

pH Defied

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Preface

Breakthrough Technology has dramatically changed the landscape of agronomy, growing vegetation. An industry that has come to rely, depend and prescribe meager solutions has shifted into the 21st century, like email, blue-tooth, Wi-Fi, electronic banking and moreover the internet to name a few have changed our world.

This document conveys what these dependencies are, namely sulfuric acids, gypsum (calcium Sulfate) and pH, how we depend on them, why over time they fail us and the shift in chemistry that replaces these three items which cause vegetation vitality like never experience before.

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pH Defied

Do most roots chase nutrition, or do they chase hydration? What's in that hydration? What's your actual water irrigation water contain versus the lab water results? What does rain make available from your soil, at what stage of the rainfall, and do you contemplate the value it brings from dissolved oxygen?

Are the most soluble elements in soil toxic (Na, Cl), and the least soluble essential Ca, K, P?

Are we assessing the impact of bacteria, their colonies that form, the slime barriers they create and the toxic wastes they produce?

How much impact does dissolved oxygen have in water, the aerification of soils and in agriculture?

If you have plenty of calcium and sulfate in your soil, should we be adding more calcium & sulfate (gypsum) because our tissue is deficient of essential calcium or should we figure out how to harvest what you already bought that is locked up in your soil that acid is not making available for your plant?

Are you acting on available nutrition by the Soil Paste Extraction method that shows how much of your nutrients are available in lab water? Or are you looking at your available nutrition using your actual water, treated? Do you understand the difference between what's available with lab or your treated irrigation water, versus how much of these nutrients are actually locked up in your soil?

Soil Analyses

Available Nutrition -vs- Exchangeable Cations

The soil analysis "method" of Exchangeable Cations reveals the total amount of minerals in your soil and most the time it is substantially much greater than what you see in the "method" of Soil Paste Extraction, commonly referred to as Available Nutrition which is just showing you what the lab water (or irrigation water, depending what is specified by the grower) will release. There may be perhaps a few years of nutrition bound in the soil that could be harvested if it could be released. Not all analyses give you this data, you have to know what to ask for. When it is offered, usually the Soil Paste extraction is represented as Avail. and the Extractable Cations is represented as Exchangeable. One phase of the WaterSOLV™ Program is designed to gradually harvest the Exchangeable cations.

Current acids leave more calcium and sulfate in the soil day over day, year over year, in turn cementing the soils when the intent of their addition is to be utilized by the plant. What we have done is determined how to release the bicarbonate from the calcium with acid, to make it soluble in the acidified water. It works, but it is only sustainable for about 1-2 years when the vegetation begins to deteriorate.

Gypsum (calcium sulfate) is acidified with sulfurous acid (sulfuric, N-pHuric, sulfur burner) and water, dissolving minerals and metals into a soluble form so that when the plant takes up water, it can take up the nutrients. And what we have stated before is at the end of each year you have more calcium and sulfate than you began with and yet you continue to see calcium deficiency in the tissue analyses, as well as water not going down into the soil. The

ever-increasing dilemma is readily identified by looking back at the amounts of Exchangeable Cations on your soil analyses, versus the Soil Paste Extraction that just shows what your water can produce.

Soil Paste Extraction

What your water can solubilize from your soil

Exchangeable Cations

What cations your soil has in its entirety

Following are soil analyses. Notice the increased available nutrients between the various solutions used to break them down. It did not require pH reduction, it required chemistry. And this is the first phase of several we need to address, the availability of nutrition with water, the fate of the nutrition through the grow season, will it re-hydrate or become part of cementing the soils. Treated is with WaterSOLV™ Curative and WaterSOLV™ BC. Untreated is sulfuric acid and gypsum. This specific data is after 9 months from beginning of the study.

