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An Economic Comparison of Commercially Available Organic and Inorganic Fertilizers for Hydroponic Lettuce Production

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Hydroponically grown agricultural products continue to grow in popularity. As compared to soil-based production systems, hydroponic systems require much less water; are easier to treat for pests and diseases; have high, stable yields; and reduce potential nutrient pollution (Resh, 2004).

Many crops can be grown hydroponically using both chemical and organic sources of hydroponic fertilizers (Kratky, 2005, and Resh, 2004). Research has been conducted in Hawaiʻi on non-circulating hydroponic production systems (Kratky et al., 2008, and Ako and Adam, 2009). The hydroponic system used in this study was a low-maintenance non-circulating system developed by Dr. Bernard Kratky (1995). This system requires little capital and can be constructed from locally available material. Recently, Ako and Adam (2009) developed a similar non-circulating hydroponic system that can be used for both hydroponic and aquaponic production. Aquaponics is the simultaneous cultivation of plants and aquatic animals in a closed system.

This publication examines the costs and benefits of commercially available organic and inorganic fertilizers in a non-circulating hydroponic lettuce-production system. The cost of production, lettuce yield in pounds, and a simple investment analysis of the payback required for each system are presented. This publication will assist backyard gardeners who are considering adopting hydroponic production systems with benchmark information for use in managing their hydroponic systems.

Experimental Design

Two nutrient tanks, each 3 feet wide by 8 feet long by 5.5 inches deep, were constructed. One was used for organic fertilizer and one for chemical fertilizer. The only difference between the production systems compared in this publication was the fertilizer. All other materials and practices were identical.

The nutrient tanks used were built using lumber that is available from any hardware store. The bottom of the tanks was constructed with a ¾-inch thick, 3-foot by 8-foot plywood sheet. The sidewalls of the tanks were constructed using 2 x 6s, which were screwed to the plywood using 2-inch stainless steel screws. The corners of the sidewall were also connected using 3-inch stainless steel screws. The tanks were elevated off the ground using 6 x 8 x 16-inch hollow cinderblocks stacked two cinderblocks high. The tanks were lined using two sheets of 6-mil polyethylene plastic. The plastic sheets were secured using staples after the nutrient solutions were added.

The organic fertilizer, Pure Blend Pro produced by Botanicare®, was purchased for $50.00 per gallon from a retail operation on Oʻahu that specializes in hydroponic supplies. It was applied at 1 Tbsp/gallon, as specified on the label. This fertilizer is derived from fishmeal, composted seabird guano, kelp, rock phosphate, and several different forms of carbonate. It has a chemical analysis of 3-2-4. The pH of the organic solution was adjusted using Earth Juice Natural pH Up purchased from the same retail operation for $9.95 per 2-pound bottle and at the rate specified on the label. The target pH of the nutrient solution was in the range of 6.5 to 7.0.

The synthetic fertilizer was purchased for $23.95 for 5 pounds from a retail operation located in Hilo that specializes in agricultural inputs. The chemical fertilizer used was Chem-Gro®'s lettuce formula, at the rate of 1 tsp/gallon, as specified on the label, which has a chemical analysis of 8-15-36. Calcium nitrate at $7.95 per 5 pounds and magnesium sulfate at $7.95 per 5 pounds were also used at the rate of ½ tsp/gallon, as specified on the label, in order to meet the expected nutrient demand of lettuce.

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The tanks were covered by four 2 x 3-foot polystyrene boards, which acted as supports for the net pots. Each board had 10 or 11 holes made using a 2-inch-hole saw drill bit. One net pot was placed in each hole. Each net pot contained one seedling. 'Red Sails' lettuce seed was planted in oasis cubes and allowed to germinate before being placed into the net pots. Seeds were purchased from Johnny's Selected Seeds© for $3.95 per packet.

Harvesting was done three to four weeks after planting by cutting the heads at the base of the plant. The lettuce harvested from each tank was weighed, and the total yield across both repetitions and fertilizer treatments was calculated. After harvesting, the roots and oasis cubes were removed and composted. All heads in a single system were removed at the same time, and replanting was only done after all heads had been removed. Replacing harvested plants while other plants are still growing is not feasible, because the solution will not contact the new seedling's roots, and the solution cannot be replenished until the old crop is removed. The nutrient solution was replenished at the rate specified on the label, and then new seedlings were replanted. This experiment was repeated twice for both fertilizer options.

