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Utah Monocot/Dicot Solution

Bruce Bugbee
Utah State University, bruce.bugbee@usu.edu

Noah Langenfeld
Utah State University, noah.langenfeld@usu.edu

UTAH HYDROPONIC SOLUTIONS

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The Utah Hydroponic solutions were developed using mass balance principles coupled with tissue analysis from studies in 25-cm deep, continuously aerated, liquid hydroponics. Because there is no solid phase (soil-less media) in liquid hydroponics, there is no absorption or desorption with media.

These solutions provide guidelines, but are not necessarily appropriate for use with soilless media where cation exchange capacity and thus absorption and desorption with the media can be significant.

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Elemental Concentration for Dicots

	Starter solution		Refill solution	
Element	**[mM]**	**[ppm]**	**[mM]**	**[ppm]**
***NO_3^-**	**5.5**	**78**	**5.8**	**81**
***NH_4^+**	**-**	**-**	**0.25**	**3.5**
P	**0.2**	**6.2**	**0.4**	**12**
K	**2.8**	**110**	**3**	**117**
Ca	**1.5**	**60**		
Mg	**0.8**	**19**		
S	**0.8**	**26**		
Si	**0.3**	**8.4**		
	[μM]	**[ppm]**	**[μM]**	**[ppm]**
Fe	**25**	**1.4**	**10**	**0.6**
B	**40**	**0.4**		
Mn	**3**	**0.2**		
Zn	**3**	**0.2**		
Cu	**2**	**0.1**		
Cl	**29**	**1.0**		
Mo	**0.1**	**9.6 ppb**		
Ni	**0.1**	**0.2 ppt****		

No Change

No Change

* Additional nitrogen comes from pH control.
The pH control solution is 50 mM nitric acid and 200 mM ammonium sulfate.
Lettuce and tomato receive about 20% additional N from pH control.
With the added N from pH control the effective N is about 100 ppm.

**ppt = parts per trillion for nickel

Elemental Concentration for Monocots

Element	STARTER [mM]	STARTER [ppm]	VEGETATIVE REFILL [mM]	VEGETATIVE REFILL [ppm]	GRAIN-FILL REFILL [mM]	GRAIN-FILL REFILL [ppm]
*NO_3^-	5.5	78	5.8	81	2.7	37
*NH_4^+	-	-	0.25	3.5	0.13	1.8
P	0.05	1.6	0.4	12	0.4	12
K	2.7	104	3	117	2	78
Ca	1.5	60	No Change		0.5	20
Mg	0.8	19			0.3	7.3
S	0.8	26			0.3	9.6
Si	0.3	8.4			0.3	8.4
	[µM]	[ppm]	[µM]	[ppm]	[µM]	[ppm]
Fe	55	3.1	10	0.6	8	0.4
B	40	0.4	No Change		40	0.4
Mn	3	0.2			3	0.2
Zn	3	0.2			3	0.2
Cu	2	0.1			2	0.1
Cl	29	1.0			22	0.8
Mo	0.1	9.6 ppb			0.1	9.6 ppb
Ni	0.1	0.2 ppt**			0.1	0.2 ppt*

* Additional nitrogen comes from pH control.
The pH control solution is 50 mM nitric acid and 200 mM ammonium sulfate.
Plants receive about 20% additional N from pH control.
With the added N from pH control the total effective N during early growth is about 100 ppm.

**ppt = parts per trillion for nickel

Elemental Concentration for *Cannabis*

	Starter solution		Refill solution	
Element	**[mM]**	**[ppm]**	**[mM]**	**[ppm]**
***NO_3^-**	**5.5**	**78**	**5.8**	**81**
***NH_4^+**	**-**	**-**	**0.25**	**3.5**
P	**1**	**31**		
K	**3.6**	**140**		
Ca	**1.5**	**60**		
Mg	**0.8**	**19**	**No Change**	
S	**0.8**	**26**		
Si	**0.6**	**17**		
	[µM]	**[ppm]**	**[µM]**	**[ppm]**
Fe	**25**	**1.4**	**10**	**0.6**
B	**40**	**0.4**		
Mn	**3**	**0.2**		
Zn	**3**	**0.2**		
Cu	**2**	**0.1**	**No Change**	
Cl	**29**	**1.0**		
Mo	**0.1**	**9.6 ppb**		
Ni	**0.1**	**0.2 ppt****		

* Additional nitrogen comes from pH control.
The pH control solution is 50 mM nitric acid and 200 mM ammonium sulfate.
Plants receive about 20% additional N from pH control.
With the added N from pH control the effective N is about 100 ppm.