DE-IONIZED WATER SATURATED PASTE EXTRACT - STANDARD																												
		1	2	4	5	6	7	8	9	11	12	13	41	24	25	26	27	28										
		Soil %	-----mg/L-----																LIME	SPe	-SPe Soluble Cations-							
Sample	SP	pH	EC	Ca	Mg	Na	K	Cl	B	SO ₄ S	SAR	PRESENCE	Cation	Ca	Mg	Na	K											
Depth		dS/m	-----SPe extracted Soil Solution Constituents-----																LP	Total mg/kg	%SPe	%SPe	%SPe	%SPe				
1.	5D Blk 1 Treated	0-6"	34	8.1	1.93	112.3	23.6	293	22.8	207	0.2	116	6.5	++++	452	24.9	5.2	64.9	5.0									
2.		6-24"	35	8.0	2.62	224.8	48.7	301	18.6	211	0.1	157	4.7	++++	593	37.9	8.2	50.7	3.1									
3.	5D Blk 2 Treated	0-6"	36	7.6	1.78	174.5	37.1	168	6.8	249	0.1	93	3.0	-	386	45.2	9.6	43.4	1.8									
4.		6-24"	42	7.5	4.21	490	99.2	290	8.3	717	0.1	205	3.1	-	887	55.2	11.2	32.7	0.9									
5.	5D Blk 3 Nontreated	0-6"	36	7.9	1.61	174	33.3	131	7.3	191	0.1	98	2.4	++++	345	50.4	9.7	37.9	2.1									
6.		6-24"	33	7.5	4.31	514	112	261	3.9	707	0.1	234	2.7	++++	891	57.7	12.6	29.3	0.4									
7.	5D Blk 3 Nontreated	0-6"	32	7.9	3.29	410	85.4	191	13.9	288	0.1	268	2.2	++++	700	58.5	12.2	27.3	2.0									
8.		6-24"	32	7.8	3.03	396	71.5	165	9.1	401	0.1	159	2.0	++++	642	61.7	11.1	25.7	1.4									
6% ACETIC ACID SATURATED PASTE EXTRACT - DIGEST																												
		1	2	4	5	6	7	8	9	11	12	13	41	24	25	26	27	28										
		Soil %	-----mg/L-----																LIME	SPe	-SPe Soluble Cations-							
Sample	SP	pH	EC	Ca	Mg	Na	K	Cl	B	SO ₄ S	SAR	PRESENCE	Cation	Ca	Mg	Na	K											
Depth		dS/m	-----Soil Solution Constituents-----																LP	Total mg/kg	%SPe	%SPe	%SPe	%SPe				
1.	5D Blk 1 Treated	0-6"	39	5.2	82.6	17,113	1113	930	134.9		0.9	271	1.9	+++	19291	88.7	5.8	4.8	0.7									
2.		6-24"	41	5.3	32.0	5,837	840	471	49.3		1.5	117	1.5	+++	7198	81.1	11.7	6.5	0.7									
3.	5D Blk 2 Treated	0-6"	41	3.9	31.4	5,723	809	452	49.1		1.5	117	1.5	-	7034	81.4	11.5	6.4	0.7									
4.		6-24"	41	3.9	42.3	8,104	1086	649	59.6		1.6	263	1.8	-	9898	81.9	11.0	6.6	0.6									
5.	5D Blk 3 Nontreated	0-6"	36	5.2	92.3	21,002	1232	610	79.3		0.7	289	1.1	+++	22923	91.6	5.4	2.7	0.3									
6.		6-24"	35	5.5	97.3	19,971	1603	777	62.3		1.0	396	1.4	+++	22413	89.1	7.2	3.5	0.3									
7.	5D Blk 3 Nontreated	0-6"	33	5.4	91.1	19,872	1310	509	87.8		0.7	366	0.9	+++	21778	91.2	6.0	2.3	0.4									
8.		6-24"	34	5.3	95.6	21,704	1018	436	80.5		0.5	376	0.8	++++	23238	93.4	4.4	1.9	0.3									
AMMONIUM ACETATE EXCHANGABLE CATIONS - pH 8.5																												
		29	30	31	32	33	34	35	36	37	38	39																
		-----AMMONIUM ACETATE EXTRACTED CATIONS (ppm - %)-											Sum.															
Sample	Depth	Calcium	Magnesium	Sodium	Potassium	Hydrogen	C.E.C.																					
		mg/L	%CEC	mg/L	%CEC	mg/L	%CEC	mg/L	%CEC	mg/L	%CEC	meq/100g																
1.	5D Blk 1 Treated	0-6"	2869	63.0	352	12.9	508	14.0	857	9.7	1	0.4	22.8															
2.		6-24"	3478	61.2	451	13.2	718	15.8	1042	9.4	1	0.4	28.4															
3.	5D Blk 2 Treated	0-6"	3150	75.1	433	17.2	179	5.3	155	1.9	1	0.5	21.0															
4.		6-24"	3750	73.7	549	18.0	252	6.2	173	1.7	1	0.4	25.5															
5.	5D Blk 3 Nontreated	0-6"	3343	71.0	365	12.9	405	10.8	446	4.9	1	0.4	23.5															
6.		6-24"	4235	69.7	567	15.5	613	12.6	223	1.9	1	0.3	30.4															
7.	5D Blk 3 Nontreated	0-6"	2963	72.8	369	15.1	231	7.1	360	4.5	1	0.5	20.4															
8.		6-24"	2474	79.0	210	11.2	154	6.1	185	3.0	1	0.6	15.7															
6% ACETIC ACID PASTE DIGEST - DISPLACED CATIONS - pH 7.8																												
		29	30	31	32	33	34	35	36	37	38	39																
		-----AMMONIUM ACETATE EXTRACTED CATIONS (ppm - %)-											Sum.															
Sample	Depth	Calcium	Magnesium	Sodium	Potassium	Hydrogen	C.E.C.																					
		mg/L	%CEC	mg/L	%CEC	mg/L	%CEC	mg/L	%CEC	mg/L	%CEC	meq/100g																
1.	5D Blk 1 Treated	0-6"	6594	80.3	339	6.9	432	6.6	847	5.3	4	1.0	41.1															
2.		6-24"	7615	78.2	403	6.9	648	8.3	1088	5.7	4	0.8	48.7															
3.	5D Blk 2 Treated	0-6"	3555	76.9	431	15.5	146	3.9	171	1.9	4	1.7	23.1															
4.		6-24"	4434	77.7	504	14.7	208	4.6	182	1.6	4	1.4	28.5															
5.	5D Blk 3 Nontreated	0-6"	6289	83.0	313	6.9	371	6.1	436	2.9	4	1.1	37.9															
6.		6-24"	7778	81.5	492	8.6	602	7.9	218	1.2	4	0.8	47.7															
7.	5D Blk 3 Nontreated	0-6"	6120	84.9	342	7.9	209	3.6	336	2.4	4	1.1	36.0															
8.		6-24"	5101	87.9	203	5.8	142	3.1	205	1.8	4	1.4	29.0															

Interesting to note, even the acetic acid has a solubility threshold regardless of pH, including a pH of zero! The calcium as CaCO₃, you would multiply the calcium number there by 2.5. That is about the capacity of the calcium acetate, roughly 38,000 ppm at room temperature even at zero pH. It can go higher as temperatures are elevated though the sequestration falls apart at about 140 deg. Similar to sugar in tea, only so much can be dissolved. Similar to sugar in hot tea, you can dissolve quite a bit more. However, when the hot tea cools, the sugar will drop out and settle on the bottom. Minerals are very much the same. While sugar and sodium resolubilize, not much of anything else does. WaterSOLV™ Curative allows them to re-dissolve in the presence of water.

Solubility of Nutrients and Toxins in Water

From most soluble to least

The more soluble, the more likely with water the plant will take it up. Notice the more toxic products are extremely soluble, where the more essential products are less soluble. Hence when it rains the plants absorb H₂O, NO₃-N, Dissolved Oxygen, followed by zinc chloride, some iron and so on. As the plant gets dehydrated, these products tend to complex and crystalize restricting hydration and nutrient flow.

