HS796

Nutrient Solution Formulation for Hydroponic (Perlite, Rockwool, NFT) Tomatoes in Florida[1]

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Plants require 16 elements for growth and these nutrients can be supplied from air, water, and fertilizers. The 16 elements are carbon (C), hydrogen (H), oxygen (O), phosphorus (P), potassium (K), nitrogen (N), sulfur (S), calcium (Ca), iron (Fe), magnesium (Mg), boron (B), manganese (Mn), copper (Cu), zinc (Zn), molybdenum (Mo), and chlorine (Cl). The key to successful management of a fertilizer program is to ensure adequate concentrations of all nutrients throughout the life cycle of the crop. Inadequate or excessive amounts of any nutrient result in poor crop performance. Excessive amounts can be especially troublesome since they can damage the crop, waste money and fertilizer resources, and pollute the environment when fertilizer is released during flushing of the nutrient delivery system.

For Florida greenhouse vegetable producers, management focuses on all nutrients except for C, H, and O. The latter three elements are usually supplied in adequate amounts from air and water. Growers in northern climates, where greenhouses are not ventilated in the winter, see benefits from additions of C from carbon dioxide (CO_2). Increased yields in Florida from additions of CO_2 are unlikely due to the need for frequent ventilation.

Crop demand for nutrients changes through the season. Small amounts of nutrients are needed early, then the demand increases as the crop grows, especially after several clusters of fruit have been set on the plant. A common problem comes early in the season when plants become too vegetative (bullish) from too much N. The bullish growth distorts the leaves and stems, causing cracks and grooves in the stems. These openings are excellent entry ports for decay-causing organisms such as soft rot. Bullish plants usually produce misshapen fruits often with significant amounts of blossom-end rot and cat-facing. Keeping the N level low (60 to 70 parts per million) early in the season helps eliminate bullishness.

High K also can be a problem since it can interfere with the plant's capability to absorb Ca and Mg. Plants exposed to excess K often develop Mg deficiency on the lower leaves and the fruits often develop blossom-end rot (BER), especially early in the season.

Nutrient management programs should begin with an understanding of the nutrient solution concentrations in parts per million (ppm) for the various nutrients required by tomato plants. By managing the concentrations of individual nutrients, growers can control the growth and yield of the crop. Table 1 presents the fertilizer recommendations for tomatoes for the various growth stages during the season in Florida. These recommendations are applicable to all types of production systems (perlite, rockwool, and NFT) in which healthy roots are maintained, and are a suitable base when determining a nutrient solution plan for cucumbers and peppers. However, cucumbers will need more N early in the season than tomato.

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The major elements to manage are N and K for the reasons cited above. The program outlined in Table 1 has been proven in Florida and should provide adequate nutrition and avoid the problems of bullishness as well as the problems of fruit ripening disorders indirectly caused by excess K. Final solution pH should be in the range of 5.8 to 6.2.

One of the first steps in a nutrient management program is to test the well water. A water sample should be analyzed for pH, carbonates, S, Mg, Ca, and Fe. Most well water in Florida has pH greather than 6.5. The pH and carbonates are used to guide in the acidification of the nutrient solution. Water from many wells in Florida contains significant amounts of Ca and often small amounts of Mg. Growers can take advantage of these nutrients, which in the case of Ca, might be 40 to 60 ppm. Some, but probably not all of this Ca is available to the crop.

Sulfur and iron concentrations are determined because they can increase potential for irrigation emitter clogging from bacterial slimes that use the Fe and S for growth. These nutrients generally are not considered in the nutrient formulation calculations.

Formulation Methods

There are basically two methods to supply the fertilizer nutrients to the crop: 1) premixed products, or 2) grower-formulated solutions. The two methods differ in the approach to formulating the fertilizer and the resulting nutrient-use efficiency. Fertilizer materials that can be used for both methods are presented in Table 2. The formulae in this publication are for a final dilution of 1 gallon each stock to 100 gallons of final solution. If using proportioners installed in parallel on one water source line, amounts of fertilizers in stocks will need to be calculated keeping in mind the intended final concentrations.

