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FIELD FERTILIZATION TRIALS OF FOUR SELECTED SPICES

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ABSTRACT

Dry matter yield (DMY) is one of several important factors to consider in developing spices as a commercial field-grown crop. The objective of the experiments conducted with 4 species is to determine the effects of N, K, and micronutrients (alone and in combination) on the DMY of the spices. The spices under consideration are Ocimum basilicum (sweet basil), Origanum majorana (sweet marjoram), Origanum onites (pot marjoram), and Origanum vulgare (orógano). Field fertilization trials were established at the University of Florida involving four levels of N and three levels of K in a complete factorial design, and one level of a micronutrient package. Regression analysis of DMY indicates that spices responded most favorably to 168 and 252 kg N ha^{-1} in combination with 168 kg K ha^{-1} or alone, depending on the species. Plants responded poorly to K treatments when not in combination with N. Highest DMY of pot marjoram was obtained when micronutrients were applied in combination with N and K.

INTRODUCTION

The United States is currently the world's largest consumer of spices, and yet only a small percentage of those spices are produced domestically. The total consumption of spices in the U.S. is 282,000 metric tons, or over 1 kg dry weight per person per year (Landes, 1987). Americans spend almost 2 billion dollars annually on spices (Burns, 1985). Investigations have shown that per capita spice consumption is inelastic, with increases in demand stemming from rises in population (Landes, 1987). The U.S. is potentially a large market for any spice producer, foreign or domestic. Most of the world's spice production takes place in the Mediterranean countries of Europe. For farmers in these countries, spice trade has been an important part of their economic well-being for centuries. It has been shown through survey that the sale of herbs and spices is a primary source of income for many small farmers in St. Thomas and St. Croix, the U.S. Virgin Islands (French, personal communication).

There is very little research currently being conducted concerning the production of these spices. Research is the first step to estimating economic benefit to farmers in the U.S. and the Caribbean. Development of nutrient response models is an important part of improving spice production under varying environments. Dry matter yield, presented in this paper, will be used in part for the development of nutrient response models.

MATERIALS AND METHODS

Research Site

Four individual experiments were conducted on Gross Arenic Paleudult soils at the University of Florida's Green Acres Research Unit, which is located 13 miles west of Gainesville. Field pH was on average 6.4. Pre-transplant blanket application of magnesium sulfate as Epsom salts was performed at a rate of 224 Kg ha^{-1}. Water was applied with overhead irrigation as needed throughout the growing season. Weeding was done by hand and with rototiller throughout the year.

Experimental Design

The four experiments were conducted using a randomized complete block design, with 14 treatments and 4 replications per species. The N, K, and NK treatments were arranged in a 3x4 complete factorial with a micronutrient package added at 2 separate NK levels. Sixteen plants per treatment plot per species were transplanted in a 4x4 plant arrangement, 30 cm on center, each plot being 1.44 m^2.

Fertilizer Treatments

Fertilization treatments were the same for all species (Table 1). Nitrogen was supplied as ammonium nitrate (34% N), potassium as muriate of potash (51% K), and micronutrients as a package at a rate of 67 Kg ha^{-1} (see Table 1 for amount of individual micronutrients applied). Fertilizer was mixed with 250 g sand and applied by hand to individual treatment plots. Four split applications were applied, the first after transplant with subsequent applications after each harvest, or every 8 wks, whichever came first. A fifth fertilizer application was made prior to harvest #2 on 18 May 1990 for pot marjoram.

Annuals

<u>Sweet Basil</u>. Sweet basil (<u>Ocimum</u> <u>basilicum</u> L.) was planted from seed on 17 February 1989 into Metromix 300 growth medium in Speedling trays (72 cells/tray) washed in 5% Clorox solution. Plants were grown for 5 weeks in a greenhouse environment. On 24 March, plants were transplanted into the field and topped above the second node. Fertilizer amendments were made on 22 April, 25 May, 1 July, and 8 August. Four center plants of each plot were harvested by hand at the onset of flowering 16 cm above ground on 23 May, 28 & 29 June, 2 August, and 4 October. Due to highly variable yields, the fourth harvest was omitted from the data

presented. Following harvest, plants were washed in distilled water, air dried, and separated into flowers (flowers considered to be raceme material above lowest floret), leaves (including petiole) and stems (remaining portion). The material was placed in separate air-tight plastic bags with a moist paper towel to allow moisture content in fresh plant material to equilibrate at 15°C for 24-48 h. Following equilibrium, fresh weights were recorded, and a subsequent FW subsample was taken and weighed. The subsample was dried at 50°C for 48 h in a forced-air oven for determination of percent dry matter (% dry matter = dry wt subsample/FW subsample). Regression analysis was performed on the dry matter yield (DMY) of N and K treatment means, with DMY = % DM x fresh wt x 26.9. Analysis of variance (ANOVA) was performed on micronutrient treatments.