Substance	Formula	Solubility, g/100 ml water	Value
Zinc chloride	ZnCl₂	395	Toxin
Iron (III) perchlorate	Fe (ClO₄)₃	368	Toxin
Calcium permanganate	Ca (MnO₄)₂	338	Toxin
Potassium nitrite	KNO ₂	306	
Potassium acetate	KC ₂ H ₃ O ₂	256	
Sodium perchlorate	NaClO₄	201	Toxin
Calcium perchlorate	Ca (ClO₄)₂	188	Toxin
Potassium thiosulfate	K ₂ S ₂ O ₃	155	
Potassium hydrogen phosphate	K ₂ HPO ₄	150	
Calcium bromide	CaBr ₂	143	
Manganese (II) nitrate	Mn (NO ₃) ₂	139	
Iron (III) nitrate	Fe (NO ₃) ₃ ·9H ₂ O	138	
Calcium nitrate tetrahydrate	Ca (NO ₃) ₂ ·4H ₂ O	129	
Calcium nitrate	Ca (NO ₃) ₂	121	
Potassium hydroxide	KOH	112	
Potassium carbonate	K ₂ CO ₃	111	
Sodium hydroxide	NaOH	109	
Urea	CO(NH ₂) ₂	108	
Potassium phosphate	K ₃ PO ₄	92	
Iron (III) chloride	FeCl₃·6H₂O	92	Toxin
Sodium permanganate	NaMnO₄	90	Toxin
Sodium nitrate	NaNO ₃	88	
Monosodium phosphate	NaH ₂ PO ₄	87	
Calcium nitrite	Ca (NO ₂) ₂ ·4H ₂ O	85	
Sodium nitrite	NaNO ₂	81	

Calcium chloride	CaCl₂	75	Toxin
Manganese (II) chloride	MnCl₂	74	Toxin
Sodium thiosulfate	Na ₂ S ₂ O ₃	73	
Hydrogen Chloride	HCl	70	Toxin
Magnesium nitrate	Mg (NO ₃) ₂	70	
Sodium metabisulfite	Na ₂ S ₂ O ₅	65	
Manganese (II) sulfate	MnSO ₄	63	
Iron (II) chloride	FeCl₂	63	Toxin
Magnesium chloride	MgCl₂	55	Toxin
Zinc sulfate	ZnSO ₄	54	
Magnesium acetate	Mg(C₂H₃O₂)₂	53	
Magnesium thiosulfate	MgS ₂ O ₃	50	
Magnesium perchlorate	Mg (ClO₄)₂	50	Toxin
Potassium hydrogen sulfate	KHSO ₄	49	
Sodium tetraphenylborate	NaB(C ₆ H ₅) ₄	47	
Sodium acetate	NaC ₂ H ₃ O ₂	46	
Potassium oxalate	K₂C₂O₄	36	
Sodium chloride	NaCl	36	Toxin
Magnesium sulfate	MgSO ₄	35	
Calcium acetate	Ca(C₂H₃O₂)₂	35	
Potassium chloride	KCl	34	
Potassium hydrogen carbonate	KHCO ₃	34	
Zinc permanganate	Zn (MnO ₄) ₂	33	
Potassium nitrate	KNO ₃	32	
Zinc acetate	Zn(C ₂ H ₃ O ₂) ₂	30	
Iron (II) sulfate	FeSO ₄	29	
Sodium sulfite	Na ₂ SO ₃	27	
Sodium metaborate	NaBO ₂	25	
Potassium dihydrogen phosphate	KH ₂ PO ₄	23	
Sodium carbonate	Na ₂ CO ₃	22	
Sodium sulfate	Na ₂ SO ₄	20	
Calcium bicarbonate	Ca (HCO ₃) ₂	17	
Oxalic acid	H ₂ C ₂ O ₄ ·2H ₂ O	13	
Sodium phosphate	Na ₃ PO ₄	12	
Potassium sulfate	K ₂ SO ₄	11	
Sodium hydrogen carbonate	NaHCO ₃	10	
Sulfur dioxide	SO ₂	9	
Potassium chlorate	KClO ₃	7	
Potassium permanganate	KMnO ₄	6	
Potassium persulfate	K ₂ S ₂ O ₈	5	
Sodium oxalate	Na ₂ C ₂ O ₄	3	
Sodium pyrophosphate at 0 deg. C	Na ₄ P ₂ O ₇	2	
Monocalcium phosphate	Ca(H ₂ PO ₄) ₂	2	
Potassium perchlorate	KClO ₄	2	

Magnesium sulfite	MgSO ₃ ·6H ₂ O	0.52	Insoluble
Hydrogen Sulfide	H ₂ S	0.33	Insoluble
Calcium sulfate	CaSO ₄ ·2H ₂ O	0.255	Insoluble
Calcium hydroxide	Ca (OH) ₂	0.173	Insoluble
Zinc sulfite	ZnSO ₃ ·2H ₂ O	0.16	Insoluble
Magnesium oxalate	MgC ₂ O ₄	0.104	Insoluble
Calcium citrate	Ca ₃ (C ₆ H ₅ O ₇) ₂	0.095	Insoluble
Magnesium carbonate	MgCO ₃	0.039	Insoluble
Manganese (II) oxalate	MnC ₂ O ₄ ·2H ₂ O	0.028	Insoluble
Iron (II) oxalate	FeC ₂ O ₄ ·2H ₂ O	0.008	Insoluble
Dicalcium phosphate	CaHPO ₄	0.004303	Insoluble
Calcium phosphate	Ca ₃ (PO ₄) ₂	0.002	Insoluble
Magnesium hydroxide	Mg (OH) ₂	0.0009628	Insoluble
Calcium carbonate (Aragonite)	CaCO ₃ -Aragonite	0.0007753	Insoluble
Calcium oxalate	CaC ₂ O ₄	0.00067	Insoluble
Calcium carbonate (Calcite)	CaCO ₃ -Calcite	0.000617	Insoluble
Manganese (II) hydroxide	Mn (OH) ₂	0.0003221	Insoluble
Magnesium phosphate	Mg ₃ (PO ₄) ₂	0.0002588	Insoluble
Iron (II) carbonate	FeCO ₃	0.00006554	Insoluble
Iron (II) hydroxide	Fe (OH) ₂	0.00005255	Insoluble
Manganese (II) carbonate	MnCO ₃	0.00004877	Insoluble
Zinc carbonate	ZnCO ₃	0.00004692	Insoluble
Iron (III) hydroxide	Fe (OH) ₃	0.000000002	Insoluble
Zinc oxalate	ZnC ₂ O ₄ ·2H ₂ O	0.000000004	Insoluble

Yet we can titrate these items in the lab using acetic acid or ammonium acetate “at a pH value up to 8.5”, and expose most all the cations where acid couldn’t even at pH values as low as 2.5.