Pre-Mix Method

There are several commercial pre-mixed fertilizer formulations and some of these generalized formulations are presented in Table 2. Some of these materials contain Mg, some do not. Those that do not will need to be supplemented with magnesium sulfate. All formulations need supplementing with Ca (from calcium nitrate or calcium chloride) and N (from several possible sources). Formulations using these premixed materials that approximate the recommended program are presented in Table 3. In Table 3, the amount of pre-mixed material was chosen to provide adequate P since the pre-mixed material is the only source of P. The pre-mixed materials contain large amounts of K making it difficult to achieve the desired K and Ca concentrations. This could cause an early problem with BER when there is excess K coming from the A stock and a low Ca concentration in the well water (below 50 ppm) because K can interfere with Ca uptake by the root. This problem is common to all pre-mixed formulae. More Ca can be supplied from calcium chloride but it would be better to have lower K concentrations. A related problem is that some of the pre-mixed formulae have too much N in the formulation to allow for providing adequate Ca by adding calcium nitrate. An option to increase the Ca in the solution is to supplement the calcium nitrate stock with calcium chloride. Each pound of calcium chloride (36% Ca) in 30 gallons of stock solution results in a 14 ppm increase in Ca in the final nutrient solution delivered to the plants. The pre-mixed materials come fairly close to providing the desired concentrations of micronutrients, although some are higher than needed in Florida.

Formulation Recipe Method

Information on formulating fertilizer solutions from individual ingredients is presented in Tables 4 and 5. Four formulae are presented to provide options for formulating nutrient solutions depending on grower preference. Formula 1 uses phosphoric acid to provide P and to simultaneously partially acidify the nutrient solution. Additional acidification might be required for some water and this can be accomplished with sulfuric acid. This formula also uses potassium chloride to provide K. There is no problem with using potassium chloride as a partial source of K. It provides K in the same form as potassium nitrate and potassium chloride is less expensive. The chloride ion is not toxic to plants in these amounts provided and some research shows that it contributes to fewer fruits with soft rot Only greenhouse soluble-grade potassium chloride should be used. Formula 1 also uses individual chemicals to provide the micronutrients.

Formula 2 is a variation of formula 1, however, formula 2 uses a pre-mixed micronutrient package, S.T.E.M. (soluble trace element mixture), to supply most of the micronutrients. However, S.T.E.M. does not, alone, provide enough B, Fe, or Mo, so these are supplemented from individual ingredients.

Formula 3 uses monopotassium phosphate to provide the P and some K. Monopotassium phosphate is the most common source of P in the commercial pre-mixed materials. Acidification of the nutrient solution should be accomplished by another acid such as sulfuric acid. Formula 3 also uses potassium chloride and provides the micronutrients from individual ingredients.

Formula 4 uses potassium nitrate to supply all of the K. One potential problem in this formula is that large amounts of N are also supplied with the potassium nitrate and this restricts the amounts of calcium nitrate that can be added. Reducing the calcium nitrate too far might lead to BER unless the well water is supplying some Ca. Supplying some of the K from potassium chloride will allow room for more calcium nitrate.

Products for the formula method are easily obtainable in Florida and this method should result in considerable financial savings, especially for large growers. There is a small amount of extra effort involved in the formula method due to the extra measuring. The resulting higher degree of control over the nutrient supply to the crop should more than pay back any increased effort.

Water-Fertilization Relationship

The nutrient solution formulations presented in this publication were designed for production systems using hydroponic approaches to tomato culture. The media discussed in this publication (perlite, rockwool or NFT) require frequent irrigations during the day, ranging from 10 to 20 cycles per day, depending on the weather and greenhouse environment, in order to maintain about 20% solution leach. It is impossible to have an exact formulation that will work for every production system under any environmental conditions. For example, when using a media of high water-holding capacity, fewer irrigation cycles will be needed during the day. In this situation, the nutrient concentrations in the irrigation water might need to be greater than those presented in this publication so that adequate nutrition is supplied. A general rule-of-thumb is that nutrient concentrations need to be greater in production systems requiring fewer irrigations, compared to systems requiring more frequent irrigations.