Results and Discussion

The synthetic formula had higher yield than the organic formula (Figure 1). Although differences in growth between the two fertilizers existed, both had marketable yield. A comparison of the production from each tank found that the average weight for the 42 heads of lettuce harvested per 3- by 8-foot tank for synthetic treatment was 3.52 oz (104.1g) and for the organic treatments was 2.56 oz (75.7g) (Figure 1). The differences between the average weights for these two treatments are significantly different at the 99% level of confidence, which means that the synthetic treatment did have a higher mean yield than the organic treatment. During the growth cycle there was a significant decrease in pH in the organic fertilizer solution, which was adjusted as needed. The growth potential for each treatment could have been affected by time till harvest. If plants had been left to grow longer, higher yield might have been observed.

The variable cost of production (CoP) was estimated for the synthetic (Table 1) and the organic (Table 2) fertilizers, based on actual input costs for purchased inputs and on a labor cost of $10.00 per hour. Costs are the same between the two experiments, but are included here so that readers can get more accurate information about the CoP. Producers will need to factor in their own labor costs, whether they are out-of-pocket costs paid to an hourly worker or the opportunity cost of the owner's time. The $10.00-per-hour figure used here is considered to be relatively low and is about comparable to the out-of-pocket costs associated with a minimum-wage employee. The variable CoP, which is a partial cost rather than a total CoP, was estimated because total fixed costs can only be estimated by the owner and, in this example, fixed costs would be the same for each type of fertilizer. Thus, the fertilizer was the only cost difference between the two treatments, resulting in a CoP of $16.78 for a

Figure 1. The average head weight (lbs) by fertilizer treatment. Each mean represents 40 heads of lettuce.

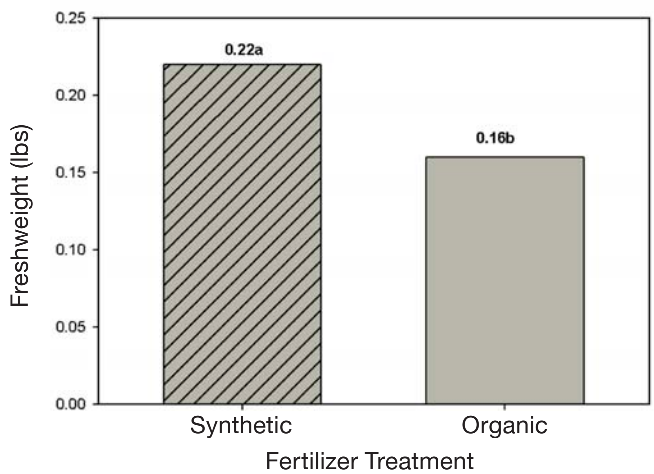

Figure 2. Estimated economic return for head lettuce after accounting for variable costs and tank costs for synthetic and organic fertilizers.

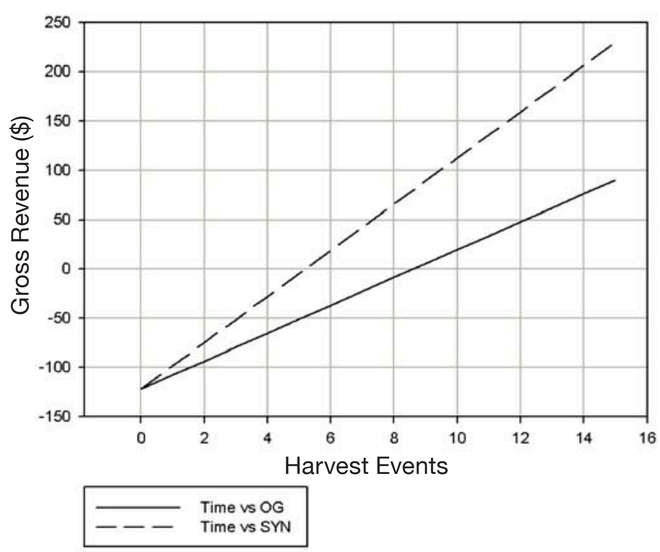

Table 1. Estimated revenues and costs for producing hydroponic lettuce in a 42-head tank using synthetic fertilizer.

