Reduced Input Production of Herbs under Sub-Tropical Conditions in Florida

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Keywords: Sweet marjoram, *Origanum majoranna,* Italian parsley, *Petroselinum crispum,* full-bed polyethylene mulch, micro irrigation, compost rates

Abstract

Sweet marjoram, *Origanum majoranna* and Italian parsley, *Petroselinum crispum* var. *neapolitanum* were grown from 1997 to 1999 in light sandy soil using the full-bed polyethylene mulch-microirrigated production system. Experimental design was a split-plot replicated three times. In the main plots the herbs were grown with (FER) or without (NFE) injected nitrogen and potassium fertilizers. Sub-plots were 0.0, 4.5, 9.0 and 18.0 Mt/ha compost applied in a narrow band under the micro-irrigation tubing. In 1997-98 herbs were planted on 17 December and in 1998-99 on 22 October. Yields were evaluated in multiple harvests. Early yields (first two harvests) of sweet marjoram were similar with NFE or FER treatments with or without compost. In later harvests, yields increased with FER treatment and with increasing compost rates. Seasonal total yields of Italian parsley also increased with N and K applications and increasing compost rates. Length of growing season was shorter and yields, especially sweet marjoram yields, were lower in the December than in the October planting. Nitrogen and K applications had little or no effect on macro- and microelement concentrations in herb shoots. In the sill, very high P concentrations were found with 9.0 and 18.0 Mt/ha compost rates.

INTRODUCTION

In the United States of America (USA) herbs for culinary use are the fastest growing segment of specialty vegetables (U.S. Dept. Agr. Economics Res. Service, 1997). Consumer demand is also increasing for horticultural products that were grown with nutrients supplied from organic sources (U.S. Federal Register, 1997). The greatest demand for herbs is from November to May market season, a time period when climatic conditions in Florida should be favorable for field production of herbs (Csizinszky, 1992). Organic fertilizers are also available for growers, since 1.7 million tons of municipal solid waste (MSW) are processed into compost or mulched annually in Florida (Florida Dept. Environmental Protection, 1998).

In previous studies conducted in west-central Florida, timing of field planting was critical for survival rate and yield of herbs (Csizinszky, 1992; Csizinszky, 1993). For example, anise (*Pimpinella anisum*) and dill (*Anethum graveolens*) had a higher survival rate thus higher yields when planted in December than in March, but sweet basil (*Ocimum hasilicum*) survival rate and yields were higher in a March than in a January planting.

The light sandy soils in west-central Florida have low cation-exchange and water holding capacity and the retention of nutrients in the soil. In studies with fresh-market tomatoes, *Lycopersicon esculentum* Mill (tomatoes) conducted on a light sand with 5.0, 10.0 and 15.0 Mt/ha compost which was applied in a narrow band under the micro- (drip-) irrigation tubing early yields were highest with 5.0 Mt/ha compost or with injected nitrogen and potassium fertilizers and no compost control (Csizinszky and Stanley, 1998). Seasonal total yields however were highest with 10.0 Mt/ha compost plus injected liquid fertilizers.

There are no published reports on herb production with organic soil amendments in Florida. Experiments were conducted therefore to investigate the yield response of herbs to compost rates with and without injected liquid fertilizers.

Proc. XXVI IHC – Future for Medicinal and Aromatic Plants
Eds. L.E. Craker et al.
Acta Hort. 629, ISHS 2004
Publication supported by Can. Int. Dev. Agency (CIDA)