Table 1. Fertilizer recommendations for hydroponic (perlite, rockwool, and NFT) tomatoes in Florida.

	Stage of growth				
	1	2	3	4	5
Nutrient	Transplant to 1st cluster	1st cluster to 2nd cluster	2nd cluster to 3rd cluster	3rd cluster to 5th cluster	5th cluster to termination
	-------------- Final delivered nutrient solution concentration (ppm)[z] --------------				
N	70	80	100	120	150
P	50	50	50	50	50
K	120	120	150	150	200
Ca	150	150	150	150	150
Mg	40	40	40	50	50
S	50	50	50	60	60
Fe	2.8	2.8	2.8	2.8	2.8
Cu	0.2	0.2	0.2	0.2	0.2
Mn	0.8	0.8	0.8	0.8	0.8
Zn	0.3	0.3	0.3	0.3	0.3
B	0.7	0.7	0.7	0.7	0.7
Mo	0.05	0.05	0.05	0.05	0.05

NOTE: Ca, Mg, and S concentrations may vary depending on Ca and Mg concentration in wellwater and amount of sulfuric acid used for acidification.
[z] 1 ppm = 1 mg/liter

Table 2. Pre-mixed and individual-salt fertilizer materials for use in hydroponic nutrient solution formulations.

Selected Pre-mixed Materials[z]				
Nutrient	**Pre-mix 1 4-18-38 %**	**Pre-mix 2 3-15-27 %**	**Pre-mix 3 5-11-26 %**	**Pre-mix 4 7-17-37 %**
N	4	3	5	7
P_2O_5 (P)	18 (7.7)	15 (6.5)	11 (4.7)	17 (7.3)
K_2O (K)	38 (32)	27 (22)	26 (22)	37 (31)
Mg	0	5.32	0	0
Fe	0.4	0.45	0.31	0.40
Mn	0.2	0.057	0.05	0.10
Zn	0.05	0.034	0.016	0.02
Cu	0.05	0.011	0.016	0.01
B	0.20	0.170	0.05	0.18
Mo	0.01	0.011	0.01	0.01

Individual Ingredients[y]	
Ammonium nitrate (NH_4NO_3)	33.5% N
Calcium nitrate liquid (7-0-0-11), 12.1 lb/gal ($Ca(NO_3)_2$)	7% N, 11% Ca
Calcium nitrate ($Ca(NO_3)_2$)-dry	15% N, 19% Ca
Calcium chloride ($CaCl_2$)	36% Ca
Potassium nitrate (KNO_3)	13% N, 36.5 K
Monopotassium phosphate (KH_2PO_4)	23% P, 28% K
Phosphoric acid (H_3PO_4), 13 lb./gal.	23% P
Potassium chloride (KCl) - greenhouse	51% K
Magnesium sulfate ($MgSO_4$)	10% Mg, 14% S
Solubor	20.5% B
Copper sulfate ($CuSO_4$)	25% Cu
Zinc sulfate ($ZnSO_4$)	36% Zn
Iron, Fe 330 chelated iron, etc.	10% Fe
Manganous sulfate ($MnSO_4$)	28% Mn
Sodium molybdate ($Na_2(Mo)_4$) (liquid), 11.4 lb/gal	17% Mo
Sodium molybdate (dry) $Na_2(MoO_4)$	39.6% Mo
Soluble Trace Element Mixture (S.T.E.M.)	1.35% B
	7.5% Fe
	8.0% Mn
	0.04% Mo
	4.5% Zn
	3.2% Cu

Convert K_2O to K by multiplying by 0.83. Convert P_2O_5 to P by multiplying by 0.44.
[z] Mention of a trade name does not constitute an endorsement or recommendation.
[y]Exact nutrient concentration of the fertilizer material may vary depending on commercial source.