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28				
			%	SP	SPe	SPe	-----SP extracted Soil Solution Constituents-----										EATON GR	SP Extract		-----Water Soluble Nutrients-----										SPe	--SPe Soluble Cations--			
Water Soluble Phase			SP	pH	pH	EC	Ca	Mg	Na	K	Cl	HCO ₃	B	SO ₄ S	SAR	lbs Gyp	Ca/	K/Na	NO ₃ N	P	Zn	Cu	Fe	Mn	Si	Cation	Ca	Mg	Na	K				
			Paste	Ext.	dS/m	-----mg/L-----										ac-ft water	HCO ₃	-----mg/L-----										Total	%SPe	%SPe	%SPe	%SPe		
1.	5D Blk 1	Treated	0-6"	38	7.9	7.9	1.62	124	24.1	165	13.0	147	133	0.1	81	3.5	0	0.93	0.08	22.6	2.0	0.01	0.07	0.57	0.02	37.9	326	38.0	7.4	50.6	4.0			
2.			6-24"	37	8.0	8.0	2.69	208	35.3	323	9.6	137	110	0.1	223	5.4	0	1.88	0.03	20.5	0.9	0.01	0.04	0.22	0.01	32.2	576	36.1	6.1	56.1	1.7			
3.	5D Blk 2	Treated	0-6"	39	7.8	7.9	1.52	150	27.0	115	11.9	96.6	115	0.1	73	2.3	0	1.31	0.10	54.4	1.9	0.01	0.05	0.50	0.01	34.6	303	49.4	8.9	37.8	3.9			
4.			6-24"	32	8.0	8.0	1.19	109	20.7	97.3	5.7	89.4	113	0.1	41	2.2	0	0.96	0.06	48.6	0.8	0.01	0.04	0.62	0.03	34.1	232	46.8	8.9	41.9	2.5			
5.	5D Blk 3	Non-T	0-6"	37	7.9	8.0	1.60	159	26.4	120	13.5	102	130	0.1	96	2.3	0	1.23	0.11	31.4	1.4	0.01	0.05	0.39	0.01	35.2	319	49.9	8.2	37.6	4.2			
6.			6-24"	35	8.0	8.1	1.26	114	19.6	118	8.4	104	127	0.1	56	2.7	0	0.90	0.07	15.9	0.5	0.01	0.04	0.20	0.01	38.0	260	43.9	7.6	45.3	3.2			
7.	5D Blk 4	Non-T	0-6"	39	7.9	8.0	1.98	213	41.7	133	8.2	119	115	0.1	109	2.2	0	1.85	0.06	69.5	2.6	0.01	0.05	0.55	0.03	34.9	396	53.8	10.6	33.6	2.1			
8.			6-24"	36	7.9	8.0	1.34	129	27.0	105	4.3	112	124	0.1	56	2.2	0	1.04	0.04	42.4	1.0	0.01	0.04	0.40	0.01	32.2	265	48.6	10.2	39.6	1.6			
			29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55					
			---AMMONIUM ACETATE EXTRACTED CATIONS (mg/kg, % of CEC)---										C.E.C.	Equiv	XCO ₃	%	-----Extracted Nutrients mg/kg-----																	
Extracted Phase			Calcium		Magnesium		Sodium		Potassium		Hydrogen		meq/100g	to %	lbs/	O.M.	TN	NO ₃ N	PO ₄ P	Zn	Cu	Fe	Mn	Co	Mo	Ni	Ba	Al	PO ₄ P/	Zn				
			mg/kg	%CEC	mg/kg	%CEC	mg/kg	%CEC	mg/kg	%CEC	mg/kg	%CEC	Summation	CaCO ₃	12 inches																			
1.	5D Blk 1	Treated	0-6"	3760	65.4	473	13.7	580	12.6	888	7.9	1	0.3	28.7	4.23	169,243	1.96	903	4.6	12.2	1.1	0.8	4.0	3.9	0.04	0.04	0.19	0.38	12.3	11.0				
2.			6-24"	3344	64.3	397	12.7	729	17.5	510	5.0	1	0.4	26.0	4.34	173,532	1.42	600	5.0	7.1	0.6	0.8	4.9	3.5	0.04	0.04	0.19	0.29	8.2	11.9				
3.	5D Blk 2	Treated	0-6"	3498	67.3	364	11.7	492	11.8	892	8.8	1	0.4	26.0	3.21	128,218	1.88	865	11.5	15.7	1.9	0.4	6.3	3.5	0.04	0.04	0.18	0.25	13.4	8.3				
4.			6-24"	3512	68.7	412	13.4	472	11.5	592	5.9	1	0.4	25.6	2.12	84,639	0.80	481	7.8	7.7	0.5	0.4	6.7	2.0	0.04	0.04	0.11	0.13	4.6	15.4				
5.	5D Blk 3	Non-T	0-6"	3117	70.5	307	11.6	324	9.2	717	8.3	1	0.5	22.1	9.27	370,941	2.29	810	6.4	18.4	0.5	0.4	5.0	3.3	0.04	0.04	0.18	0.50	6.2	36.0				
6.			6-24"	2601	75.2	220	10.6	216	7.8	388	5.8	1	0.6	17.3	18.26	730,429	2.25	669	2.8	8.6	0.3	0.4	5.2	3.3	0.04	0.04	0.19	0.40	4.2	34.0				
7.	5D Blk 4	Non-T	0-6"	2861	72.4	335	14.1	272	8.6	335	4.3	1	0.5	19.8	1.66	66,391	1.82	970	9.9	12.6	0.5	0.4	4.6	4.7	0.04	0.04	0.21	0.49	8.1	25.9				
8.			6-24"	3207	73.5	461	17.6	199	5.7	232	2.7	1	0.5	21.8	0.66	26,579	1.06	555	7.3	6.3	0.2	0.7	6.1	3.5	0.04	0.04	0.15	0.77	7.4	29.3				
Average			3238	69.7	371	13.2	411	10.6	569	6.1	1	0.4	23.4	5.47	218,747	1.69	732	6.9	11.1	0.7	0.5	5.4	3.5	0.04	0.04	0.17	0.40	8.0	21.5					

Below Here is a soil analysis using “ammonium acetate” (NH4OAc) to expose all the cations in the soil - Exchangeable Cations. Note the pH necessary to do this is NOT acidic, it is actually well above an acidic pH. How does ammonium acetate break down these complexed nutrients without needed to be acidic? Can you do this in your fields, gradually, as to harvest all the revenue locked up in the soils? That is what we do with WaterSOLV™, and more!

Calcium, Ca	NH4OAc (pH 8.5)	2,900 ppm	High
Magnesium, Mg	NH4OAc (pH 8.5)	270 ppm	Very High
Sodium, Na	NH4OAc (pH 8.5)	250 ppm	High
Potassium, K	NH4OAc (pH 8.5)	140 ppm	Medium

It’s likely most the soil analyses you have had have been displaying both the Avail. (SPe / Saturation Paste Extract) and the Exchangeable (Exch., Exchangeable Cations). Available being what lab water can make available, extractable being what is actually there in the soil but not available with your water, or your treated water, irrespective of pH.

