Title: Fertigation Applications and Costs in Organic Vegetables

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Procedures:

Cost analysis for fertigation products: A cost analysis was done for 29 liquid and powder organic fertilizers that could be used for fertigation. Fertilizer products included in this analysis included those listed on the WSDA Brand Name Material List and the Organic Materials Review Institute (OMRI) product list. To calculate the cost of each fertilizer product, the organic fertilizer calculator developed by Oregon State University http://smallfarms.oregonstate.edu/organic-fertilizer-calculator/ was used.

The fertilizer product cost analysis is based on the cost per unit of nitrogen on percent by weight basis for each product and involved three steps. First, we determined the price of the product from commercial suppliers. Second, for products sold on a volume basis we contacted manufactures for volume weight information. And third, for each product we calculated the cost of nitrogen per pound using the value for nitrogen content stated on the label.

Fertigation field study: To test the impact of fertigation rate on vegetable yield, a field study was conducted at Washington State University Mount Vernon Northwest Washington Research and Extension Center (NWREC). The experimental design was a randomized complete block design with a split plot and four replications. The main plot consisted of three fertigation rates, 4, 8 and 12 pounds of nitrogen (N) per acre, representing low, medium and high fertigation rates. The split plot was vegetable crop lettuce cv. 'Simpson Elite', broccoli cv. 'Green Magic' and pumpkin cv. 'Small Sugar,' representing 3 rates of production (early, medium and late).

Crops were seeded in the greenhouse on April 14 and were transplanted to the field June 1, 2009. The greenhouse was managed following organic standards and the field was certified organic. In the greenhouse, plants were fertilized May 2 and 19. The first application was made at the 2-leaf stage and the second application was made approximately 2 weeks later. At each application, BioLink 6-0-0 Vegan Nitrogen Fertilizer (295.7 grams) and Acadian Seaweed Extract (4.54 grams) were combined in five gallons of water.

The field was prepared for transplanting on May 1. Par 4 (9-3-7) fertilizer was applied in a 2-foot wide band over the top of the beds at the rate of 65 lbs N/Acre. Raised beds were formed using a Rain Flo 2600 Plastic Mulch layer and bed shaper. At the time raised beds were formed, plastic mulch (0.9 mil Black Embossed Plastic mulch) and irrigation drip tape were installed, thereby incorporating the fertilizer to a depth of approximately 4-6 inches. Beds were on 12 foot centers, and alleys were maintained with a white clover cover crop (planted 2007) to facilitate weed control and to improve overall soil health and nutrition for long-term field management.

Pumpkins and broccoli were transplanted into a single row; spacing between plants was 36 inches for pumpkins and 18 inches for broccoli. Lettuce was transplanted into a double row;

spacing between rows was 12 inches and spacing between plants in the row was 12 inches. Starting June 1, plants were drip-irrigated every 10 days with 1 inch of water split between two application days. Starting June 17, plants were fertigated at each irrigation application with a mixture of Converted Organics 521 (5-1-1) and 1 lb per acre of Acadian Seaweed Extract. Fertilizer was injected into the irrigation using a Venturi system. Fertigation treatment rates were 4, 8 and 12 pounds N per acre. Plants were fertigated a total of 5 times, and total amount of nitrogen applied by fertigation was 20, 40 and 60 lbs N per acre for the three treatments. Total nitrogen applied per treatment (pre-plant + fertigation) was 85, 105 and 125 lbs N per acre.

At transplanting and each week thereafter for 2 weeks, First Choice Sluggo Snail and Slug Bait (OMRI listed) was applied in each transplant hole at the rate of 9.5 lbs /acre. For weed control, the edge of the plastic mulch was hand hoed every two weeks. White clover in alleys was mowed 3 times every 3 weeks (June 23, July 14 and August 4) to prevent weeds from setting seed, until pumpkin vines grew into alleys and prevented mowing.