Table 3. Examples of formulations using pre-mixed commercial materials.

	Stage of growth				
	1	**2**	**3**	**4**	**5**
	Transplant to 1st cluster set	**1st cluster to 2nd cluster**	**2nd cluster to 3rd cluster**	**3rd cluster to 5th cluster**	**5th cluster to termination**
	--------------------------Pre-mix 1 (4-18-38)-----------------------				
	1	2	3	4	5
A Stock	16 lb Pre-mix 1 10 lb $MgSO_4$	16 lb. Pre-mix 1 10 lb $MgSO_4$	16 lb. Pre-mix 1 10 lb $MgSO_4$	16 lb Pre-mix 1 12 lb $MgSO_4$	16 lb Pre-mix 1 12 lb $MgSO_4$
B Stock	7.5 lb $Ca(NO_3)_2$	9.5 lb $Ca(NO_3)_2$	12.0 lb $Ca(NO_3)_2$	16.5 lb $Ca(NO_3)_2$	20.5 lb $Ca(NO_3)_2$
	------------------------Final concentrations (ppm)------------------				
N	70	82	100	124	148
P	49	49	49	49	49
K	200	200	200	200	200
Ca	56	71	94	124	154
Mg	40	40	40	48	48
S	50	50	50	60	60
Fe	2.5	2.5	2.5	2.5	2.5
Cu	0.3	0.3	0.3	0.3	0.3
Mn	1.3	1.3	1.3	1.3	1.3
Zn	0.3	0.3	0.3	0.3	0.3
B	1.3	1.3	1.3	1.3	1.3
Mo	0.06	0.06	0.06	0.06	0.06
	---------------------------------Pre-mix 2 (3-15-27)--------------------------				
A Stock	20 lb Pre-mix 2	20 lb Pre-mix 2	20 lb Pre-mix 2	20 lb Pre-mix 2 2 lb $MgSO_4$	20 lb Pre-mix 2 2 lb $MgSO_4$
B Stock	7.5 lb $Ca(NO_3)_2$	9.2 lb $Ca(NO_3)_2$	12. 4 lb $Ca(NO_3)_2$	15.7 lb $Ca(NO_3)_2$	19 lb $Ca(NO_3)_2$ 2 lb KNO_3
	------------------------Final concentrations (ppm)-------------------------				
N	70	80	100	120	150
P	51	51	51	51	51
K	178	178	178	178	208
Ca	57	69	93	118	143
Mg	42	42	42	50	50
S	(est.) 50	50	50	60	60
Fe	3.6	3.6	3.6	3.6	3.6
Cu	0.09	0.09	0.09	0.09	0.09
Mn	0.45	0.45	0.45	0.45	0.45
Zn	0.27	0.27	0.27	0.27	0.27
B	1.35	1.35	1.35	1.35	1.35
Mo	0.09	0.09	0.09	0.09	0.09
	-------------------------Pre-mix 3 (5-11-26)---------------------------				
	1	2	3	4	5
A Stock	27 lb Pre-mix 3 10 lb $MgSO_4$	27 lb Pre-mix 3 10 lb $MgSO_4$	27 lb Pre-mix 3 10 lb $MgSO_4$	27 lb Pre-mix 3 12 lb $MgSO_4$	27 lb Pre-mix 3 12 lb $MgSO_4$
B Stock	2.8 lb $Ca(NO_3)_2$	4.4 lb $Ca(NO_3)_2$	7.7 lb $Ca(NO_3)_2$	11 lb $Ca(NO_3)_2$	16 lb $Ca(NO_3)_2$
	---------------------Final concentrations (ppm)---------------------				
N	70	80	100	120	150

