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 We use this protocol and it's working

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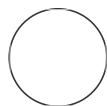
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Nutrient solution for rice hydroponics culture

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ABSTRACT

This represents a heavily modified Yoshida's solution. Compared to Yoshida's formulation, this solution has almost the same concentration of macro and micronutrients, but the formulation has been simplified. Key advantages:

- * The solution is now formulated as three solutions at 1000× concentration, greatly simplifying dilution.
- * The solution is less acidic than Yoshida's formulation, reducing the amount of hydroxide required to adjust pH.
- * The solution eliminates Na⁺ and almost all Cl⁻ from the medium, allowing independent investigation of toxicities of these ions. In addition much of the K⁺ is supplied as KOH, potentially allowing control of the Na/K ratio independently of absolute concentrations and of Cl⁻ levels.

MATERIALS

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-  Zinc sulfate heptahydrate **Sigma Aldrich Catalog #204986**
-  Manganese(II) chloride tetrahydrate **Sigma Aldrich Catalog #M3634**
-  500g Potassium Phosphate (Monobasic) **G-Biosciences Catalog #RC-083**
-  citric acid monohydrate **Sigma-aldrich Catalog #33114**
-  Boric acid **Bio Basic Inc. Catalog #BB0044.SIZE.500g**
-  Calcium nitrate tetrahydrate **Bio Basic Inc. Catalog #CB0258.SIZE.500g**
-  Copper (II) sulfate pentahydrate **Bio Basic Inc. Catalog #CDB0063.SIZE.500g**
-  Iron chloride (Ferric chloride), hexahydrate **Bio Basic Inc. Catalog #FD0201.SIZE.250g**
-  Magnesium sulfate, heptahydrate, ACS **Bio Basic Inc. Catalog #MB0329.SIZE.500g**
-  Potassium hydroxide **Bio Basic Inc. Catalog #PB0441.SIZE.500g**
-  Sulfuric Acid (H₂SO₄) **Contributed by users**
-  Sodium metasilicate nonahydrate **Sigma Aldrich Catalog #S4392-250G**

⊗ Ammonium sulfate **Sigma Aldrich Catalog #A5132-1KG**

⊗ Ammonium molybdate tetrahydrate **Sigma Aldrich Catalog #A7302-500G**

Solution A, 1000× (Macro and micronutrients, minus Ca, Mg and Si)

Common name	Formula	[Stock] (g/mol)	[Final] (M)	g/L	g/2L	Element
Sulfuric acid (5M stock, diluted from concentrated; ~18M)	H ₂ SO ₄	5.00 M	0.8510	170.2 mL	340.4 mL	S
Ammonium sulfate	(NH ₄) ₂ SO ₄	132.1400	0.6753	89.23	178.46	NH ₄ , S
Potassium phosphate monobasic	KH ₂ PO ₄	136.0855	0.3225	43.89	87.77	K, P
Potassium hydroxide	KOH	56.1056	0.7020	39.39	78.77	K
Citric acid, monohydrate	C ₆ H ₈ O ₇ ·H ₂ O	210.1388	0.0708	14.87	29.750	
Ferric chloride, 6-Hydrate	FeCl ₃ ·6H ₂ O	270.2964	0.0356	9.62	19.250	Fe
Manganous chloride, 4-hydrate	MnCl ₂ ·4H ₂ O	197.9052	0.0094742	1.88	3.750	Mn
Ammonium molybdate, 4-Hydrate	(NH ₄) ₆ Mo ₇ O ₂₄ ·4H ₂ O	1235.8577	0.0000749	0.0925	0.1851	Mo
Zinc sulfate, 7-hydrate	ZnSO ₄ ·7H ₂ O	287.5796	0.0001521	0.0437	0.0875	Zn
Boric acid	H ₃ BO ₃	61.8330	0.0189	1.17	2.335	B
Cupric sulfate, 5-Hydrate	CuSO ₄ ·5H ₂ O	249.6860	0.0001553	0.0388	0.0775	Cu

Solution B, 1000× (Ca, nitrate)