MATERIALS AND METHODS

Experiments were conducted during the winter-spring (December-May) 1997-98 and fall-spring (October-May) 1998-99 at the University of Florida Gulf Coast Research and Education Center, Bradenton, FL (latitude 27°30'N, longitude 82°30'W). Soil was an Eau Gallic fine sand (sandy siliceous hyperthermic Alfic Haplaquods) with a sodic horizon at 86 cm (U.S. Dept. Agr., 1980). Production system was the full-bed polyethylene mulch (Geraldson et al., 1965) with micro-(drip-) irrigation. Soil samples taken prior to land preparation in both seasons were extracted with Melich I extract (Hanlon et al., 1990) then analyzed for macro- and microelements at the Analytical Research Laboratory of the University of Florida at Gainesville (Table 2). Nitrogen in the soil was determined on the water extract by the Kjeldahl method (Tecator, Inc., 1987). In 1997, the soil pH was adjusted by dolomite that was applied at the equivalent of 976 kg/ha. Plots were established on 81-cm wide and 20-cm high beds formed on 152 cm centers. Experimental design was a split-plot replicated three times. Main plots, each 20.56 m long and 1.52-m wide, were two N and K applications, sub plots, each 5.14-m row and 1.52-m wide were four compost rates and sub-sub plots each 2.57-m long were two herbs: Italian parsley (parsley) and sweet marjoram (marjoram). In one of the main plots (FER) nitrogen and potassium were applied for the herbs from a liquid 4-0-3.32 (N-P-K) fertilizer, injected at a rate of 0.77 kg/ha N and 0.64 kg/ha K per day through the micro irrigation tubing. In the second main plot (NFE) plants were grown without nitrogen and potassium fertilizers. In the sub-plots `Disney World' compost (NutriSource, Inc., Orlando, FL) (Table 3) was applied at four rates: Ox, lx, 2x, and 4x(lx=4.5 Mt/ha fresh wt; and ha=6579 linear m of mulched bed). Feedstocks for the compost were garden trimmings, food waste, animal manure and sewage sludge. The compost was banded in the center of the pre-bed, then beds were formed and micro irrigation tube (T-tape, 20 cm emitter spacing; 2.5 I/min. flow-rate/30.5 m tube length at 0.56 kglcm^2 pressure) was laid in the bed center above the compost band in a narrow 5-cm deep furrow. Soil was fumigated with methyl bromide:chloropicrin (2:1 v/v) at 257 kg/ha and then covered with a black 0.032 mm thick polyethylene film.

Two weeks later, on 17 December 1997 and on 27 October 1998, marjoram and parsley seedlings (raised in planter trays with 38 mm x 38 mm x 63.5 mm inverted pyramid cells) were transplanted to the field in double rows in the bed at 30.5 cm between-and 18cm within row spacing. Soil moisture at 15 cm in the beds was monitored by tensiometers (irrometer Co., Riverside, CA). Pesticides were not applied on the herbs but plants were inspected periodically for the presence of insects and apparent disease symptoms. Plants were harvested from a 1.5-m long section in the center of each plot when the stems reached marketable length (U.S. Dept. Agr., 1986) and fresh weight was recorded.

Nitrogen concentration in the shoots was determined by the Kjeldahl method with the Kjeltic System (U.S. Dept. Agr., 1986) and other elements at the IFAS Analytical Research laboratory at the University of Florida (Hanlon and deVore, 1989). Data were analyzed by ANOVA (SAS Institute, Inc., 1988). When significant F values were found a regression analysis was performed on the compost rates.

RESULTS AND DISCUSSION

In 1997-98 average monthly maximum and minimum temperatures were near the 45 yr average for the area (Table 1). Rainfall was above the average from December 1997 to March 1998 followed by *very* little rain in April and May. In the 1998-99 experimental period monthly maximum temperatures except for May were above the average. Rainfall, except in November 1998 and January 1999, was below the average. Freezing temperatures were not recorded during the two experimental periods. Plants had no apparent disease symptoms or insect damage during the two seasons, but root knot nematodes (*Meloidogyne* sp) were detected on parsley roots at the end of both seasons.

Length of growing season was shorter in 1997-98 when the herbs were transplanted in December than in the October planting in 1998-99 and marketable stem lengths of the herbs, 18-25 cm for marjoram and 21-25 cm for parsley, were reached earlier in the December than in the October planting (Table 4).

Cumulative fresh weight yields of marjoram in the first two harvests in both seasons were similar with all treatments (Table 4). Seasonal total yields in 1997-98 were lower P'<0.05) in the NFE treatment with 0.0, 4.5 and 9.0 Mt/ha compost than in the FER treatment with or without compost amendment. Yields in the FER treatment with 0.0 Mt/ha compost and in the NFE treatment with 18.0 Mt/ha compost were similar to yields with FER treatment and 4.5, 9.0 or 18 Mt/ha compost. In the 1998-99 study, marjoram yields for the season were higher in the FER treatments with or without compost than in the NFE treatments. Highest yield, 24.9 Mt/ha, was recorded with the FER treatment and 18.0 Mt/ha compost.