	Stage of growth				
	1	**2**	**3**	**4**	**5**
	Transplant to 1st cluster set	**1st cluster to 2nd cluster**	**2nd cluster to 3rd cluster**	**3rd cluster to 5th cluster**	**5th cluster to termination**
P	51	51	51	51	51
K	232	232	232	232	232
Ca	21	33	58	83	120
Mg	40	40	40	50	50
S	50	50	50	60	60
Fe	3.3	3.3	3.3	3.3	3.3
Cu	0.17	0.17	0.17	0.17	0.17
Mn	0.55	0.55	0.55	0.55	0.55
Zn	0.17	0.17	0.17	0.17	0.17
B	0.55	0.55	0.55	0.55	0.55
Mo	0.11	0.11	0.11	0.11	0.11
	----------------------Pre-mix 4 (7-17-37)----------------------				
	1	2	3	4	5
A Stock	17 lb Pre-mix 4 10 lb $MgSO_4$	17 lb Pre-mix 4 10 lb $MgSO_4$	17 lb Pre-mix 4 10 lb $MgSO_4$	17 lb Pre-mix 4 12 lb $MgSO_4$	17 lb Pre-mix 4 12 lb $MgSO_4$
B Stock	4 lb $Ca(NO_3)_2$	6 lb $Ca(NO_3)_2$	9 lb $Ca(NO_3)_2$	12 lb $Ca(NO_3)_2$	17 lb $Ca(NO_3)_2$
	------------------------Final concentrations (ppm)---------------------				
N	71	83	101	119	149
P	49	49	49	49	49
K	208	208	208	208	208
Ca	30	45	67	89	127
Mg	40	40	40	48	48
S	50	50	50	60	60
Fe	2.7	2.7	2.7	2.7	2.7
Cu	0.07	0.07	0.07	0.07	0.07
Mn	0.67	0.67	0.67	0.67	0.67
Zn	0.14	0.14	0.14	0.14	0.14
B	1.2	1.2	1.2	1.2	1.2
Mo	0.07	0.07	0.07	0.07	0.07

NOTE: Calculations in above table are for amount of fertilizer material in 30-gal stock tanks and then for a 1:100 dilution (1 gal each stock in 100 gals final nutrient solution). Fertilizer amounts placed in each stock tank will need to be doubled if fertilizer proportioner (1:100) pumps are installed in parallel in same incoming water line.
Ca, Mg, and S values will vary upwards depending on the amount of Ca and Mg coming from the water source, and the of S coming from the sulfuric acid used for acidification.

Table 4. The following list provides the ppm of a specific nutrient provided by a specified amount of a particular fertilizer material for a 30-gal stock tank and a final dilution of 1:100.

Amount of material	Material	ppm nutrient provided
1 lb	Potassium nitrate	5 ppm N 14.5 ppm K
1 lb	Ammonium nitrate	13.3 ppm N
1 lb	Potassium chloride	20.3 ppm K
1 lb	Magnesium sulfate	4 ppm Mg 5.6 ppm S
1 pint	Liquid calcium nitrate	4.2 ppm N 6.6 ppm Ca
1 lb	Dry calcium nitrate	6.1 ppm N 7.5 ppm Ca
1 lb	Calcium chloride	14.3 ppm Ca
1 quart	Phosphoric acid	30 ppm P
1 gram[z]	Solubor	0.018 ppm B
0.5 lb	Fe 330 chelated iron	2.0 ppm Fe
100 grams	S.T.E.M.	0.12 ppm B 0.28 ppm Cu 0.66 ppm Fe 0.70 ppm Mn 0.0035 ppm Mo 0.39 ppm Zn
1 gram	Copper sulfate	0.021 ppm Cu
1 gram	Manganese sulfate	0.024 ppm Mn
1 gram	Zinc sulfate	0.03 ppm Zn
1 ml	Liquid sodium molybdate	0.02 ppm Mo
1 gram	Dry sodium molybdate	0.03 ppm Mo
1 lb	Monopotassium Phosphate	9 ppm P 11 ppm K

[z]A gram scale or laboratory pipette will be needed to measure amounts of micronutrients or to calibrate a measuring spoon set to provide the correct amount of micronutrient materials. The following are some approximate equivalences for measuring dry fertilizer materials.

