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Nutrient Analysis of Selected Commercial Organic Fertilizers for Greenhouse Lettuce Production

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Introduction

The market for organic produce continues to expand (Thompson, 2000). Kentucky has more than 75 acres of greenhouses with modified pond or tank hydroponic beds for "float" tobacco transplant production. The development of a certified organic greenhouse production system for lettuces and greens could allow Kentucky tobacco farmers access to a new market for their facilities as the tobacco market changes. In this study, commercial organic fertilizers were used to grow 'Ostinata' Bibb and 'Red Sails' leaf lettuce in a pond, tank, or "float" production system. Plant growth was evaluated, and the fertilizer solutions were analyzed for nutrient amounts and compared to recommended standards for inorganic fertilizers (Muckle, 1993, Thompson et al., 1998).

Lettuce was grown in 1 oz. soufflé cups placed into a polystyrene board floating on the nutrient solution.

Materials and Methods

In this study, nine 12-square-foot wooden hydroponic ponds or tanks were built in three rows of three on one side of a 30-foot x 60-foot naturally ventilated sidewall plastic greenhouse. Tanks were lined with black polyethylene and filled with water to a depth of 6 inches to make a tank volume of approximately 38 gallons. Electric water pumps were placed in each tank to oxygenate the water; previous work demonstrated that oxygen levels would be maintained at 4 to 6 ppm with this procedure. Holes (35) were cut in eighteen 36-inch x 22-inch x 1-inch polystyrene sheets. The holes were 1.5 inches in diameter and spaced 5 inches x 6 inches. Lettuce plants were grown in 1-ounce plastic soufflé cups (Solo Cup Company, Urbana, IL) that had holes drilled in the bottom.

Inorganic fertilizer (Peter's 20-10-20, Scotts, Marysville, Ohio) or one of three commercially available, water-soluble organic fertilizers (Peaceful Valley Farm Supply, Grass Valley, California) was added to the water in each tank. Algamin, 0.2N-0P-3.3K, (18 percent cold processed kelp, *Ascophyllum nodulosum* from Norway) was applied at the label rate and three times the label rate, approximately 1 Tbs/gal. and 3 Tbs/gal., respectively. EcoNutrients, 0.2N-0.4P-0.8K (21 percent digested bull kelp, *Nereocystis luetkeana*, from Northern California) was applied at the label rate, 2 Tbs/gal. Omega 6N-2.6P-5K (microbe-digested organic fertilizer derived from blood meal, bone meal, and sulfate of potash) was applied at the label rate and one-half the label rate, approximately 2 Tbs/gal. and 1 Tbs/gal., respectively.

Three crops of lettuce were grown sequentially, one in September, the second in October, and the third in November of 2000. Cups were filled with a peat-based germination media (Scott's Redi-Earth, Marysville, Ohio) and placed in trays. Bibb lettuce 'Ostinata' and Grand Rapids lettuce 'Red Sails' seeds were sown in the cups and germinated at an average daily temperature of 76°F. Seedlings were grown for 14 days and fertigated with 150 ppm 20-10-20 inorganic fertilizer before placement in the hydroponic tanks. The plants grew under natural light conditions, and the greenhouse had a heat set point of 60°F and a ventilation set point of 75°F.

Plants were harvested from the tanks after 30 days, and the fresh and dry weights were measured. Five water samples were taken during each crop and analyzed as standard greenhouse water samples (available nutrients) and as organic samples (total nutrients). The September crop evaluated the label rate of Algamin, EcoNutrients, and inorganic fertilizer; the October crop evaluated the 3X label rate of Algamin, the label rate of Omega, and inorganic fertilizer; and the November crop evaluated inorganic fertilizer, the one-half label rate, and the label rate of Omega in randomized complete block experiments.

Results and Discussion

Water soluble materials derived from algae (Algamin and EcoNutrients) had little value as an organic fertilizer for lettuce in a tank hydroponic system. Dry weight of lettuce grown with these materials was only 10 to 18 percent of those grown in inorganic fertilizer, depending on the cultivar (Table 1). Nitrate nitrogen and phosphorus levels were less than 1 percent, and potassium was 5 to 20 percent of the recommended levels when used at the label rate or the 3X label rate for these fertilizers (Table 2). These results are comparable to our previous unpublished trials with fish waste (fish emulsion and fish powder). However, the poor plant growth with fish waste was attributed to the high biological oxygen demand from the fertilizers that prevented root penetration into the nutrient solution for three or more weeks, despite moderate nutrient levels.

