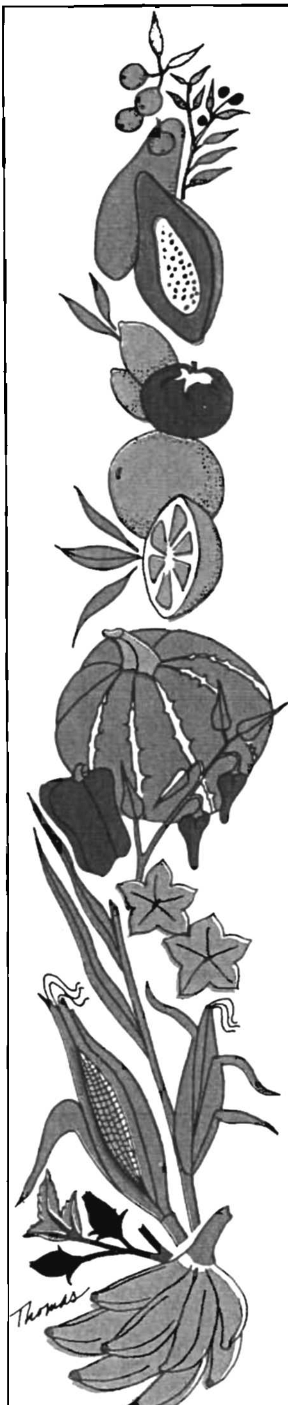

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GROWTH AND YIELD RESPONSE OF THYME (*THYMUS VULGARIS* L.) TO SOURCES OF NITROGEN FERTILIZER

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ABSTRACT

The response of thyme (*Thymus vulgaris* L.) to sources of nitrogen (N) fertilizer application was studied in field experiments conducted in 1992 and 1993. Thyme plants were grown in plots consisting of 3 rows 2.1 m long with 40 cm between rows. In 1992, thyme plants were fertilized with N at a rate of 115 kg. ha^{-1} using N-source treatments of ammonium nitrate (35% N), ammonium sulfate (21% N), and urea (45% N). One treatment was applied with cow manure (2% N) at a rate of 230 kg N. ha^{-1}. A control plot (no N) was included as a treatment. In 1993, the same N fertilizer sources were used but N was applied at a rate of 100 kg. ha^{-1} for inorganic fertilizers and 200 kg. ha^{-1} for organic (cow manure) fertilizer. In both experiments phosphorus (P) and potassium (K) were applied at a rate similar to the P and K content of cow manure equivalent to 50 and 190 kg. ha in 1992 and 44 and 166 kg.ha^{-1} in 1993, respectively. In 1992, results indicated no significant differences in plant height, plant fresh yield and total dry matter yield among nitrogen fertilizer sources and the control. Results obtained in 1993 showed that urea and cow manure were superior to ammonium nitrate and the control in terms of total plant fresh yield. Plants fertilized with urea and cow manure produced total fresh yields of 7.5 and 7.2 t. ha^{-1}, respectively. Lowest plant fresh yield of 5.1 t. ha^{-1} was obtained from plots applied with ammonium nitrate. No significant differences in plant height were observed between treatments. It appears that urea and cow manure are the best sources of N fertilizer for thyme production in the Virgin Islands.

INTRODUCTION

Thyme (*Thymus vulgaris* L.) is one of the top selling culinary herbs in the Caribbean. It is commonly produced by small-scale vegetable and herb growers as well as home gardeners. Most of the thyme produced in the Virgin Islands are sold in local markets. However, there is potential for an export market since the U.S. mainland imports large quantities of herbs and spices annually from the Caribbean. Costa Rica, Dominican Republic, Jamaica, Puerto Rico and Trinidad are the major exporters of herbs and spices to the U.S. (USDA/ERS, 1993).

A major constraint to increased production of thyme in the Virgin Islands is the lack of technical information and recommended crop management practices. For example, there are no available information and guidelines on fertilizer application for herbs and spices. Most recommendations are based on other crops which have similar growth habit (Simon, 1987). Studies on fertilizer requirement of various herb species are important in determining what type of nutrient, formulation and rate of application will be optimum. The primary objective of this study was to determine the effect of sources of nitrogen fertilizer on the growth and yield of thyme.