Plant color and vigor (as compared with other plants of the same variety) was rated weekly from June 6 until July 17, on a scale of 1 to 5, where 5 was the most healthy/vigorous. Plant diameter (lettuce), plant height (broccoli), and primary vine length (pumpkin) were measured for 10 plants per plot every two weeks, from June 6 to July 14. Total harvested weight and number, and marketable weight and number were measured for each crop.

Several diseases were observed during the season. Galls were found on broccoli stems and roots, plants were stunted, and leaf tissue became necrotic. A total of 8 plants in 4 plots were affected; plants were removed from the field. Plant samples were collected on August 27 and sent to the lab (Oregon State University Extension Service – Botany and Plant Pathology, Corvallis, OR) and crown gall (Agrobacterium tumefaciens) was confirmed. Pumpkins were affected by powdery mildew (Leveillula taurica) starting mid July. The disease started in the eastern most row and progressed across the field, so that by the end of August all rows were affected. No control measures were taken as in general this disease has little impact on yield.

Results:

Cost analysis for fertigation products: Costs per unit nitrogen for organic fertilizer products showed a substantial range, from $4.40 to $187.50 per pound (Table 1). Amount of nitrogen in fertilizer products ranged from 0.4 to 11%. All products included in Table 1 are suitable for fertigation application to vegetable crops according to their labels.

When selecting a fertilizer product for fertigation, there are other considerations to be made in addition to price per unit of nitrogen. Ease of application is important, as some products dissolve easily in water and are rapidly injected into the irrigation system without causing problems such as clogged filters and emitters. Rate of availability of the nitrogen in the fertilizer product is another important consideration. Many of these fertilizer products are derived from soluble fish byproducts and their nitrogen is generally readily available. Salt levels are another important consideration when choosing a fertilizer product. This study did not investigate these issues, and further studies are needed to further characterize each fertilizer product.

Table 1. Cost analysis of confirmed (as of November 1, 2009) organic fertilizer products that can be injected through drip irrigation systems.

Product	Product Cost	Product Unit	Lbs/gal	Price /lb	N Cost ($/lb)
Converted Organics GP 3-2-1	1.45	Gal	9.7	0.15	$5.00
Alaska Salmon Fish Fertilizer	3.00	Gal	9.35	0.32	$6.67
Phytamin 801	6.25	Gal	9.69	0.64	$8.00
Converted Organics XK 2-2-4	1.65	Gal	9.8	0.17	$8.50
BWF Banducci Inc. 3-1-1	2.50	Gal	9.6	0.26	$8.67
BWF Banducci Inc. Secure Organics 4-1-1	3.75	Gal	9.6	0.39	$9.75
Phytamin 522 Fish	5.00	Gal	9.8	0.51	$10.20
BWF Banducci Inc. Organique Exquis 3.5-1-1	3.75	Gal	9.6	0.39	$11.14
Phytamin 434	4.50	Gal	9.6	0.47	$11.75
Converted Organics LC 1-1-1	1.25	Gal	9.1	0.14	$14.00
Converted Organics Pacific Choice 1-4-0	1.25	Gal	8.8	0.14	$14.00
Eco-Nutrients Eco-Hydro Fish 2-4-0.2	3.50	Gal	9.0	0.39	$19.50
BioFert ORGUNIQUE Blood Meal 12-0-0	2.38	Lb		2.38	$19.83
Aqua Power 100 % Fish Emulsion (5 gal.)	11.98	Gal	9.7	1.24	$24.80
Liquid Fish Solubles Foliar Fertilizer 5-1-1	20.00	Gal	9.2	2.17	$43.40
Converted Organics NC 0.4-1-0	1.65	Gal	9.1	0.18	$45.00
Liquid Fish Fertlizer 2-4-0.2	9.99	Gal	10.0	1.00	$50.00
BioFert ORGUNIQUE General Purpose Plant Food 3-2-5	14.72	Gal	9.4	1.57	$52.33
BioFert ORGUNIQUE Tomato & Vegetable Food 3-1-4	14.72	Gal	9.4	1.57	$52.33
BioFert ORGUNIQUE Lawn Food 3-1-5	14.72	Gal	9.4	1.57	$52.33
Drammatic ONE Plant Food 4-4-.5	37.20	Gal	9.6	3.88	$77.60
BioFert BioFish 3-1-2	2.59	Lb		2.59	$86.33
Organic Gem 3-3-3	27.95	Gal	8.5	3.29	$109.67
Earth Juice Grow 2-1-1	23.50	Gal	9.0	2.61	$130.50
Brix Mix Liquid 2-1.8-2.5	24.00	Gal	9.0	2.67	$133.50
Neptune Harvest Liquid Fish 2-4-1	30.00	Gal	11.0	2.73	$136.50
Drammatic Lawns 5-1-2	55.96	Gal	9.6	5.83	$145.75
Drammatic Garden Fertilizer 4-4-1	7.50	Gal	11.0	0.68	$187.50
Converted Organics 521 5-1-1*	2.25	Gal	9.8	0.23	$4.60

