylene mulch production system.

## Material and Methods

The study was conducted during the winter-spring (Dec.-Apr.) 1993-94 at the Gulf Coast Research and Education Center, Bradenton, FL. Soil was an EauGallie fine sand and the production system was the full-bed polyethylene mulch with seepage (modified furrow) irrigation (Geraldson et al., 1965). The experimental design was the split-plot, arranged in a randomized complete block with four replications. Main plots, 40-ft long and 5-ft wide, established on 32-inch wide and 8-inch high beds, were four herbs: Sweet-marjoram, Italian parsley, French thyme (*Thymus vulgaris* L.) and Russian tarragon (*Artemisia dracunculus* L.) Subplots, 10-ft-long and 5-ft wide were three N and K rates, 1×, 2×, and 3×, where 1× N and K was equivalent to 44 N and 36 K lb/acre [acre = 8712 linear bed feet (lbf). Nitrogen and K sources were $NH_4NO_3$ and $KNO_3$. Phosphorous from a 0-8.74-0 (N-P-K) superphosphate was applied at 30.5 lb P/acre in all N and K treatments. The superphosphate also contained 13.9 lb/acre of micronutrient frit (F503 oxide). The superphosphate was placed in an 8-inch wide band on the false bed, and $NH_4NO_3$ and $KNO_3$ were applied in a narrow, 2-inch deep furrow in the bed center. Beds were fumigated with methyl bromide: chloropicrin (66.6:33.3) at 238 lb/acre and covered with a black polyethylene film. Two weeks after fumigation, on 22 Dec. 1993, seedlings of the four herbs, raised in 1-inch cell size planter trays, were transplanted in the field. Seedings were set in double rows, 6 inches from the center on each half of the bed at 6.5 inch within-row spacing. In addition to the four herbs above, summer savory (*Satureja hortensis* L.) was also planted at the three N and K rates in one main plot only for observation. Pesticides were not applied during the season, but the plants were inspected weekly for the presence of insects and apparent disease symptoms. Plants were harvested from a 5-ft long section in the center of each plot and fresh weight was recorded. Dry matter in shoots was determined by the AOAC methods (Assoc. Agr. Chem., 1980), N by the Kjeldahl method with the Kjeltic System (Tector, Inc. 1987) and other elements at the IFAS Analytical Research Laboratory at the University of Florida (Hanlon and deVore, 1989). Total soluble salts (TSS) and pH in the soil were determined from the water extract (Geraldson, 1967). Data were analyzed by ANOVA (SAS Institute, 1988). When significant F values were found, a regression analysis was performed on the N and K-rates.

## Results and Discussion

Plants had no apparent disease symptoms during the season. Aphids (*Aphididae*), whiteflies (*Bemisia* sp.), leafminer (*Lyrioniyzae* sp.), and mites (*Myzus* sp.) were observed on the plants from late January. Whiteflies and mites were most numerous on the marjoram, aphids and leafminers on the tarragon. Leafminers were observed only on the older leaves of the parsley. Thyme, apart from a few whiteflies, was free of insects. Whiteflies and aphids are known vectors for plant pathogenic viruses (Yokomi et al., 1990; Polston et al., 1993). Since there are no insecticides labeled for use on herbs, it is important to grow herbs and finish their harvest before vegetables, which may be susceptible to the insect-transmitted virus diseases, are planted in nearby fields.

Seed germination and seedling development were very slow for all five herbs (Table 2). In our previous studies, herbs also required over 60 days to reach transplantable size (Csizinszky, 1992). In the field, parsley reached marketable stem length in 36 days, while French thyme, which had the slowest growth among the herbs, needed 57 days from transplanting to first harvest (Table 2).

Fresh weight yield of marjoram in the first harvest was higher with the 1×, than with 2× or 3× N and K rates (Table 3). For the season, however, marjoram yields were best with the 2× N and K rate. Parsley yields were similar with all 3 N

Table 2. Growing period of herbs and number of harvests during winter-spring 1993-94.

| | Herb: Sweet marjoram | Italian parsley | Summer savory | Russian tarragon | French thyme |
|---|---|---|---|---|---|
| Days from seeding to transplanting[z] | 72 | 72 | 72 | 72 | 72 |
| Days from transplanting to first/last harvest | 42/120 | 36/120 | 41/93 | 41/120 | 57/120 |
| Number of harvests | 4 | 5 | 3 | 5 | 3 |

[z]Transplanted: 22 Dec. 1993.