REVIEW OF RELATED STUDIES

Herbs like other crops take nutrients from the soil during growth and development. As the availability of nutrients becomes depleted in the soil, the grower must add the nutrients back to the soil to ensure continued growth of the present and future plantings of the crop. Information on fertilizing herbs and medicinal plants is limited and often contradictory (Cox, 1992). This is probably due to conflicting goals of producing herbs for maximum fresh and dry matter yields or growing herbs for maximum production of secondary products.

Nitrogen (N), phosphorus (P) and potassium (K) are the major nutrients required by herbs and thus fertilizers containing these elements are the most widely used. Of these fertilizer elements, the largest growth and yield response in herbs generally results from nitrogen application (Cox, 1992). The first increments of N added to the soil are almost always effective in increasing dry matter yields and secondary product accumulation in herbs. Further increases in N application generally do not result in large yield increase. High N fertilization may actually reduce plant growth and accumulation of secondary products. Such a relationship between N levels and plant response has been observed in such diverse species as poppy (Laughlin, 1983), peppermint (Hornok, 1983), lovage (Galambosi and Galambosi, 1992) and rosemary (Boyle and Craker, 1991).

The source and form of N fertilizer can also affect growth and yield as well as the quality of secondary products in herbs. Although N is absorbed by plant roots in either ammonium (NH_4^+) or nitrate (NO_3^-), some plants species seem to prefer one N form over the other while other plants have no preference. For example, sweet basil plants fertilized with NH_4-N contains less linalool and eugenol oils than plants fertilized with NO_3-N (Adler, et al., 1989). Ammonium form of N had similar effects on the production of essential oil in Japanese mint (Singh and Singh, 1978). In one study, NH_4-N limited the production of alkaloids in poppy (Costes, et al., 1978), but these results could not be duplicated in a second study (Laughlin, 1983).

There are few studies comparing the effects of sources of N fertilizer on fresh and dry matter yields of herbs and spices. In a related study using various levels of ammonium nitrate in combination with P and K and micronutrients, it was found that sweet basil, sweet marjoram, pot marjoram and oregano responded favorably to 168 and 252 kg N. ha^{-1} (Angell, et al., 1990). Experiments in Virgin Islands showed that using urea, the cumulative fresh and dry matter yields of thyme with N applications of 112 and 169 kg. ha^{-1} were superior to the control (no nitrogen) treatment (Crossman and Collingwood, 1991).

MATERIALS AND METHODS

The experiments were conducted at the Agricultural Experiment Station, University of the Virgin Islands on St. Croix (Lat. 17°42'N and Long. 64°48'W). The soil is Fredensborg loamy, fine carbonatic, isohyperthermic, shallow, typic calciustolls. The initial soil analysis showed a soil pH of 7.98, organic matter content of 4.15%, 19 ppm P, 345 ppm K, and a CEC of 25 meq/100 g. The average annual rainfall is 1016 mm, but evapotranspiration exceeds precipitation 10 months of the year resulting in a negative water balance.

The experiments were established using a randomized complete block design with four replications. The treatments consisted of N sources coming from ammonium nitrate (35% N), ammonium sulfate (21% N), urea (45% N) and dry cow manure (2% N). A control plot (no fertilizer N) was added as a treatment. In 1992, thyme plants were fertilized with N at a rate of 115 kg. ha^{-1} using the various N fertilizer sources, except the cow manure where N was applied at a rate of 230 kg. ha^{-1}. In 1993, similar N fertilizer sources were used, but N was applied at a rate of 100 kg. ha^{-1} for inorganic fertilizers and 200 kg. ha^{-1} for organic (cow manure) fertilizer. In both experiments, P and K were applied at rates similar to P and K contents of cow manure (50 and 190 kg. ha^{-1} in 1992 and 44 and 166 kg.ha^{-1} in 1993, respectively). The inorganic fertilizers were applied in bands at the base of each plant. Nitrogen was applied in 2 and 3 splits in 1992 and 1993, respectively. All the P and K were applied at planting. All of the cow manure was applied at planting. Thyme seedlings were planted in plots measuring 3 m long by 1.2 m wide. Each plot consisted of 3 rows spaced at 30 cm. Plants were spaced 30 cm within rows. All plots were drip irrigated to maintain soil moisture tension at 30 kPa.