Table 1. Fertilizer treatment

Treatment number	Treatment N - P - K ($kg\ ha^{-1}$)
1.	0 - 0 - 0
2.	84 - 0 - 0
3.	84 - 0 - 84
4.	84 - 0 - 168
5.	168 - 0 - 0
6.	168 - 0 - 84
7.	168 - 0 - 168
8.	252 - 0 - 0
9.	252 - 0 - 84
10.	252 - 0 - 168
11.	0 - 0 - 84
12.	0 - 0 - 168
13.	252 - 0 - 168 + micros⁺
13a.	168 - 0 - 84 + micros⁺

⁺ Micronutrient package:

Element	$kg\ ha^{-1}$
Cu	0.168
Mn	1.55
Fe	2.49
S	6.7
mg	6.22
Zn	0.48
B	0.017
Mo	0.001

Sweet Marjoram. Sweet marjoram (*Origanum majorana* L.) was planted from seed on 26 February 1989 into Metromix 250 growth medium contained in washed Speedling trays. Plants were removed from the greenhouse environment and transplanted in the field on 14 April. Fertilizer treatments were applied 5 May, 1 July, 29 September, and 20 November. Four center plants in each plot were harvested by hand 8 cm above ground after the initiation of flowering on 30 June, 14 September, and 18 November. Field weights were recorded and plants were washed in distilled water and air dried. Whole plant samples were then put in 'Zip-Lock' plastic bags with moistened towel and held at 15^{o}C for 24-48 h to attain moisture equilibrium. Fresh weight was recorded and a subsample taken and dried for 48 h at 120^{o}C in a forced-air oven. Regression was run on DMY treatment means and ANOVA performed on treatments 10 and 13, 6 and 13a.

Perennials

Pot Marjoram. Pot marjoram (*Origanum onites* L.) was propagated vegetatively from existing germplasm on 19 & 20 February 1989. Samples were cut, dipped in Hormatid root hormone, and placed in Metromix 300 potting soil contained in washed Speedling trays. Cuttings were allowed to root 6 wks in a greenhouse and transplanted to the field 12 April 1989. Fertilizer treatments were applied to all plots 22 April, 2 July, 28 August, and 6 November in 1989 and on 18 May and 12 July 1990. Areas of 0.84 m^2 were harvested 5.2 cm above the ground surface with a gas powered hedge clipper modified with an aluminum catchpan. Harvests occurred on 22 December 1989 and 17 May 1990. Field weights, FW, SSW, and DW were recorded after harvest. Regression was run on treatment DMY means and ANOVA performed on micronutrient and corressponding NK treatments.

Oregano. Orégano (*Origanum vulgare* L.) was propagated vegetatively from existing germplasm on 21 February 1989. Plant samples were cut, dipped in Hormatid root hormone and placed directly into Metromix 300 potting soil in washed Speedling trays. Cuttings were transplanted from the greenhouse to the field on 1 April 1989. Fertilizer treatments were applied to all plots 22 April, 30 June, 8 August, and 6 November. Plants were harvested 5.2 cm above ground with modified hedger over 0.84 m^2 on 19 November 1989. Field weights, FW, SSW, and DW were recorded. Regression was run on treatment DMY means and ANOVA performed on micronutrient and corresponding N, K treatments.

RESULTS AND DISCUSSION

Sweet Basil. Nitrogen treatments without K had DMY consistently below treatments with NK together (Fig. 1). Nitrogen treatments with K = 84 Kg ha^{-1} showed DMYs consistently above those treatments where K = 0 or K = 168 Kg ha^{-1}. With all K treatments, DMYs were lower when N = 0 and peaked when N = 200. A sharp increase in basil yield resulting from the application of N was obtained by Putievsky and Basker in 1977. It has been suggested that basil responds most favorably to the interaction of N and K (Simon, 1987). Dry matter yield declined significantly at the fourth harvest ($P = .05$), and treatment DMYs were inconsistent. For these reasons, the fourth harvest was not considered in the regression analysis. Putievsky and Basker (1987) noted that their final basil harvest was half that of their penultimate harvest. Treatments having micronutrients were not significantly different ($P = .05$) from those same NK treatments without micronutrients or from each other (Table 2).