	Approximate weight (grams) for several measuring utensils		
Fertilizer	**1 teaspoon (level)**	**1 tablespoon (level)**	**1 dry "ounce" in measuring cup**
Sequestrene Fe 330	4	14	20
Ammonium molybdate	7	-	-
Sodium molybdate	4	-	-
Solubor	2	6	10
S.T.E.M.	5	14	25
Manganese sulfate	6	16	30
Zinc sulfate	5	13	26
Copper sulfate	7	20	35

Table 5. Several examples of tomato nutrient solution formulations using the "formula method" with individual ingredients.

	Stage of growth				
	1	**2**	**3**	**4**	**5**
	Transplant to 1st cluster	**1st cluster to 2nd cluster**	**2nd cluster to 3rd cluster**	**3rd cluster to 5th cluster**	**5th cluster to termination**
	---------------------------------**FORMULA 1**------------------------------				
A Stock	3.3 pts Phos. acid	3.3 pts Phos. acid	3.3 pts Phos. acid	3.3 pts Phos. acid	3.3 pts Phos. acid
	6 lb KCl 10 lb $MgSO_4$	6 lb KCl 10 lb $MgSO_4$	6 lb KCl 10 lb $MgSO_4$ 2 lb KNO_3	6 lb KCl 12 lb $MgSO_4$ 2 lb KNO_3	6 lb KCl 12 lb $MgSO_4$ 6 lb KNO_3 1 lb NH_4NO_3
	10 gr $CuSO_4$ 35 gr $MnSO_4$ 10 gr $ZnSO_4$ 40 gr Solubor 3 ml Na Moly	10 gr $CuSO_4$ 35 gr $MnSO_4$ 10 gr $ZnSO_4$ 40 gr Solubor 3 ml Na Moly	10 gr $CuSO_4$ 35 gr $MnSO_4$ 10 gr $ZnSO_4$ 40 gr Solubor 3 ml Na Moly	10 gr $CuSO_4$ 35 gr $MnSO_4$ 10 gr $ZnSO_4$ 40 gr Solubor 3 ml Na Moly	10 gr $CuSO_4$ 35 gr $MnSO_4$ 10 gr $ZnSO_4$ 40 gr Solubor 3 ml Na Moly
B Stock	2.1 gal $Ca(NO_3)_2$	2.4 gal $Ca(NO_3)_2$	2.7 gal $Ca(NO_3)_2$	3.3 gal $Ca(NO_3)_2$	3.3 gal $Ca(NO_3)_2$
	or 11.5 lb dry $Ca(NO_3)_2$	or 13.1 lb dry $Ca(NO_3)_2$	or 14.8 lb dry $Ca(NO_3)_2$	or 18.0 lb dry $Ca(NO_3)_2$	or 18.0 lb dry $Ca(NO_3)_2$
	0.7 lb Fe 330	0.7 lb Fe 330	0.7 lb Fe 330	0.7 lb Fe 330	0.7 lb Fe 330
	---------------------**Final concentrations (ppm)**-----------------------				
N	70	80	100	120	153
P	50	50	50	50	50
K	119	119	148	148	206
Ca	111 (86)[z]	127 (98)	143 (111)	174 (135)	174 (135)
Mg	40	40	40	48	48
S	56	56	56	66	66
Fe	2.8	2.8	2.8	2.8	2.8
Cu	0.2	0.2	0.2	0.2	0.2
Mn	0.8	0.8	0.8	0.8	0.8
Zn	0.3	0.3	0.3	0.3	0.3
B	0.7	0.7	0.7	0.7	0.7
Mo	0.06	0.06	0.06	0.06	0.06
	--------------------------------**FORMULA 2**------------------------------				
A Stock	3.3 pts Phos. acid	3.3 pts Phos. acid	3.3 pts Phos. acid	3.3 pts Phos. acid	3.3 pts Phos. acid
	6 lb KCl 10 lb $MgSO_4$	6 lb KCl 10 lb $MgSO_4$	6 lb KCl 10 lb $MgSO_4$ 2 lb KNO_3	6 lb KCl 12 lb $MgSO_4$ 2 lb KNO_3	6 lb KCl 12 lb $MgSO_4$ 6 lb KNO_3 1 lb NH_4NO_3
	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly
B Stock	2.1 gal $Ca (NO_3)_2$	2.4 gal $Ca (NO_3)_2$	2.7 gal $Ca (NO_3)_2$	3.3 gal $Ca (NO_3)_2$	3.3 gal $Ca (NO_3)_2$
	or 11.5 lb dry $Ca (NO_3)_2$	or 13.1 lb dry $Ca (NO_3)_2$	or 14.8 lb dry $Ca (NO_3)_2$	or 18.0 lb dry $Ca (NO_3)_2$	or 18.0 lb dry $Ca (NO_3)_2$
	0.5 lb Fe 330	0.5 lb Fe 330	0.5 lb Fe 330	0.5 lb Fe 330	0.5 lb Fe 330
	--------------------------**final concentrations (ppm)**-------------------------				
N	70	80	100	120	150