[x] Converted Organics 521 5-1-1 was approved for use in certified organic production at time of field trial the initiation in May 2009, but was not confirmed approved as of October 1, 2009. Information is presented here for comparison purposes and in no way implies this product is approved for use in certified organic production in the U.S. at the time of report publication in December 2009.

For our field study, we chose to use the fertilizer product Converted Organics 521 (5-1-1) because it had a relatively high amount of nitrogen per pound (5%) and a relatively low cost ($4.40 per pound N). Converted Organic 521 is a liquid fertilizer with nutrients derived from left over corn bi products using in the wet milling of corn (Corn Steep Water). According to the company, it is composed of 4.89% water soluble nitrogen that is immediately available for plant use (2.17% nitrate nitrogen, 1.22% Ammoniacal nitrogen, 1.50% other water soluble nitrogen). The product was easy to mix with water and to inject through low flow drip irrigation tape with 5/8-inch diameter, 6 mil wall thickness, and 12 inch emitter spacing.

[1]Miles, *et al.*; Washington State University, Vegetable Research & Extension http://vegetables.wsu.edu/

The National Organic Program recently became aware that two liquid organic fertilizer products on the market in the U.S. were not compliant with USDA regulations. The two products were Marizyme and Agrolizer, both made by Port Organic, Ltd. This discovery has sparked a thorough review of liquid organic fertilizers with nitrogen levels higher than 3%. Fertilizers with higher nitrogen percentages must now have documentation provided by a third party inspection, proving that all nitrogen is accounted for organically. Third party reviewers must audit producers based on NOP regulations as a condition of being recognized by the NOP, as well as undergo an audit themselves. These more rigorous measures are intended to help certifiers make the best judgment they can when approving organic fertilizers and other inputs. The product Converted Organics 521 that we used in our field study was not yet confirmed allowable at the time of this report.

Fertigation field study: Plant vigor and color ratings were good (above 4.0) for all crops and all fertigation rates from July 1 onward. However, during the first 3 weeks after transplanting, vigor rating was medium (2.4 – 3.9) for the three crops and was medium-low (2.91-3.25) for lettuce at all fertigation rates. Lettuce tended to have the lowest plant vigor and color ratings of the three crops just after transplanting, however by 1 month after transplanting lettuce plant vigor and color was the same as broccoli and pumpkin. There were essentially no statistical differences in plant vigor and color from transplanting to mid July due to fertigation rate (Tables 2 and 3). Plant diameter (lettuce), plant height (broccoli), and vine length (watermelon) were measured (inches) in the field and essentially no statistical differences were found due to fertigation rate for any of the three crops (Table 4).