Sweet Marjoram. At the low N levels ($N < 75$ Kg ha^{-1}), regression analysis indicates that high K treatments yielded better than low K treatments (Fig. 2). As N increased above 75 Kg ha^{-1}, the DMYs of the lowest K treatment exceed those of the two higher K treatments. Maximum DMY was obtained with treatment #8. When K = 84 Kg ha^{-1}, the plants responded in a manner similar to the basil, with DMY peaking at 190 Kg N ha^{-1}. The interaction between N and K was strong. Lowest DMY was obtained at high NK combinations. Treatment DMYs involving the micronutrients were not significantly different from each other or from the corresponding treatments withoutmicro-nutrients (Table 2).

Pot marjoram. Lowest DMYs were obtained across all N treatments when K = 0 Kg ha^{-1}, while highest DMYs were obtained across all N treatments when K = 168 Kg ha^{-1} (Fig. 3). Similar to the basil and sweet marjoram (when K = 84 Kg ha^{-1}), yields of all K treatments were optimal when N = 190 Kg ha^{-1}. Yield declined at levels exceeding 190 Kg ha^{-1}. The difference between the micronutrient treatments was significant at $P = 0.05$. While the micronutrients increased yields at the 252-0-168 level, the difference was not significant (Table 2).

Oregano. As with the pot marjoram, highest oregano DMY was attained with K = 168 Kg ha^{-1} across all N levels except when $N < 25$ Kg ha^{-1} (Fig. 4). Dry matter yield never attained maximum yield at K = 168 Kg ha^{-1}. Lowest DMY occurred when $K < 84$ Kg ha^{-1}, no matter the level of N. Similar to the other spices tested, DMYs at K = 0 and 84 Kg ha^{-1} peaked around 200 Kg N ha^{-1}. Pot marjoram and oregano are genetically very similar with similar growth habits, and both persist from year to year under field conditions. This may in part explain the similar positive response to the high K level of 168 Kg ha^{-1}. Yield of pot marjoram was almost double that of oregano, which is somewhat less erect and vigorous. Micronutrient DMYs were not significantly different from each other or from corresponding treatments.

Table 2. Response of selected spices to N, K treatments with and without applied micronutrients

Specie	Treatments N - P - K	Dry matter yield: With micros	Dry matter yield: Without micros
		kg ha^{-1}	
Basil	252 - 0 - 168	4360.0az*	5100.0z
	168 - 0 - 84	2760.3az	4253.6z
Sweet marjoram	252 - 0 - 168	348.6az	312.8z
	168 - 0 - 84	311.6az	506.1z
Pot marjoram	252 - 0 - 168	1963.6az	1838.1z
	168 - 0 - 84	1368.1bz	1581.6z
Oregano	252 - 0 - 168	652.6az	929.1z
	168 - 0 - 84	826.5az	600.9z

* Using Duncan's Multiple Range Test, means within each column and row followed by the same letter are not statistically different ($P < 0.05$).

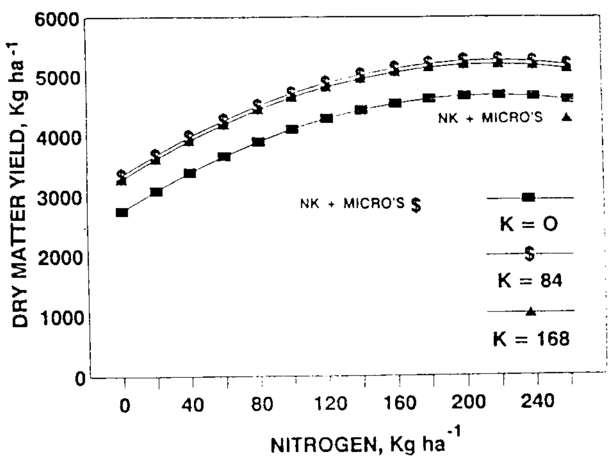

Fig. 1. Basil mean dry matter yield regression of N, K, and micro-nutrient fertilizer treatments. Data totals means of 1 year's growth (3 harvests) in 1989.