Common name	Formula	[Stock] (g/mol)	[Final] (M)	g/L	g/2L	Element
Calcium nitrate, tetrahydrate	Ca(NO ₃) ₂ ·4H ₂ O	236.1490	0.9978	235.62	471.25	Ca, NO ₃

Solution C, 1000× (Mg, S)

Common name	Formula	[Stock] (g/mol)	[Final] (M)	g/L	g/2L	Element
Magnesium sulfate, 7-hydrate	MgSO ₄ ·7H ₂ O	246.4756	1.6432	405.00	810.00	Mg, S

Elemental comparison with Yoshida's original formulation

	Nutrient	Yoshida's [Final] (mM)	Modified [Final] (mM)	Difference (mM)	Percentage of original	Fold change (×)
	Na	0.322482	0.031668	-0.290814	9.82%	0.098×
	K	1.024330	1.024482	0.000151	100.01%	1×
	N	2.855149	3.346067	0.490918	117.19%	1.171×
	NH ₄	1.427799	1.350516	-0.077283	94.59%	0.945×
	NO ₃	1.427350	1.995551	0.568201	139.81%	1.398×
	PO ₄	0.322482	0.322482	0.000000	100.00%	1×
	SO ₄	3.324387	3.169730	-0.154657	95.35%	0.953×
	Ca	0.997775	0.997775	0.000000	100.00%	1×
	Mg	1.643165	1.643165	0.000000	100.00%	1×
	Mn	0.009474	0.009474	0.000000	100.00%	1×
	Mo	0.000524	0.000524	0.000000	100.04%	1×
	Zn	0.000152	0.000152	0.000000	100.00%	0.999×
	H ₃ BO ₃	0.018881	0.018882	0.000000	100.00%	1×
	Cu	0.000155	0.000155	0.000000	100.04%	1×
	Fe	0.035609	0.035609	0.000000	100.00%	0.999×
	Cl	2.130801	0.125775	-2.005025	5.90%	0.059×
	Si	0.015834	0.015834	0.000000	100.00%	1×
	Citrate		0.000071			

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SAFETY WARNINGS

- ! The formulation makes use of 5M sulfuric acid. This is prepared by diluting concentrated sulfuric acid (~18M) to achieve the final 5M stock. Diluting strong acids is hazardous and appropriate protocols should be followed.

Solution A, 1000× (Main macro and micronutrients)

- 1 Make this solution up as a SINGLE stock solution. For 1L of stock solution,
 - * Start with ~600mL de-ionised water.
 - * Weigh out and dissolve each component (except ferric chloride and citric acid) directly in the 600mL solution. Allow each to dissolve completely before adding the next.
 - * For the KOH, add pellets slowly, a few at a time, with constant mixing.
 - * Dissolve the citric acid separately in 100mL de-ionised water. Dissolve the ferric chloride 6-hydrate directly in the citric acid solution. Stir the ferric chloride-citrate solution for 15 minutes, then add slowly to the main stock solution while stirring.
 - * Make up to 1L.

Solution B, 1000× (Ca, NO₃)

- 2 For 1L of stock solution, dissolve the calcium nitrate 4-hydrate directly in 700mL de-ionised water. Make up to 1L.

Solution C, 1000× (Mg, S)

- 3 For 1L of stock solution, dissolve the magnesium sulfate 7-hydrate in 700mL de-ionised water. Make up to 1L.

Solution D, 1000× (silicon)

- 4 (Optional): For 1L of stock solution, dissolve 4.50g sodium metasilicate 9-hydrate in 700mL de-ionised water. Make up to 1L.
The sodium metasilicate can also be weighed out and dissolved directly in the growth medium at the time of preparation.

Preparation of hydroponics medium

- 5 For 100L of 1× hydroponics solution:
 - * Prepare ~90L of water.
 - * Mix in 100mL of each stock solution, mixing well before adding next stock solution.
 - * Add sodium metasilicate 9-hydrate (0.00450g/L) and dissolve with stirring, if not done as solution D.
 - * Adjust pH to 5.5
 - * Dispense to growth trays.
- 6 Monitor and adjust pH of stock solution daily at pH 5.5 with KOH/HCl as required.
Refresh stock solution twice per week.