Table 3. Cumulative fresh weight yields of herbs in multiple harvests.

| N and K Rate[z] | Harvest 1 | 1-2 | 1-3 | 1-4 | 1-5 |
|---|---|---|---|---|---|
| | (lb/acre) | | | | |
| Sweet marjoram | | | | | |
| 1× | 946 | 1861 | 4954 | 8149 | |
| 2× | 568 | 2039 | 4905 | 9935 | |
| 3× | 688 | 1214 | 4089 | 7023 | |
| Signif.[y] | Q* | L*Q* | ns | Q* | |
| Italian parsley | | | | | |
| 1× | 1999 | 5043 | 8761 | 14,140 | 14,140 |
| 2× | 2016 | 5144 | 9134 | 18,885 | 24,988 |
| 3× | 1845 | 4882 | 8998 | 20,046 | 26,443 |
| Signif.[y] | ns | ns | ns | L* | L*Q* |
| Russian tarragon | | | | | |
| 1× | 1214 | 2643 | 3563 | 8327 | 12,638 |
| 2× | 1195 | 2439 | 3323 | 8484 | 15,284 |
| 3× | 1396 | 2687 | 4138 | 8015 | 16,988 |
| Signif.[y] | ns | ns | ns | ns | L*Q* |
| French thyme | | | | | |
| 1× | 1194 | 3676 | 5377 | | |
| 2× | 1272 | 4161 | 6062 | | |
| 3× | 1241 | 4008 | 5764 | | |
| Signif.[y] | ns | ns | ns | | |
| Summer savory[x] | | | | | |
| 1× | 209 | 296 | 505 | | |
| 2× | 366 | 767 | 767 | | |
| 3× | 192 | 279 | 331 | | |

[z]N and K rate: 1× = 44 N and 36 K lb/acre (acre = 8712 linear bed ft).
[y]Significance is linear (L) or quadratic (Q) at P ≤ 0.05 (*) or non-significant (ns).
[x]Observation only.

Table 4. Cumulative dry weight yields of herbs in multiple harvests.

| N and K Rate[z] | Dry Matter (%) | Harvest 1 | 1-2 | 1-3 | 1-4 | 1-5 |
|---|---|---|---|---|---|---|
| | | (lb/acre) | | | | |
| Sweet marjoram | | | | | | |
| 1× | 13.07 | 124 | 243 | 647 | 1065 | |
| 2× | 13.40 | 76 | 273 | 657 | 1331 | |
| 3× | 13.51 | 93 | 164 | 552 | 1070 | |
| Signif.[y] | ns | L* | L*Q* | ns | Q* | |
| Italian parsley | | | | | | |
| 1× | 12.88 | 257 | 650 | 1128 | 1821 | 1821 |
| 2× | 12.44 | 251 | 640 | 1136 | 2349 | 3109 |
| 3× | 12.88 | 238 | 629 | 1159 | 2582 | 3406 |
| Signif.[y] | ns | ns | ns | ns | L* | L&Q* |
| Russian tarragon | | | | | | |
| 1× | 18.32 | 222 | 484 | 653 | 1526 | 2315 |
| 2× | 18.02 | 215 | 440 | 599 | 1529 | 2754 |
| 3× | 18.34 | 256 | 493 | 759 | 1470 | 3116 |
| Signif.[y] | ns | ns | ns | ns | ns | L* |
| French thyme | | | | | | |
| 1× | 10.76 | 128 | 396 | 579 | | |
| 2× | 11.02 | 140 | 459 | 668 | | |
| 3× | 10.33 | 128 | 414 | 595 | | |
| Signif.[y] | ns | ns | ns | ns | | |
| Summer savory[x] | | | | | | |
| 1× | 11.28 | 24 | 33 | 57 | | |
| 2× | 11.02 | 40 | 85 | 85 | | |
| 3× | 12.45 | 24 | 35 | 41 | | |

[z]N and K rate: 1× = 44 N and 36 K lb/acre (acre = 8712 linear bed ft).
[y]Significance is linear (L) or quadratic (Q) at P ≤ 0.05 (*) or non-significant (ns).
[x]Observation only.

and K rates in the first three harvests, then yields increased linearly with increasing N and K rates. Tarragon yields were also similar in the first four harvests, but for the season yields were best with the 3× N and K rate. Thyme yields were similar with the N and K rates, however, there was a trend toward higher yields with the 2× N and K rate. Summer savory in the observational plot also had a higher yield with the 2×, than with the 1× or 3× N and K rates (Table 3). Dry weight yields of herbs followed similar patterns to the fresh weight yields for all five crops (Table 4).