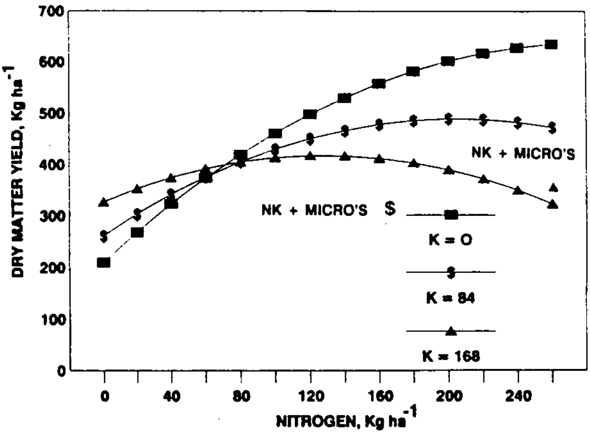

Fig. 2. Sweet marjoram mean dry matter yield regression of N, K, and micronutrient fertilizer treatments. Data totals means of 1 year's growth (3 harvests) in 1989.

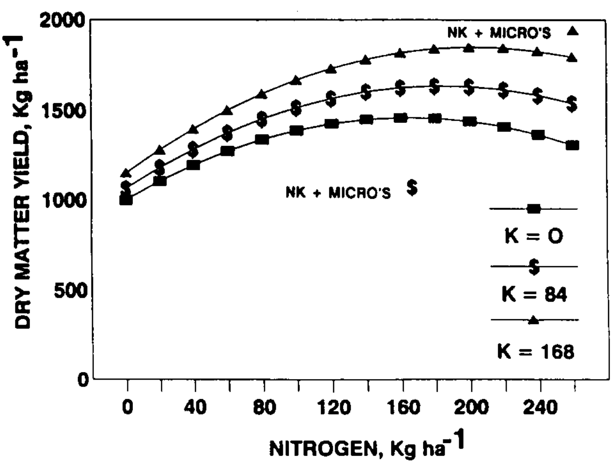

Fig. 3. Pot marjoram mean dry matter yield regression of N, K, and micronutrients fertilizer treatments. Data totals means of 1 year's growth (2 harvests) in 1989 and 1990.

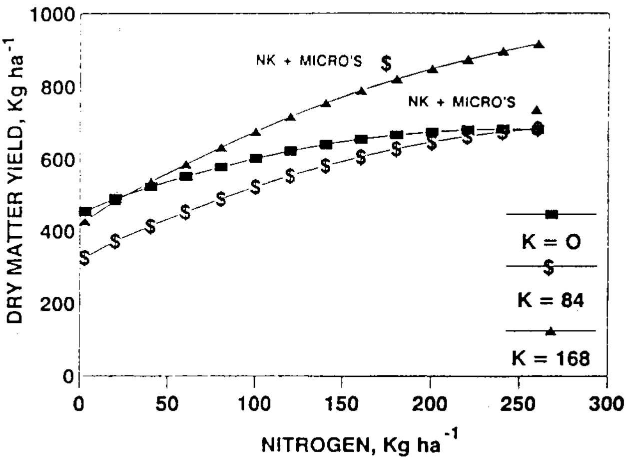

Fig. 4. Oregano dry matter yield regression of N, K, and micro-nutrient fertilizer treatments. Data totals means of 1 year's growth (1 harvest) in 1989.

CONCLUSIONS

1. Dry matter yield of spices tested maximized at approximately 200 Kg N ha^{-1} for all K levels in most cases, while lowest DMY resulted from no applied N.

2. Maximum yield of sweet marjoram and oregano were not attained for K = 84 and 168, respectively. These results indicate that higher DMY could be achieved by applying N above the 252 Kg ha^{-1} level used in this test at the elevated K levels.

3. High DMYs were attained by oregano, pot marjoram, and basil at the highest K rates (168 and 84 Kg ha^{-1}, whereas the lowest DMY was attained by sweet marjoram at K = 168 Kg ha^{-1} with applied nitrogen.

4. Sweet marjoram attained highest DMYs with increasing N and K=0.5.

5. The addition of micronutrients did not significantly influence yield positively or negatively compared to the comparable micronutrient treatments. However, the lowest yields attained by basil and pot marjoram resulted from the addition of micronutrients with 168 Kg ha^{-1} N and 84 Kg ha^{-1} K.

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