Early yield of parsley in the 1997-98 season was highest ($P<0.05$) in the FER treatment with 18 Mt/ha compost (Table 4). Seasonal total yield (5 harvests) was highest in the FER treatment with 18 Mt/ha compost, but it was similar to yields in the FER plots with 4.5 or 9.0 Mt/ha compost. In 1998-99 early yields of parsley were similar with 9.0 or 18.0 Mt/ha compost with or without FER treatment (Table 4). Seasonal total yield was greater with FER and 18 Mt/ha compost, than with any other treatment.

Elemental concentrations in the herb shoots were similar in both seasons, therefore only the 1997-98 analytical results are presented. Nitrogen and potassium applications and the interaction of nitrogen and potassium applications with compost rates had little or no effect on macro element concentrations in the herbs (data not presented).

There were small but significant differences in dry matter and macro element concentrations in the herb shoots (Table 5). In the marjoram, dry matter concentration was quadratic, higher concentration ratio were found at 4.5 and 9.0 Mt/ha than at 0.0 or 18.0 Mt/ha compost. Nitrogen, P, K and Ca concentrations also had quadratic trends but elemental concentrations were lower at 4.5 and 9.0 Mt/ha than at 0.0 or 18.0 *Mt/ha compost.* Magnesium concentrations in the marjoram shoots increased linearly with increasing compost rates.

In the parsley shoots dry matter, K and Ca concentrations decreased while P and Mg concentrations increased linearly with increasing compost rates (Table 5). Nitrogen concentrations were higher at 0.0 and 18.0 Mt/ha than at 4.5 or 9.0 Mt/ha compost.

Among the microelements, Mn concentrations in both marjoram and parsley shoots increased with compost rates (Table 5). All other micronutrient concentrations were similar in both herbs with compost rates or N and K applications (data not presented).

In the soil, pH was lower in the FER than in the NFE plots (Table 6). Electrical conductivity (EC) and the concentrations of all macroelements analyzed were similar with or without nitrogen and potassium applications. Concentrations of pH decreased while EC and macroelemental concentrations except Ca increased linearly with increasing compost rates. Among the macroelements, very high P concentrations were found in the soil especially at the 9.0 and 18.0 Mt/ha compost rates. Potassium concentrations were in the very low range at 0.0 and 4.5; in the low range at 9.0 and in the medium range at 18.0 Mt/ha compost rate (Hanlon et al., 1990).

Micro-elemental concentrations in the soil, except Fe, were similar at the four compost rates (data not presented). Iron concentrations increased linearly with increasing compost rates and were (in mg/kg) 39.0, 38.5, 56.5, and 58.5 respectively at 0.0, 4.5, 9.0 and 18.0 Mt/ha compost. Nitrogen and potassium applications, herbs and treatment interactions had no significant effect on micronutrient concentrations in the soil (data not presented).

The observed differences in the length of growing season, number of harvests, fresh weight yields and in the amounts of nitrogen and potassium fertilizers applied for the herbs between the December 1997 and October 1998 plantings indicate the importance of selecting the proper planting time under the environmental conditions of west-central Florida. Both herbs in the studies had a longer growing reason and higher N and K application rates that resulted in higher fresh weight yields in the October than in the December planting. The only exceptions to higher fresh weight yields in the longer growing season and with higher N and K applications were the seasonal total yields of parsley in the NFE plots with 4.5 Mt/ha compost, and in the FER plots with 0 Mtlha compost (Table 4).

Yield differences in the first two harvests between the NFE and FER treatments with or without compost were small. Therefore, when the herbs are harvested only one or two times, 9.0 Mt/ha compost without additional inorganic fertilizers or inorganic fertilizers without compost may be used for satisfactory yields. However, when market demands require longer growing periods then compost should be used at a higher rate or in combination with supplemental fertilizers to maintain yields at an economical level.