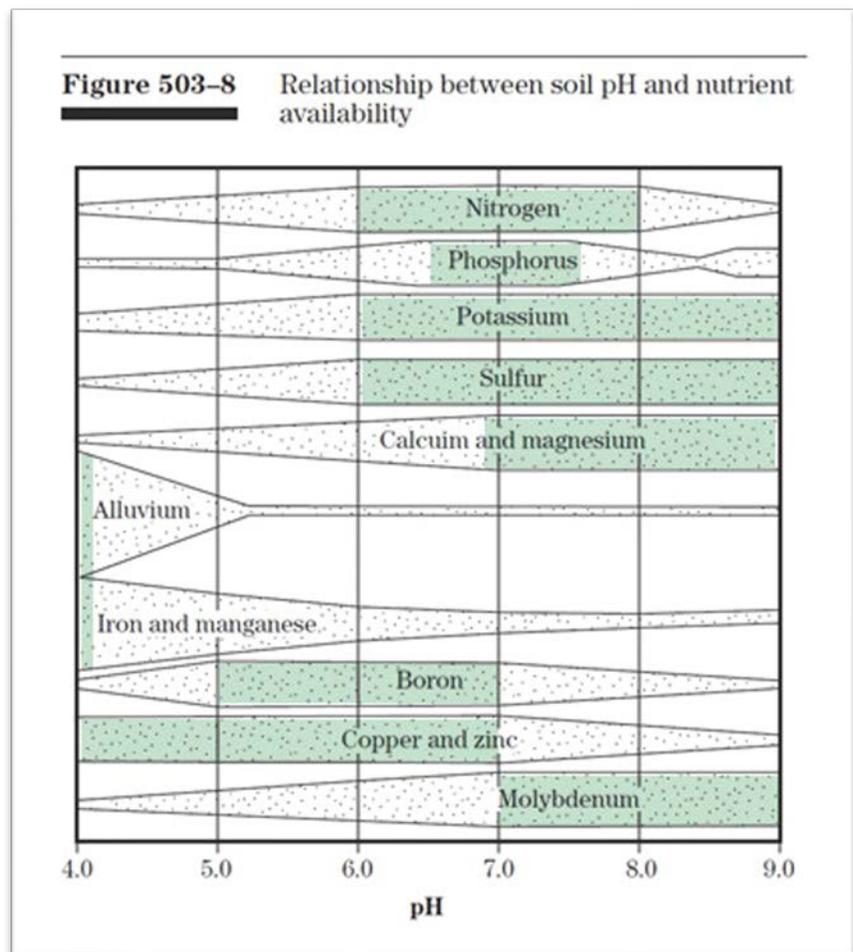
This is pH Defied

Because WaterSOLV™ Products react with the water similarly to the ammonium acetate, gradually releasing all this bound nutrient, nutrient you’ve purchased over time and have not yet used.

By not having to lower the pH excessively to make soluble nutrition, look at what the USDA says are the ideal pH values for the uptake of various elements;

The USDA/NCRS in 2011 Published Solubility of Elements are various pH Values. Driving pH low and adding sulfuric acid is not a sustainable solution.

Figure 6 – pH Sweet Spots (conventional Agronomy) - USDA – NRCS – National Agronomy Manual - Section 503.8 - Relationship Between soil pH and Nutrient Availability



EXTRACTABLE POTASSIUM, CALCIUM, MAGNESIUM, AND SODIUM

S - 5.10

Ammonium Acetate Method

Scope and Application

This method semiquantitatively determines the amount of soil plant available K, Ca, Mg, and Na residing on the soil colloid exchange sites by displacement with ammonium acetate solution buffered to pH 7.0. Cation concentrations are determined using atomic emission (AES), absorption spectrometry (AAS) or ICP-AES instrumentation. A chemical interference solution is used to minimize chemical matrix effects. It is based on a modification of the procedure outlined by Knudsen et al. (1982) for exchangeable K. Generally, these cations are associated with the exchange sites. The exception are soils that have high soluble salts and are saline, which requires a special preanalysis treatment. The method doesn't correct for calcium and magnesium extracted as free carbonates or gypsum. In the northern Great Plains the method has been used to determine available sulfur. The method detection limit is approximately of 25 mg kg⁻¹ (on a dry soil basis) and is generally reproducible ± 7%.

EXTRACTABLE POTASSIUM, CALCIUM, MAGNESIUM, AND SODIUM

S - 5.11

Ammonium Acetate Method - Buffer 8.5

Scope and Application

This method semiquantitatively determines the amount of soil plant available K, Ca, Mg, and Na residing on the soil colloid exchange sites by displacement with ammonium acetate solution buffered to pH 8.5. Cation concentrations are determined using atomic emission (AES), absorption spectrometry (AAS) or ICP-AES instrumentation. A chemical interference solution is used to minimize chemical matrix effects for the AES method. It is based on a modification of the procedure outlined by Knudsen et al. (1982) for exchangeable K but is buffered to pH 8.5 to minimize dissolution of calcium carbonate (CaCO₃). Generally, these cations are associated with the exchange sites. The exception are soils that have high soluble salts and are saline, which requires a special preanalysis treatment. The method doesn't correct for calcium and magnesium extracted as free carbonates or gypsum. In the northern Great Plains the method has been used to determine available sulfur. The method detection limit is approximately of 25 mg kg⁻¹ (on a dry soil basis) and is generally reproducible ± 7%.

**SATURATION PASTE EXTRACT
CALCIUM, MAGNESIUM, SODIUM, AND SAR**

S - 1.60

AAS or ICP-AES Method

Scope and Application

This method quantitatively determines the concentration (mmolc L⁻¹, meq L⁻¹) of dissolved Ca, Mg and Na in the soil saturation paste extract (Method S - 1.00) using atomic absorption spectrometry (AAS) or Inductively coupled plasma emission spectrometry (ICP-AES). A chemical interference solution is used to minimize chemical matrix effects. The Sodium Absorption Ratio (SAR) of saturation paste extract is calculated from the concentration of these cations. The relationship between cation solution concentrations and exchangeable cations in the soil, is used to estimate exchangeable sodium percentage (ESP) from the SAR (Robbins, 1990). The method detection limit for these cations is approximately 0.02 mmolc L⁻¹ on a solution basis and it is generally reproducible within ± 7%. The unit mmolc L⁻¹ is the accepted scientific unit for reporting the concentration of anions and cations and is equivalent to meq L⁻¹.