In 1992, the plants were harvested on March 11 and June 15. Yield samples were taken from middle rows. Plants were cut at the base and weighed. Stems were separated from leaves and each component weighed and oven-dried at 70°C. In the 1992-93 trial, plants were harvested on December 21, 1992 and March 24, 1993. Similar sampling procedures and data collection were followed as in 1992. Plant height was measured at every harvest using 10 plants in middle rows. To determine the effect of N fertilizer source on nutrient content of thyme, leaf samples were analyzed for the major and minor elements. Likewise, initial and final soil pH were measured to determine the influence of N fertilizer source on soil pH. All data were statistically analyzed using the Statistiscal Analysis System (SAS) GLM procedure. Significant differences among treatment means were determined using the Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Plant Height, Fresh and Dry Matter Yield, 1992 Trial

Nitrogen fertilizer source did not influence plant height or fresh and dry matter yields of thyme in the 1992 trial (Table 1). In fact, plants in the control plots (no N fertilizer) were slightly taller and had slightly higher yield than plants in the fertilized plots. The high initial soil organic matter content may explain this small difference. Generally, yields from the first harvest were higher than the second harvest in all treatments. After the first harvest some plants were infected by a soil borne fungus which resulted in gradual die back. Fungal infection was random and occurred in all treatments. Although dead plants were replanted, growth of new transplants was slow to catch up with mature plants. The relatively low yield of the second harvest may be attributed to this fungal infection.

Plant Height, Fresh and Dry Matter Yield, 1993 Trial

There were significant differences among treatments in fresh and dry matter yields, but not in plant height in the 1993 trial (Table 2). Total fresh thyme and dry matter yield were highest (7.45 and 2.16 t. ha^{-1}) in plots fertilized with urea and lowest (5.07 and 1.31 t. ha^{-1}) in ammonim nitrate plot. Differences in fresh thyme yield were not significant between urea, cow manure and ammonium sulfate, but urea and cow manure were superior to ammonium nitrate and the control. This trend was similar for dry matter yield. There was no significant difference in plant yield between ammonium nitrate and ammonium sulfate- fertilized plots, although plants applied with ammonium sulfate resulted in slightly higher yield than plants fertilized with ammonium nitrate. Yield from plots applied with ammonium nitrate resulted in similar yield to the control plots (Table 2). Similar soil borne fungal disease was observed in 1993. The incidence was common after the first harvest which resulted in lower yield of the second harvest.
The yield data indicate that urea and cow manure are better sources of N fertilizer for thyme compared to ammonium nitrate and ammonium sulfate. This would also suggest that organic fertilizers might be beneficial for thyme production.

Leaf Nutrient Content

In 1993, leaf samples from plants fertilized with various N fertilizer sources were analyzed for contents of major and minor elements. Results indicate that for the major nutrients, there were no significant differences among treatments, except for magnesium content (Table 3). Leaf samples from plants fertilized with ammonium nitrate and ammonium sulfate were higher in magnesium content than other treatments. Except for boron, the minor nutrient content of thyme leaves were not significantly affected by sources of N fertilizer (Table 4). This indicates that sources of N fertilizer have little infleunce on the nutrient content of thyme.

Changes in Soil pH

All treatments resulted in slight increase of soil pH after harvest as shown in Table 5. The highest increase was from plots fertilized with ammonium nitrate followed by plots applied with urea (Table 5). These treatments resulted in soil pH increments of 0.40 and 0.27, respectively. The lowest increment was observed in the control plots (0.11). Plots applied with ammonium sulfate resulted in soil pH change from 8.12 to 8.28, a 0.16 increment. It has been reported that continuous application of fertilizers containing sulfur such as ammonium sulfate will result in decrease of soil pH (Lathwell and Reid, 1984; Lorenz and Maynard, 1988), but in this short term study, this change was not observed. In calcareous soils, such as in the Virgin Islands, continuous use of fertilizers containing ammonium may be detrimental to plant growth as these fertilizers raise the soil pH which is already alkaline. Since the increase in soil pH was slight in all fertilizer treatments, it may take several years of fertilizer application before the effect on plant growth can be observed

CONCLUSIONS

The response of thyme to sources of N fertilizer was studied in two trials conducted in 1992 and 1993. The results showed no response in 1992 in terms of plant height, fresh and dry matter yields. In 1993, significant differences were seen among treatments. Urea and cow manure were superior to ammonium nitrate and the control in both the fresh and dry matter yields. Except for magnesium and boron, all treatments did not significantly change the nutrient contents of thyme leaves. All treatments resulted in slight increase in soil pH, but the least pH change was in the control and plots applied with ammonium sulfate. Based on this study, it appears that urea and cow manure are best sources of N fertilizer for thyme production in the Virgin Islands.