	Stage of growth				
	1	2	3	4	5
	Transplant to 1st cluster	**1st cluster to 2nd cluster**	**2nd cluster to 3rd cluster**	**3rd cluster to 5th cluster**	**5th cluster to termination**
P	50	50	50	50	50
K	119	119	148	148	206
Ca	111 (86)[z]	127 (98)	143 (111)	174 (135)	174 (135)
Mg	40	40	40	48	48
S	56	56	56	66	66
Fe	2.7	2.7	2.7	2.7	2.7
Cu	0.28	0.28	0.28	0.28	0.28
Mn	0.7	0.7	0.7	0.7	0.7
Zn	0.39	0.39	0.39	0.39	0.39
B	0.84	0.84	0.84	0.84	0.84
Mo	0.06	0.06	0.06	0.06	0.06
--------------------------------**FORMULA 3**--------------------------------					
A Stock	5.5 lb KH_2PO_4 4 lb KNO_3 10 lb $MgSO_4$	5.5 lb KH_2PO_4 4 lb KNO_3 10 lb $MgSO_4$	5.5 lb KH_2PO_4 5 lb KNO_3 10 lb $MgSO_4$ 1 lb KCl	5.5 lb KH_2PO_4 8 lb KNO_3 12 lb $MgSO_4$ 1 lb KCl	5.5 lb KH_2PO_4 8 lb KNO_3 12 lb $MgSO_4$ 1 lb KCl 2 lb NH_4NO_3
	10 gr Cu SO_4 35 gr Mn SO_4 10 gr Zn SO_4 40 gr Solubor 3 ml Na Moly	10 gr Cu SO_4 35 gr Mn SO_4 10 gr Zn SO_4 40 gr Solubor 3 ml Na Moly	10 gr Cu SO_4 35 gr Mn SO_4 10 gr Zn SO_4 40 gr Solubor 3 ml Na Moly	10 gr Cu SO_4 35 gr Mn SO_4 10 gr Zn SO_4 40 gr Solubor 3 ml Na Moly	10 gr Cu SO_4 35 gr Mn SO_4 10 gr Zn SO_4 40 gr Solubor 3 ml Na Moly
B Stock	1.5 gal $Ca(NO_3)_2$	1.8 gal $Ca(NO_3)_2$	2.2 gal $Ca(NO_3)_2$	2.4 gal $Ca(NO_3)_2$	2.5 gal $Ca(NO_3)_2$
	or 8.2 lb dry $Ca(NO_3)_2$	or 9.8 lb dry $Ca(NO_3)_2$	or 12.3 lb dry $Ca(NO_3)_2$	or 13.1 lb dry $Ca(NO_3)_2$	or 13.7 lb dry $Ca(NO_3)_2$
	0.7 lb Fe 330	0.7 lb Fe 330	0.7 lb Fe 330	0.7 lb Fe 330	0.7 lb Fe 330
	-----------------------**Final concentrations (ppm)**----------------------				
N	70	80	100	120	150
P	50	50	50	50	50
K	119	119	153	153	196
Ca	79 (61)[z]	94 (74)	118 (92)	126 (98)	131 (103)
Mg	40	40	40	48	48
S	56	56	56	66	66
Fe	2.8	2.8	2.8	2.8	2.8
Cu	0.2	0.2	0.2	0.2	0.2
Mn	0.8	0.8	0.8	0.8	0.8
Zn	0.3	0.3	0.3	0.3	0.3
B	0.7	0.7	0.7	0.7	0.7
Mo	0.06	0.06	0.06	0.06	0.06
---------------------------**FORMULA 4**---------------------------					
A Stock	3.3 pts Phos. acid 8.3 lb KNO_3 10 lb $MgSO_4$	3.3 pts Phos. acid 8.3 lb KNO_3 10 lb $MgSO_4$	3.3 pts Phos. acid 10.3 lb KNO_3 10 lb $MgSO_4$	3.3 pts Phos. acid 10.3 lb KNO_3 12 lb $MgSO_4$	3.3 pts Phos. acid 13.8 lb KNO_3 12 lb $MgSO_4$