Source: <https://www.dropbox.com/s/0u1vshxw1n8x5qv/western-states-methods-manual-2013.pdf?dl=0>

Adding Calcium Sulfate to Soils Saturated with Calcium Sulfate

I asked why labs recommend sulfuric acid and gypsum to soils saturated with calcium and sulfate and the answer is always that's what the system instructs. And when we enter the discussion this is not in the grower's best interest, the universal response is "we're not in the business of making recommendations, or, we can't recommend a product due to the potential bias of their existing clients".

But the recommendation is already being made, add gypsum and sulfuric acid to soils already saturated with them. Add more sulfur from the sulfuric acid and N, even when N is saturated. From our perspective, the system is flawed in that the standard was set decades ago, the problems with it have been identified by the trusted authorities and nobody is doing anything about it, at the expense of the grower!

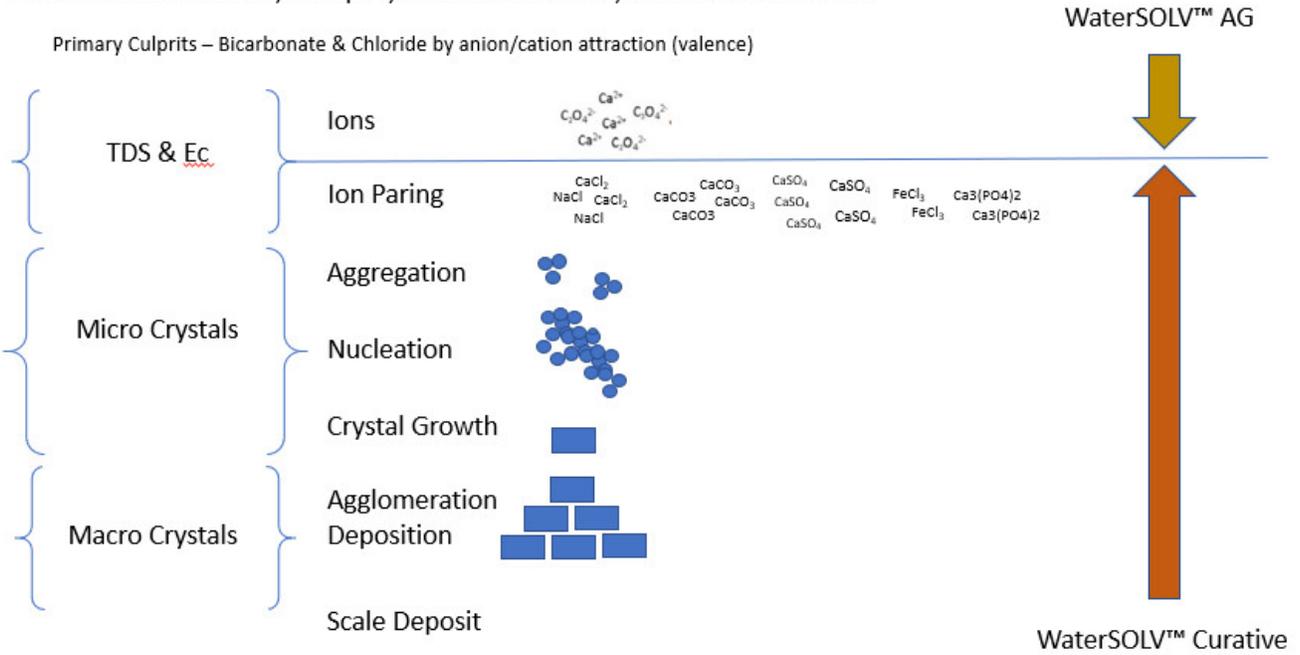
Let's start with the formation of scale. We believe the addition of acid to reduce the pH will dissolve scale in water and make nutrient available in the water for the plant to drink. This is accurate but only for a given amount of time. As the UC Davis study shows, and most growers have some to see, hardpan, the cementation of the soils, standing water, the accumulation of sodium, chloride, boron, zinc, iron, manganese, increasing annually along with calcium and phosphate – followed by increase pest and disease, more acid and more gypsum, ...

STOP. The problem is known!

Below is the formation of scale. Exactly like growing rick crystals where they use mono ammonium phosphate and as the water evaporates, the cations absorb bicarbonate and crystalize. Scale is the agglomeration of what we refer to as cations, elements, minerals and metals, collectively referred to as TDS, TSS, Ec, total hardness, but not "water", carried in water. As the water dissipates, this is what happens – hard water spots, crystals.

As we dissolve scale it disassociates bicarbonates from the cations. As we dissolve salt, it disassociates sodium from chloride. What disassociates calcium from phosphate is a higher energy than the energy that attracts them called valence, the Cation+ and Anion- attraction similar to a magnet. You can put something on one side of the magnet so that it doesn't connect. In chemistry, we call that sequestration. Represented by the WaterSOLV™ arrows below, WaterSOLV™ AG readily sequesters the anions and cations. WaterSOLV™ AG is too weak to disassociate the already formed complexes so WaterSOLV™ Curative is applied to readily disassociate the complexes and sequester them so that they do not re-complex. They will remain hydratable ions, hydratable as available nutrition in the form of TDS and Ec,

The Formation of Scale, Hardpan, Insoluble Minerals, Metals and Nutrients



As we add gypsum and sulfuric acid to drive calcium into solution for the plants to drink, over time, this is what happens. **Usually over 3 years it becomes an intolerable** and expensive issue.

“Strong Acids will NOT Dissolve the Salts of Strong Acids”

Why Sulfuric has a Short Range Benefit



UC DAVIS

Sulfurous Acids
Sulfuric, N-pHuric, UN32

Salts of weak acids are soluble in strong acids

The solubility of a sparingly soluble salt of a weak acid or base will depend on the pH of the solution. To understand the reason for this, consider a hypothetical salt MA which dissolves to form a cation M⁺ and an anion A⁻ which is also the conjugate base of a weak acid HA. The fact that the acid is weak means that hydrogen ions (always present in aqueous solutions) and M⁺ cations will both be competing for the A⁻:

$$\text{MA(s)} \xrightarrow{1} \text{M}^+ + \text{A}^- \quad \text{H}^+ \xrightarrow{2} \text{HA}$$

The weaker the acid HA, the more readily will reaction 2 take place, thus gobbling up A⁻ ions. If an excess of H⁺ is made available by addition of a strong acid, even more A⁻ ions will be consumed, eventually reversing reaction 1, causing the solid to dissolve.