Plant survival of marjoram and thyme was very poor by the last harvest (Table 5). Plant stand of both thyme and marjoram decreased as total soluble salts (TSS) in the soil increased with N and K rates. Tarragon and parsley plant survivals were affected only slightly by soil TSS concentrations. However, at the last harvest on 21 April, 100% of the parsley plants with the 1× N and K rate, 86% of the plants with the 2× N and K rate, and 73% of the plants with the 3× N and K rate had chlorotic leaves and were judged as non-marketable. The chlorosis was not observed on the parsley at the 4th harvest (in Mar.) and shoot samples collected on that date, had adequate concentrations of macronutrients (Table 5) It is possible therefore, that parsley, when grown for longer that 90 days for multiple harvest, requires a higher N rate that the 132 lb N per acre applied with the 3× N and K treatment in this study. Nitrogen concentrations in thyme shoots at the 1× N and K rate were also less that 2%, and some of the plants had light green color that indicated N-deficiency in the leaves. Phosphorous concentrations in parsley shoots increased with increasing N and K rates, and Ca concentrations in thyme shoots decreased as K concentration increased (Table 6). All

Table 5. Soil total soluble salt (TSS) concentrations (ppm) and survival of herbs at last harvest.

| | Plant | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sweet marjoram | | Italian parsley | | Russian tarragon | | French thyme | |
| N and K Rate[z] | TSS (ppm) | Plant Stand (%) | TSS (ppm) | Plant Stand (%) | TSS (ppm) | Plant Stand (%) | TSS (ppm) | Plant Stand (%) |
| 1× | 2760 | 21 | 2150 | 100 | 2330 | 100 | 3310 | 32 |
| 2× | 3350 | 39 | 2470 | 100 | 2830 | 94 | 3470 | 22 |
| 3× | 4660 | 7 | 3150 | 98 | 5940 | 97 | 5510 | 20 |
| Signif.[y] | L* | L*Q* | L* | ns | L* | ns | L* | L* |

[z]N and K rate: 1× = 44 lb N and 36 lb K/acre (acre = 8712 linear bed ft).
[y]Significance is linear (L) or quadratic (Q) at P ≤ 0.05 (*) or non-significant (ns).

Table 6. Macroelement concentration in herb shoots at 93 days after planting.[z]

| N and K Rate[y] | N | P | K | Ca | Mg |
|---|---|---|---|---|---|
| | | | (% DW)[x] | | |
| Sweet marjoram | | | | | |
| 1× | 3.35 | 0.41 | 3.51 | 1.37 | 0.56 |
| 2× | 3.95 | 0.45 | 4.22 | 1.72 | 0.61 |
| 3× | 3.47 | 0.38 | 3.33 | 1.46 | 0.49 |
| Signif.[w] | ns | ns | ns | ns | ns |
| Italian parsley | | | | | |
| 1× | 2.43 | 0.37 | 4.74 | 1.52 | 0.41 |
| 2× | 3.26 | 0.45 | 5.27 | 1.43 | 0.44 |
| 3× | 3.63 | 0.47 | 5.29 | 1.41 | 0.47 |
| Signif.[w] | L* | L*Q* | ns | ns | ns |
| Russian tarragon | | | | | |
| 1× | 2.94 | 0.34 | 3.21 | 1.02 | 0.63 |
| 2× | 2.91 | 0.36 | 3.59 | 1.21 | 0.67 |
| 3× | 2.76 | 0.31 | 3.08 | 1.17 | 0.59 |
| Signif.[w] | ns | ns | ns | ns | ns |
| French thyme | | | | | |
| 1× | 1.54 | 0.40 | 3.16 | 1.01 | 0.37 |
| 2× | 2.02 | 0.40 | 3.20 | 0.90 | 0.34 |
| 3× | 3.32 | 0.38 | 3.54 | 0.82 | 0.40 |
| Signif.[w] | L* | ns | ns | L* | ns |
| Summer savory[v] | | | | | |
| 1× | 5.01 | 0.51 | 3.69 | 1.50 | 0.68 |
| 2× | 5.21 | 0.54 | 4.34 | 1.54 | 0.69 |
| 3× | 4.68 | 0.53 | 3.96 | 1.72 | 0.67 |
| Signif.[w] | — | — | — | — | — |

[z]Planted: 22 Dec. 1997.
[y]N and K rate: 1× = 44 lb N and 36 lb K/acre.
[x]DW = dry weight.
[w]Significance is linear (L) or quadratic (Q) at $P \leq 0.05$ (*) or non-significant (ns).
[v]Observation only.

other elemental concentration in the herbs in this study were similar with the three N and K rates.

In summary, herbs in this study grew very slowly and required just over 10 wk in the greenhouse from seeding to transplant stage. For up to three harvests, at 14 to 21 day intervals, herbs in the full-bed polyethylene mulch system can be grown with 44 lb N and 36 lb K/acre without reducing fresh or dry yields. For longer harvest periods, sweet marjoram required 88 lb N and 72 lb K/acre and Italian parsley required 132 lb N and 108 lb K/acre for the increased yields. As with other crops, the cost of extra fertilizers against the expected benefits from higher yields have to be considered by the grower when deciding N and K rates for herbs in multiple harvests.

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