Dry weight of lettuce grown with a formulated organic fertilizer (Omega) was similar or significantly lower than lettuce grown in inorganic fertilizer, depending on the cultivar (Table 1). Although dry weights were similar, head size was visually smaller with the organic fertilizer. Nitrate levels were 50 percent, P levels were 300 percent, and K levels were 100 to 120 percent of recommended levels (Table 2).

Production of lettuce in this study was simplified when compared to the sophisticated practices evaluated by Thompson et al. (1998). A commercial fertilizer was used as a control, rather than a formulated fertilizer. Plus, the inorganic fertilizer was supplemented only with additional fertilizer as the conductivity decreased and pH was not manipulated. The pH dropped dramatically throughout this study (Table 2), yet no apparent effects on lettuce growth were noted. Additionally, the commercial fertilizer did not match recommended nutrient amounts precisely. Fresh weights in this study did not reach the commercial goal of 5 ounces per head (Thompson et al., 1998). The heads of lettuce grown in the inorganic and Omega treatments averaged approximately 3.9 ounces. The dry weights, however, were generally similar to dry weights reported by Thompson et al. (1998), but difficult to compare because of different temperatures and light levels used in these studies.

In conclusion, this study indicates that it may be possible to formulate an organic fertilizer for the hydroponic production of lettuce in the greenhouse. It is unknown if state and federal agencies would certify such production practices as organic production.

Table 1. Mean shoot dry weight (oz) of 'Ostinata' (O) and 'Red Sails' (RS) lettuce grown with inorganic and selected commercial organic fertilizers in 2000.

		September Crop		October Crop		November Crop	
Fertilizer	Rate	O	RS	O	RS	O	RS
Inorganic		0.134 a[1]	0.141 a	0.067 a	0.049 a	0.067 a	0.061 a
Omega	½ x					0.062 b	0.058 a
Omega	1 x			0.067 a	0.039 b	0.063 b	0.057 a
Algamin	1 x	0.027 b	0.049 b				
Algamin	3 x			0.005 b	0.015 b		
EcoNutrients	1 x	0.034 b	0.048 b				

1 - Means followed by the same letter in a column are not significantly different at $p = 0.05$ according to the Least Squares Means procedure.

Table 2. Recommended amounts (Muckle, 1993; Thompson, 1998) and measured amounts of macronutrients and pH in inorganic and selected commercial organic fertilizers used during September, October and/or November crops of lettuce in a pond culture system.

		Fertilizer type					
	Recommended amounts	Inorganic	Omega	Omega	Algamin	Algamin	EcoNutrients
N-P-K		20-4-16.6	6-2.6-5	6-2.6-5	.2-0-3.3	.2-0-3.3	.2-.4-.8
Rate			1 x	½ x	3 x	1 x	1 x
Weeks Used		12	8	4	4	4	4
NO_3 ppm	125-156	90	80	42	2	0	0
NH_3 ppm	0	6	22	11	0	0	0
P ppm	28-31	34	95	45	2	0.3	0
K ppm	215-252	140	240	145	48	8	10
Ca ppm	84-93	10 [x]	0	0	16	8	6
Mg ppm	24-26	10 [x]	0	0	70	21	4
pH	5.6-6.0	4.8	5.8	6.5	7.1	7.4	7.5
EC dSm^{-1}	1.2	1.2	2.0	1.4	0.9	0.3	0.1

x - Municipal water used for the nutrient solutions added a mean of 52 ppm Ca and 27 ppm Mg and negligible amounts of N, P, and K.

Literature Cited

Muckle, M.E. 1993. Hydroponic Nutrients. Growers Press, Inc., Princeton, B.C., Canada.

Thompson, H.C., R.W. Langhans, A.J. Both, L.D. Albright. 1998. Shoot and root temperature effects on lettuce growth in a floating hydroponic system. J. Amer. Soc. Hort. Sci. 123(3):361-364.

Thompson, G. 2000. International consumer demand for organic foods. HortTechnology 10(4):663-674.

For More Information:

A Handbook for the Production of CEA-Grown Hydroponic Lettuce—Cornell University <http://www.cals.cornell.edu/dept/flori/lettuce/index.html>

Hydroponic Food Production. A Definitive Guide to Soilless Culture. 1994. Howard M. Resh. 5th ed. Woodbridge Press, Santa Barbara, Calif.