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Table 1. Plant height, total fresh and dry matter yields (t ha^{-1}) of thyme applied with various sources of nitrogen fertilizer, 1992.

Nitrogen Source	Plant height (cm)[1]	Plant Fresh Yld (1)[2]	Plant Fresh Yld (2)[3]	Total Fresh Yld	Dry Matter Yld (1)[2]	Dry Matter Yld (2)[3]	Total Dry Matter
NH_4NO_3	23.0	10.0	9.47	19.5	3.48	3.43	6.91
$(NH_4)_2SO_4$	21.8	11.6	6.91	18.5	3.77	2.52	6.29
Urea	21.6	9.8	8.05	17.9	3.33	2.93	6.26
C. Manure	23.0	11.8	5.83	17.6	3.95	2.17	6.12
Control	23.7	10.6	9.68	20.3	3.72	3.48	7.20
Pr>F	NS	NS	NS	NS	NS	NS	NS

[1]Measured at first harvest. NS=not significant
[2]Yield of 1st harvest
[3]Yield of 2nd harvest

Table 2. Plant height, total fresh and dry matter yields (t ha^{-1}) of thyme applied with various sources of nitrogen fertilizer, 1993.

Nitrogen Source	Plant height (cm)[1]	Plant Fresh Yld (1)	Plant Fresh Yld (2)	Total Fresh Yld	Dry Matter Yld (1)	Dry Matter Yld (2)	Total Dry Matter
NH_4NO_3	19.8 a	3.03 bc	2.04 b	5.07 b	0.81 ab	0.50 b	1.31 c
$(NH_4)_2SO_4$	19.9 a	2.56 c	3.42 a	5.98 ab	0.68 b	0.94 a	1.62 abc
Urea	18.7 a	4.12 ab	3.33 a	7.45 a	1.25 ab	0.91 a	2.16 a
C. Manure	19.9 a	5.23 a	1.93 b	7.16 a	1.35 a	0.60 ab	1.95 ab
Control	18.3 a	3.33 bc	2.15 b	5.48 b	0.85 ab	0.58 ab	1.43 c

[1]Measured at first harvest
[2]Yield of 1st harvest
[3]Yield of 2nd harvest
For each column, values with common letters are not significantly different (P=0.05)

Table 3. Major nutrient content (%) of thyme leaves as affected by sources of nitrogen fertilizer, 1993.

Nitrogen Source	N	P	K	Ca	Mg
NH_4NO_3	3.08	0.30	3.65	1.52	0.30
$(NH_4)_2SO_4$	3.01	0.27	3.02	1.31	0.32
Urea	2.82	0.29	3.41	1.35	0.28
Cow Manure	2.80	0.26	2.87	1.46	0.28
Control	2.82	0.27	3.20	1.31	0.27
Prob>F	NS	NS	NS	NS	*

*Significant at P=0.05. NS = not significant

Table 4. Minor nutrient content (ppm) of thyme leaves as affected by sources of nitrogen fertilizer, 1993.

Nitrogen Source	Al	Bo	Cu	Fe	Mn	Zn
NH_4NO_3	1380	24.6	12.8	846	210	36.1
$(NH_4)_2SO_4$	1197	25.2	13.2	738	214	35.3
Urea	1291	23.8	14.0	798	203	37.7
Cow Manure	1557	30.3	11.8	952	191	39.4
Control	1283	25.9	13.0	787	197	38.8
Prob>F	NS	**	NS	NS	NS	NS

**Significant at P=0.01. NS = not significant

Table 5. Changes in soil pH as influenced by sources of nitrogen fertilizer.

Nitrogen Source	Initial pH	Final pH	Difference
NH_4NO_3	8.12	8.52	0.40
$(NH_4)_2SO_4$	8.12	8.28	0.16
Urea	8.12	8.39	0.27
Cow Manure	8.12	8.31	0.19
Control	8.12	8.23	0.11