The high concentrations of P and Fe in the soil with increasing compost rates indicate the difficulty in controlling the quantity and balance of essential plant nutrients that are applied from the compost. It is important therefore to select a compost for crop production that has a balanced concentration of essential macro and microelements.

In summary, with the full bed polyethylene mulch-micro-irrigation system, 4.5 to 9.0 Mt/ha compost applied in a narrow band under the micro-irrigation tubing, may be used without additional nitrogen and potassium fertilizers for herb production when the herbs will be *harvested* once or twice during the season. During longer harvest periods, nutrients for the crops can be supplemented from injected liquid fertilizer sources or higher compost rates to maintain yields.

ACKNOWLEDGEMENTS

Florida Agricultural Experiment Station Journal Series No.

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Tables

Table 1. Average monthly temperatures and rainfall during the herb growing periods at the GCREC-Bradenton, FL, USA.

Month	1997-1998 [z]			1998-99 [y]			45-yr average		
	Max.	Min.	Rain	Max.	Min.	Rain	Max.	Min.	Rain
	---- (°C)----		mm	----(°C)----		mm	----(°C)----		mm
January	22.8	11.7	261	25.0	11.7	94	22.2	10.0	72
February	22.8	11.1	150	25.0	11.1	13	23.3	11.1	75
March	24.4	12.2	207	26.1	10.0	25	25.0	12.8	86
April	27.8	15.0	3	30.0	16.1	14	27.8	15.6	45
May	31.1	18.3	12	29.9	18.7	2	30.6	18.3	82
June	---	---	---	---	---	---	32.2	21.1	195
July	---	---	---	---	---	---	32.8	22.2	233
August	---	---	---	---	---	---	32.8	22.2	244
September	---	---	---	---	---	---	32.8	22.2	204
October	---	---	---	31.1	19.4	0	29.4	17.8	77
November	---	---	---	28.3	16.1	69	26.1	14.4	51
December	22.2	12.1	110	26.1	13.3	26	23.3	11.1	58

[z] 17 Dec. 1997 to 11 May 1998.
[y] 22 Oct. 1998 to 20 May 1999.

Table 2. Pre-plant pH, total soluble salts (TSS) and elemental concentrations in the soil. Macro element.

Year	pH	TSS	Macroelement					
			NH_4+	NO_3-	P	K	Ca	Mg
			(mg/kg)					
1997	5.03	434	3.7	2.1	55.3	3.7	508.0	41.7
1998	6.01	266	0.7	0.9	39.8	15.1	586.0	24.2

	Microelement				
	Al	Cu	FE	Mn	Zn
1997	36.0	11.0	18.2	5.1	12.2
1998	39.9	11.9	8.5	3.8	11.3

Table 3. Concentrations of selected elements in 'Disney World' compost and their amounts applied for herbs from the compost.

		Compost applied (t/ha)[1]		
		4.5	9.0	18.0
Element	g/kgDW[2]	Element applied (kg/ha)		
N	34.0	74.0	148.0	296.0
P	18.7	40.7	81.4	162.8
K	8.9	19.4	38.8	77.6
Ca	21.0	45.7	91.4	182.8
Mg	3.4	7.4	14.8	29.6
Al	2.650	5.77	11.50	23.08
B	0.037	0.08	0.16	0.32
Cu	0.251	0.55	1.10	2.20
Fe	8.850	19.28	38.56	77.12
Mn	0.232	0.51	1.02	2.04
MO	0.014	0.03	0.06	0.12
Zn	0.232	0.51	1.02	2.04

[1]Moisture: 51.6%; C:N=22.1. [2] DW=dry weight.

Table 4. Interaction of N and K treatments and compost rates on the cumulative yields of sweet marjoram and Italian parsley and the amounts of N and K applied to harvest dates.