	Stage of growth				
	1	**2**	**3**	**4**	**5**
	Transplant to 1st cluster	**1st cluster to 2nd cluster**	**2nd cluster to 3rd cluster**	**3rd cluster to 5th cluster**	**5th cluster to termination**
	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly	100 gr S.T.E.M. 40 gr Solubor 3 ml Na Moly
B Stock	6.7 pt $Ca(NO_3)_2$	9 pt $Ca(NO_3)_2$	11.4 pt $Ca(NO_3)_2$	2 gal $Ca(NO_3)_2$	2.4 gal $Ca(NO_3)_2$
	or 4.6 lb dry $Ca(NO_3)_2$	or 6.2 lb dry $Ca(NO_3)_2$	or 7.9 lb dry $Ca(NO_3)_2$	or 11.1 lb dry $Ca(NO_3)_2$	or 13.3 lb dry $Ca(NO_3)_2$
	0.7 lb Fe 330	0.7 lb Fe 330	0.7 lb Fe 330	0.7 lb Fe 330	0.7 lb Fe 330
	---------------------Final concentrations (ppm)------------------------				
N	70	80	100	120	150
P	50	50	50	50	50
K	120	120	150	150	200
Ca	44 (35)[z]	59 (47)	75 (59)	105 (83)	127 (100)
Mg	40	40	40	48	48
S	56	56	56	67	67
Fe	2.7	2.7	2.7	2.7	2.7
Cu	0.28	0.28	0.28	0.28	0.28
Mn	0.7	0.7	0.7	0.7	0.7
Zn	0.39	0.39	0.39	0.39	0.39
B	0.84	0.84	0.84	0.84	0.84
Mo	0.06	0.06	0.06	0.06	0.06

[z] Numbers in parentheses are the ppm Ca when dry $Ca(NO_3)_2$ is used instead of liquid.
NOTE: Calculations in above table are for amount of fertilizer material in 30-gal stock tanks and then for a 1:100 (1 gal each stock in 100 gals final nutrient solution). Fertilizer amounts placed in each stock tank will need be doubled if proportioner (1:100) pumps are installed in parallel in same incoming water line.
Ca, Mg, and S values will vary upwards depending on the amount of Ca and Mg coming from the water source, and the amount of S coming from the sulfuric acid used for acidification.