**ppt = parts per trillion for nickel

Dicot and Monocot Mixing Instructions

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		STARTER First Fill Only		VEGETATIVE GROWH Refill		GRAIN FILL Refill	
Compound	STOCK CONC. [Molar]	mL per 100 L	FINAL CONC. mM	mL per 100 L	FINAL CONC. mM	mL per 100 L	FINAL CONC. mM
$Ca(NO_3)_2$	1	150	1.5	150	1.5	50	0.5
NH_4NO_3	0.25	-	-	100	0.25	50	0.13
KNO_3	1	200	2	200	2	100	1
KH_2PO_4	0.2	100 DICOT 25 MONOCOT	0.2 0.05	200	0.4	200	0.4
$MgSO_4$	0.5	160	0.8	160	0.8	60	0.3
K_2SiO_3	0.1	300	0.3	300	0.3	300	0.3
HNO_3	1	54 DICOT 59 MONOCOT	0.54 0.59	54 59	0.54 0.59	54 59	0.54 0.59
	[mMolar]		µM		µM		µM
$FeCl_3$	50	10	5	10	5	5	2.5
Fe-DTPA (Sequestrene 330)	25	80 DICOT	20	20 (DTPA)	5	20 (DTPA)	5
Fe-HEDTA	250	20 MONOCOT	50				
$MnCl_2$	20	15	3	15	3	15	3
$ZnCl_2$	30	10	3	10	3	10	3
H_3BO_3	400	10	40	10	40	10	40
$CuCl_2$	20	10	2	10	2	10	2
Na_2MoO_4	1	10	0.1	10	0.1	10	0.1
$NiCl_2$	1	10	0.1	10	0.1	10	0.1
Final EC (mS/cm)		0.95		1.00		0.85	

Notes

Nitrogen

pH is automatically controlled with a pH electrode, controller, and solenoid. These add frequent, small amounts of acid to maintain steady pH. The additions are triggered every 5 to 10 min. and add about 2 mL of acid each dose. The pH control solution is 50 mM nitric acid and 200 mM ammonium sulfate. Plants receive about 20% of their nitrogen from pH control.

Phosphorous

Phosphorus (P) concentration in the Starter solution is low to minimize Fe precipitation as $FePO_4$. This is especially important with monocots like corn. The concentration of P is less than 0.01 mM (10 µM) in field soil solution, but this is continuously replenished from the solid phase.

Potassium Silicate – Reagent Grade

To make a 0.1 M stock solution, dissolve 11.22 g KOH per liter of water. Add 6.01 g fumed silica per liter of water. Mix until dissolved/clear (~4 hrs. at 80 °C or ~12 hrs. at 25 °C).

Initial pH

K_2SiO_3 is highly alkaline, causing the pH of the solution to increase. Nitric acid is used to adjust pH down to 5 in monocots to minimize iron chlorosis and 5.8 in dicots. Dicots rarely suffer from iron chlorosis.

History of changes since 2009

November 2015: Reduced Mn and Zn concentrations by half to reduce accumulation in plant tissue.

January 2017: Reduced Cu from 4 to 2 µM to reduce accumulation in tissue. Reduced concentration of EDDHA stock solution to make it more soluble. Increased HEDTA from 25 to 50 µM and KH_2PO_4 from 0.02 to 0.05 mM.

June 2018: Increased boron (B) in monocot solution from 4 to 40 µM; 4 µM provides adequate B for monocots but 40 µM may not be toxic; and the vegetative and reproductive solutions are now identical. Combined monocot and dicot tables for simplicity.

July 2020: Decreased KNO_3 and increased $Ca(NO_3)_2$ to give more Ca and less K. Determined initial HNO_3 volumes. Adjusted $MgSO_4$ to provide the same concentration in initial and refill solutions.

August 2020: Changed from Sequesterene 138 to FerriPlus EDDHA to improve solubility. Switched from EDDHA to DTPA to remove solution color.

December 2020: Added Ni to solution to ensure availability. Added ammonium nitrate as a source of ammonium.

January 2021: Switched from AgSil16H to Fumed Silica as a Si source to minimize Pb contamination.

March 2021: Increased Mn concentration from 2 to 3 µM to increase Mn in plant tissue.