... but strong acids will not dissolve salts of strong acids

Neither will RO, DI or Rain Water

$$\text{CaSO}_4(\text{s}) \xrightarrow{1} \text{Ca}^{2+} + \text{SO}_4^{2-} \quad \text{H}^+ \xrightarrow{2} \text{HCl}$$

What happens is as the water evaporates, the minerals and metals acidified that were not consumed by the plant concentrate, nucleate and form a denser crystal that does not re-acidify i.e. “The evaporated salts of strong acids are not re-dissolved by strong acids”. For example, the calcium becomes more like quartz or glass, insoluble in the acids we use in agronomy. Calcium sulfate / gypsum, is itself extremely insoluble. Gypsum also absorbs moisture, competing with the plant for water. As the plant becomes dehydrated, it also has the effects of these insoluble salts within its cellular structure hindering growth, health and overall vitality.



National Agronomy Manual

Reference: <https://www.dropbox.com/s/p43pypi4ctzy42/USDA-NRCS-National%20Agronomy%20Manual%20-%202011.pdf?dl=0>

Nutrient Pollution in Areas Where Nutrients are Accumulating

Part 503-2 Page 47

While farmers collectively have been making sound economic management decisions, the unexpected consequence of these decisions has resulted in the increased potential for nutrient pollution in the areas where nutrients are accumulating.

503.22 Basic soil fertility

Plant nutrition - What is an essential element? An essential mineral element is one that is required for normal plant growth and reproduction. **With the exception of carbon (C) and oxygen (O), which are supplied from the atmosphere**, the essential elements are obtained from the soil. The amount of each element required by the plant varies; however, all essential elements are equally important in terms of plant physiological processes and plant growth.

Effect of pH on nutrient availability

Many soil elements change form as a result of chemical reactions in the soil. Plants may or may not be able to use elements in some of these forms. Because pH influences the soil concentration and, thus, the availability of plant nutrients, it is responsible for the solubility of many nutrient elements. Figure 503-8 illustrates the relationship between soil pH and the relative plant availability of nutrients.

• *K, Ca, and Mg*—These nutrients are most available in soils with pH levels greater than 6.0. They are generally not as available for plant uptake in acid soils since they may have been partially leached out of the soil profile.

- *P*—Phosphorus solubility and plant availability are controlled by complex soil chemical reactions, which is often pH-dependent. Plant availability of P is generally greatest in the pH range of 5.5 to 6.8. When soil pH falls below 5.8, P reacts with Fe and Al to produce insoluble Fe and Al phosphates that are not readily available for plant uptake. At high pH values, P reacts with Ca to form Ca phosphates that are relatively insoluble and have low availability to plants.

- *Micronutrients*—In general, most micronutrients are more available in acid than alkaline soils. As pH increases, micronutrient availability decreases, and the potential for deficiencies increase. An exception to this trend is Mo, which becomes less available as soil pH decreases. In addition, B becomes less available when the pH is <5.0 and again when the pH exceeds 7.0.

- *Al, Fe, and Mn toxicity*—At pH values less than 5.0, Al, Fe, and Mn may be soluble in sufficient quantities to be toxic to the growth of some plants. Aluminum toxicity limits plant growth in most strongly acid soils. Aluminum begins to solubilize from silicate clays and Al hydroxides below a pH of approximately 5.3, which increases the activity of exchangeable Al³⁺. High concentrations of exchangeable Al are toxic and detrimental to plant root development.

- *Soil organisms*—Soil organisms grow best in near-neutral soil. In general, acid soil inhibits the growth of most organisms, including many bacteria and earthworms. Thus, acid soil slows many important activities carried on by soil microbes, including nitrogen fixation, nitrification, and organic matter decay. Rhizobia bacteria, for instance, thrive at near-neutral pH and are sensitive to solubilized Al.

Acid soils and liming

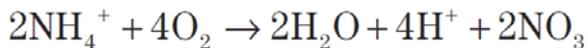
Acidification is a natural process that occurs continuously in soils. It is caused by the following factors:

- The breakdown of organic matter can cause acidification of the soil as amino acids are converted into acetic acid, hydrogen gas, dinitrogen gas, and carbon dioxide by the reaction:



The movement of acidic water from rainfall through soils slowly leaches basic essential elements such as Ca, Mg, and K below the plant root zone and increases the concentration of exchangeable soil Al. Soluble Al³⁺ reacts with water to form this equation, which makes the soil acid.

- Soil erosion removes exchangeable cations adsorbed to clay particles.
- Hydrogen is released into the soil by plant root systems as a result of respiration and ion uptake processes during plant growth. Nitrogen fertilization speeds up the rate at which acidity develops, primarily through the acidity generated by nitrification:



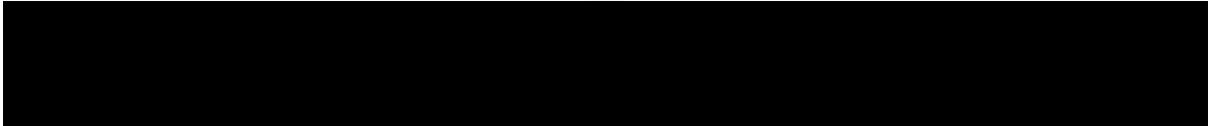
- The harvesting of crops removes basic cations.

Soil pH is a commonly measured soil chemical property and also one of the more informative. Soil pH “implies” certain characteristics that might be associated with a soil. Since pH (the negative log of the hydrogen ion activity in solution) is an inverse, or negative, function, soil pH decreases as hydrogen ion, or acidity, increases in soil solution. Soil pH increases as acidity decreases. A soil pH of 7 is considered neutral. Soil pH values greater than 7 signify alkaline conditions, whereas those with values less than 7 indicate acidic conditions. Soil pH typically ranges from 4 to 8.5, but can be as low as 2 in materials associated with pyrite oxidation and acid mine drainage. In comparison, the pH of a typical cola soft drink is about 3. **Soil pH has a profound influence on plant growth. Soil pH affects the quantity, activity, and types of microorganisms in soils which in turn influence decomposition**

of crop residues, manures, sludges and other organics. It also affects other nutrient transformations and the solubility, or plant availability, of many plant essential nutrients. Phosphorus, for example, is most available in slightly acid to slightly alkaline soils, while all essential micronutrients, except molybdenum, become more available with decreasing pH. Aluminum, manganese, and even iron can become sufficiently soluble at pH < 5.5 to become toxic to plants. Bacteria which are important mediators of numerous nutrient transformation mechanisms in soils generally tend to be most active in slightly acid to alkaline conditions.