Lettuce was harvested in all plots July 20. When plots were evaluated on July 17 (Friday), essentially all plants in the fertigation rates of 40 and 60 lb N/A had reached marketable size whereas only approximately 40% of the plants in fertigation rate 20 lb N/A were of marketable size. Marketable head diameter in the field was determined to be approximately 11-14 inches, and was determined by measuring ten marketable plants. However, at harvest on July 20 (Monday), plants in all fertigation rate plots appeared to have reached marketable size.

Total harvest weight (lbs) and plant number per plot were measured. Plants were then sorted by size for marketability (11-14 inches) and plants that were too small were discarded. Heads of marketable size were inspected for insect and disease contamination (aphids were the primary issue) and physiological disorders, and contaminated plants were discarded. For marketable plants, damaged and unhealthy leaves were trimmed, and marketable harvest weight and number were measured for each plot. Broccoli was harvested from July 24 to August 3, when head diameter was between 6 and 8 inches. At each harvest, total harvest weight (lbs) and number of heads per plot were measured. Heads were inspected for insect, disease contamination and physiological disorders, and marketable heads were trimmed, and marketable weight, number of heads, and head diameter were measured. Afer the main head was harvested, broccoli side shoots were harvested from July 31 to August 17. Side shoots could be marketable at farmers markets, CSAs and other direct market avenues. Pumpkins were harvested on September 21 when green leaf material had died back and the majority of the pumpkins were orange. At harvest total number and total weight (lbs) of the pumpkins were measured. No statistical differences were found in total or marketable yield for any crop due to fertigation rate (Table 5).

[1]Miles, *et al*.; Washington State University, Vegetable Research & Extension
http://vegetables.wsu.edu/

In calculating the partial net returns (cost of the fertigation product per treatment) over fertilizer costs, we found the 40 lb N/A fertigation rate to provide the greatest yield and the greatest partial net return compared to other treatments (Table 6). Growers would need to determine harvesting costs and other additional costs in order to determine if complete net returns would also be greater for this application rate.

Table 2. Plant vigor measured on a scale of 1-5 where 5 was most healthy.

vigor

CROP	RATE	6/18/2009	6/26/2009	7/1/2009	7/10/2009	7/16/2009
Lettuce	**20 lbs N/Acre**	2.69 a	3.33 a	4.79 a	4.91 a	4.95 a
	40 lbs N/Acre	2.46 a	3.35 a	4.61 a	4.95 a	4.99 a
	60 lbs N/Acre	2.56 a	3.45 a	4.85 a	4.96 a	4.96 a
		NS	**NS**	**NS**	**NS**	**NS**
Broccoli	**20 lbs N/Acre**	3.74 a	3.59 a	4.83 ab	4.72 a	4.89 a
	40 lbs N/Acre	3.96 a	4.20 a	4.96 a	4.98 a	4.98 a
	60 lbs N/Acre	3.89 a	4.30 a	4.47 b	4.66 a	4.56 a
		NS	**NS**	**0.05**	**NS**	**NS**
Pumpkin	**20 lbs N/Acre**	2.89 a	3.60 a	4.63 a	4.98 a	4.98 a
	40 lbs N/Acre	2.94 a	3.84 a	4.71 a	5.00 a	5.00 a
	60 lbs N/Acre	2.88 a	4.06 a	4.51 a	4.98 a	4.96 a
		NS	**NS**	**NS**	**NS**	**NS**

Table 3. Plant color ratings on a scale of 1-5 where 5 was most healthy.

CROP	RATE	6/18/2009	6/26/2009	7/1/2009	7/10/2009	7/16/2009
Lettuce	**20 lbs N/Acre**	2.91 a	3.05 a	4.01 a	4.91 a	5.00 a
	40 lbs N/Acre	2.98 a	3.25 a	4.18 a	4.95 a	4.99 a
	60 lbs N/Acre	2.98 a	3.01 a	4.50 a	4.99 a	4.96 a
		NS	**NS**	**NS**	**NS**	**NS**
Broccoli	**20 lbs N/Acre**	4.90 a	4.95 a	4.80 a	4.68 a	4.89 a
	40 lbs N/Acre	4.98 a	5.00 a	4.93 a	4.98 a	4.96 a
	60 lbs N/Acre	4.95 a	4.98 a	4.57 a	4.63 a	4.58 a
		NS	**NS**	**NS**	**NS**	**NS**
Pumpkin	**20 lbs N/Acre**	3.89 a	3.11 a	4.43 a	4.91 a	4.88 b
	40 lbs N/Acre	3.98 a	2.99 a	4.59 a	4.91 a	4.93 ab
	60 lbs N/Acre	3.98 a	2.96 a	4.42 a	4.96 a	4.95 a
		NS	**NS**	**NS**	**NS**	**0.05**