Synthetic Fertilizer	Average Yield	Units	Price/Cost per Unit	Total	Percentage of Gross Revenue
GROSS REVENUE	9	pounds	$4.71	$43	100%
VARIABLE PRODUCTION COSTS					
Planting					
Lettuce seeds	0.25	grams	$1.00	$0.25	0.58%
Oasis cubes	42	cubes	$0.04	$1.68	3.93%
Labor	0.5	hours	$10.00	$5.00	11.70%
Fertilizer	42	teaspoons	$0.11	$4.62	10.81%
Total planting costs				$11.55	27.02%
Irrigation	75	gallons	$0.003	$0.23	0.53%
Harvesting labor	0.5	hours	$10.00	$5.00	11.70%
TOTAL VARIABLE COST OF PRODUCTION				$16.78	39.25%
Margin to pay other costs and profit (gross revenue minus variable costs)				$25.96	60.75%

Table 2. Estimated revenues and costs for producing hydroponic lettuce in a 42-head tank using organic fertilizer.

Organic Fertilizer	Average Yield	Units	Price/Cost per Unit	Total	Percentage of Gross Revenue
GROSS REVENUE	7	pounds	$5.98	$41	100%
VARIABLE PRODUCTION COSTS					
Planting					
Lettuce seeds	0.25	grams	$1.00	$0.25	0.61%
Oasis cubes	42	cubes	$0.04	$1.68	4.07%
Labor	0.5	hours	$10.00	$5.00	12.10%
Fertilizer	42	teaspoons	$0.11	$12.50	30.26%
pH Up	1	teaspoons	$0.25	$0.25	0.61%
Total planting costs				$20.03	47.03%
Irrigation	75	gallons	$0.003	$0.23	0.54%
Harvesting labor	0.5	hours	$10.00	$5.00	12.10%
TOTAL VARIABLE COST OF PRODUCTION				$24.25	58.69%
Margin to pay other costs and profit (gross revenue minus variable costs)				$17.07	41.31%

tank raised using this synthetic fertilizer and $24.25 for a tank raised using this commercial organic fertilizer.

In order to calculate the net revenues for the variable CoP, market prices were needed. The retail prices for a head of lettuce were collected at three different supermarkets during August 2010 and averaged across all observations. The average price for a head of lettuce was $4.71 for local lettuce produced with synthetic fertilizer and $5.98 for a local organic head. Thus, the organic premium was 26.9%. The exact per-pound prices and organic price premiums that producers across the state may experience will vary, depending on the situation (Olberholtzer et al., 2007).

The gross revenues were obtained by multiplying the average weight per head for each treatment by 42, the total number of heads per tank, and by the average per-head market price. The revenue margins, after accounting for variable costs, were $25.96 and $17.07 respectively. Based on these returns and on the initial capital cost of $121.76 (Ako and Adam, 2009), the system will pay for itself after the sixth harvest for the synthetic fertilizer and the ninth harvest for the organic fertilizer (Figure 2). This means that the economic return is zero until the cost of the tank has been paid. Given that each crop grows three to four weeks in the tank before harvest can occur, the synthetic tank will produce enough revenue to pay for the tank in about 24 weeks, while the organic one will require about 36 weeks. This means that the organic premium was not large enough to compensate for the increased cost of the organic fertilizer.

The hydroponic lettuce-production system can be adjusted to various scales of production. At the same time, the CoP will have to be adjusted to include the operator's fixed costs, which may include more than just the cost of the tank. In this publication the only fixed cost included in the analysis was the cost of the tank. Most homeowners will not be able consume the total amount of lettuce one system can produce. In this case the system size must be reduced to fit the household's consumption amount. The reduction in system size will reduce the capital cost, which will make these systems more feasible for the homeowner.

For large-scale operations, more tanks will need to be added to increase production. Producers will need to determine their cost of production and net returns based on the costs they incur for labor and other purchased inputs, along with their market prices.

Several factors, which were not included in the study, could help to increase gross revenues of both the organic and synthetic fertilizer systems. These factors include increasing plant density of the system as well as increasing fertilizer rate. Further research is needed to determine if increased fertilizer rates increase crop growth. If so, then a new CoP needs to be produced for the corrected gross revenues.

Table 3. Heads from both treatments (A) and heads grown in synthetic (B) and organic (C) treatments.

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