		Sweet marjoram				Italian parsley			
		1997-1998 Harvest		1998-1999 Harvest		1997-1998 Harvest		1998-1999 Harvest	
		1-2	2-5	1-2	1-6	1-2	1-5	1-2	1-5
	Compost	DAT[1]		DAT[1]		DAT[1]		DAT[1]	
N&K[2]	Mt/ha	69	145	76	210	63	111	77	177
		mt/ha							
NFE	0.0	1.9	8.5	3.4	11.6	4.0	9.0	5.0	14.7
NFE	4.5	2.1	7.6	2.8	12.1	6.8	12.0	4.5	12.4
NFE	9.0	2.9	9.9	4.0	15.3	8.8	15.6	6.2	18.9
NFE	18.0	3.1	11.2	3.3	14.2	7.3	13.1	7.0	23.1
FER	0.0	3.2	15.9	3.9	22.2	7.8	20.4	4.6	20.2
FER	4.5	3.0	15.5	3.0	19.3	10.1	23.9	5.6	25.4
FER	9.0	3.1	16.2	3.0	22.9	9.5	24.1	6.0	27.7
FER	18.0	3.2	16.3	3.1	24.9	12.6	28.9	6.7	36.9
LSD 0.05[3]		ns	5.2	ns	2.4	1.9	5.9	1.1	6.7
		N and K applied (Kg/ha) in the FER treatment							
N		33.8	102.0	37.4	161.0	28.6	73.6	45.7	133.0
K		28.1	84.7	31.0	133.7	23.8	61.1	37.9	110.4

[1] DAT=days after transplanted to field (17 Dec. 1997; 27 oct. 1998).
[2] N and K: NFE=not fertilized; FER=fertilized with N and K from liquid fertilizer.
[3] LSD is significant at P <0.05 or non-significant (ns).

Table 5. Dry matter (DM) and elemental concentrations in herb shoots at four compost rates. 1997-1998.

Compost rate	DM	N	P	K	Ca	Mg	Mn
		Element					
(Mt/ha)	(%)	(g/100 g dry wt)[1]					(mg/kg)[1]
Sweet marjoram							
0.0	15.50	3.25	0.39	2.82	1.45	0.33	25
4.5	16.03	3.09	0.37	2.56	1.33	0.37	42
9.0	16.12	2.85	0.36	2.55	1.31	0.36	42
18.0	15.19	3.35	0.39	2.70	1.44	0.39	56
Signif.P<0.05[2]	Q	Q	Q	Q	Q	L	L
Italian parsley							
0.0	14.60	3.68	0.49	4.38	1.72	0.50	54
4.5	14.63	3.31	0.53	3.60	1.68	0.53	78
9.0	14.26	3.56	0.55	3.70	1.70	0.55	69
18.0	13.63	4.19	0.55	3.60	1.49	0.59	96
Signif P<0.05[2]	L	Q	L	L	L	L	L

[1] Averaged over two N and K treatments and three replications.
[2] Signif. P<0.05=significance is linear (L), quadratic (Q) or non-significant (ns.).

Table 6. pH, total soluble salts (TSS) and macro elemental concentrations in the soil at first harvest. 1997-1998.

Treatment	pH	EC	NH_4-N	NO_3-N	P	K	Ca	Mg
			Element					
N and K[1]	(MS/Cm)		(mg/kg')					
NFE	6.73	0.46	1.7	2.0	102.0	20.1	712.0	83.0
FER	6.55	0.57	2.1	4.7	112.0	24.5	773.0	84.0
$LSD_{0.05}$[2]	0.11	ns	ns	ns	ns	ns	ns	ns
Compost (Mt/ha)								
0.0	6.90	0.33	1.1	1.1	85.0	11.2	781.0	70.0
4.5	6.68	0.41	1.5	2.5	91.0	15.8	642.0	81.0
9.0	6.56	0.54	2.0	4.1	118.0	24.7	759.0	86.0
18.0	6.43	0.78	3.0	5.8	134.0	37.6	789.0	97.0
Signif.[3]	L*	L*	L*	L*	L*	L*	L*	L*
Herb								
Sweet marjoram	6.65	0.55	1.9	1.8	109.0	27.3	751.0	82.0
Italian parsley	@		1.8	3.9	103.0	14.3	759.0	85.0
$LSD_{0\ 05}$[2]	ns	0.08	ns	0.9	ns	8.2	ns	ns

[1] N and K:NFE=not fertilized; FER=fertilized with N and K from liquid fertilizer.
[2] LSD is significant or non-significant (ns) at P<0.05.
[3] Signif.: significance is linear (L) or non-significant (ns) at P<0.05.