[1]Miles, *et al*.; Washington State University, Vegetable Research & Extension
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Table 4. Plant diameter (lettuce), plant height (broccoli), or vine length (watermelon) measured (inches) in the field.

CROP	RATE	6/18/2009	6/30/2009	7/14/2009
Lettuce	**20 lbs N/Acre**	2.64 a	5.89 a	10.58 b
	40 lbs N/Acre	2.65 a	6.45 a	11.52 a
	60 lbs N/Acre	3.11 a	6.97 a	11.37 ab
		NS	**NS**	**0.05**
Broccoli	**20 lbs N/Acre**	3.82 a	5.17 a	7.58 a
	40 lbs N/Acre	3.80 a	5.47 a	8.02 a
	60 lbs N/Acre	4.38 a	5.31 a	7.35 a
		NS	**NS**	**NS**
Pumpkin	**20 lbs N/Acre**	30.02 a	40.72 a	
	40 lbs N/Acre	29.49 a	40.83 a	
	60 lbs N/Acre	29.96 a	42.59 a	
		NS	**NS**	

Table 5. Total number of heads/fruit, total weight (lbs), marketable number of heads/fruit, marketable weight (lbs), and average head diameter (inches) per plot.

	RATE	Total No. Heads/Fruit	T. Harvest Weight (lbs)	No. Market. Heads/Fruit	Market. Weight (lbs)	Avg. Head Diameter (in)
Lettuce	**20 lbs N/Acre**	15.75 a	17.90 a	12.50 a	14.89 a	
	40 lbs N/Acre	15.75 a	20.13 a	14.00 a	17.14 a	
	60 lbs N/Acre	14.75 a	19.83 a	12.00 a	16.74 a	
		NS	**NS**	**NS**	**NS**	
Broccoli	**20 lbs N/Acre**	19.50 a	41.20 a	17.50 a	31.39 a	6.35 a
	40 lbs N/Acre	19.75 a	39.64 a	19.25 a	38.69 a	6.53 a
	60 lbs N/Acre	18.50 a	40.17 a	17.75 a	32.33 a	6.70 a
		NS	**NS**	**NS**	**NS**	**NS**
Pumpkin	**20 lbs N/Acre**	114.50 a	392.22 a			
	40 lbs N/Acre	118.75 a	406.24 a			
	60 lbs N/Acre	121.50 a	392.48 a			
		NS	**NS**			

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http://vegetables.wsu.edu/

Table 6. Crop yield, value of yield, cost of fertigation product, and simple return per acre for each crop and rate.

CROP	Fert. Rate	Yield lbs/A	$/A	Fert. Cost/A	$ Return
Lettuce	**20 lbs N/Acre**	13,600	7,367	92	7,275
	40 lbs N/Acre	15,232	8,251	184	8,067
	60 lbs N/Acre	13,056	7,072	220	6,852
Broccoli	**20 lbs N/Acre**	8,500	5,313	92	5,221
	40 lbs N/Acre	10,472	6,545	184	6,361
	60 lbs N/Acre	8,772	5,483	220	5,263
Pumpkin	**20 lbs N/Acre**	40,768	15,725	92	15,633
	40 lbs N/Acre	42,224	16,286	184	16,102
	60 lbs N/Acre	40,794	15,735	220	15,515