This is the Defect!

Adding sulfuric acid (and gypsum) to soils already saturate with sulfur, sulfate and calcium and sulfate (gypsum). When addressed by the grower for a solution, a remediation approach, what answers will you receive? We are commonly told the analytical lab is not a consultant, yet advising the application of the acid and the gypsum, is acting as a consultant and has led to the accumulation of the challenge. se challenges. This is just one example of the thousands of soil analyses we have observed these conditions of saturated cations, sulfur, sulfate and related accumulations of “nutrient pollution”.



General Irrigation Suitability Analysis

Test Description	Result				Graphical Results Presentation				
	mg/L	Meq/L	% Meq	Lbs/AF	Good	Possible Problem	Moderate Problem	Increasing Problem	Severe Problem
Cations									
Calcium	207	10	44	560	**				
Magnesium	68	5.6	24	180	**				
Potassium	5	0.13	1	14	**				
Sodium	172	7.5	32	470					
Anions									
Carbonate	< 10	0	0	0					
Bicarbonate	270	4.4	20	730	**				
Sulfate	608	13	56	1700	**				
Chloride	180	5.1	23	490					
Nitrate	18.7	0.3	1	51					
Nitrate Nitrogen	4.2			11					
Fluoride	0.3	0.016	0	0.8					
Minor Elements									
Boron	0.70			1.9					
Copper	< 0.01			0					
Iron	< 0.03			0					
Manganese	0.030			0.082					
Zinc	< 0.02			0					
TDS by Summation	1530			4200					
Other									
pH	9.5			units					
E. C.	2.3			dS/m					
SAR	2.7								
Crop Suitability									
No Amendments	Poor								
With Amendments	Poor								
Amendments									
Gypsum Requirement	0.0			Tons/AF					
Sulfuric Acid (98%)	15			oz/1000Gal	Or 37 oz/1000Gal of urea Sulfuric Acid (15/49)				
Leaching Requirement	20			%					

Good Problem

Note: Color coded bar graphs have been used to provide you with 'AT-A-GLANCE' interpretations.

** Used in various calculations: mg/L = Milligrams Per Liter (ppm) meq/L = Milliequivalents Per Liter



Likewise, you can see by the sentence highlighted below, there are no specific references cited or provided when requested.

Water Amendments Application Notes:

The Amendments recommended on the previous pages include:

Sulfuric Acid:

These products should be applied as needed to prevent emitter plugging in micro irrigation systems and/or as a soil amendment to adjust soil pH to improve nutrient availability and to facilitate leaching of salts. Please exercise caution when using this material as excesses may be harmful to the system and/or the plants being irrigated. The reported Acid requirement is intended to remove approximately 80 % of the alkalinity. The final pH should range from 5.4 to 6.7. We recommend a field pH determination to confirm that the pH you designate is being achieved. This application is based upon the use of a 98% Sulfuric Acid product. The application of Urea Sulfuric Acid is based upon the use of a product that contains 15% Urea (1.89 lbs Nitrogen), 49% Sulfuric Acid and has a specific gravity of 1.52 at 68 °F.

Guidelines for the above interpretations are sourced from USDA & U.C. Cooperative Extension Service publications.

Please contact us if you have any questions.



This is happening universally in all phases of agronomy and the problems usually noticed at year 3. All the while more gypsum and acid is required, while the exchangeable cations continue to increase and hinder infiltration.

What are we doing? Are we trying to get a low pH implying we are making more soluble available nutrition for our plant to drink, or is the goal to make sustainable, available nutrients for our plant to drink? Must we create infiltration and retention of nutrient rich water to make that happen 24/7 for the optimum vegetation vitality – nutrition and hydration on demand?

So, we're doing everything right and it seems we continue to see more calcium, sulfate, sodium, bicarbonates, chlorides and iron in our soils and less in our tissues, right?

And you see more sulfur and chloride salts in the tissue, iron and aluminum, but where's the calcium, right? We move the pH lower and lower, we have worse infiltration year over year, our chloride salts and calcium are building in the soils, so our actions are till, organic matter, heavy weak acid to push sodium away, more money, more work, meager results, lower ROI.

Then look at the soil and tissue again and see the same challenges have not changed improved and actually become worse. You are NOT alone; it's happening universally and trusted advisors are not doing anything about it.

So, the principles and/or goals are still the same -But implementing a deeper understanding of the principles and/or goals has changed the way we gear up for improving plant health.

Everything we tell you here has been validated repeatedly and reproduced across the USA in varying soils, waters, biology and environments. Note that the industry does NOT incorporate biology or biofilms, as we do. They also do NOT incorporate oxygen, as we do. There are NO University Research papers on what our industry does today with "sulfuric acid and gypsum". If there were, you'd not be using sulfurous acids.

Legends:

Cations - A positively charged atom, such as Na⁺ or K⁺, which is attracted towards a negative electrode (cathode). An atom which, in solution, takes a positive charge. Unlike charges attract; like charges repel.

TDS - Total dissolved solids (TDS) is a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular (colloidal sol) suspended form.

TSS - Total suspended solids (TSS) is the dry-weight of suspended particles, that are not dissolved, in a sample of water that can be trapped by a filter that is analyzed using a filtration apparatus.

Ec - EC or Electrical Conductivity of water is its ability to conduct an electric current. Salts or other chemicals that dissolve in water can break down into positively and negatively charged ions. These free ions in the water conduct electricity, so the water electrical conductivity depends on the concentration of ions.

Minerals and Salts; Ca, MN, P, K & Na

Nutrient Minerals: C, Mg, P, K

Toxic Minerals: Na

Problematic Gasses: HCO₃, Cl, H₂S

CEC - The relative ability of soils to store one particular group of nutrients, the cations, is referred to as cation exchange capacity or CEC. Soils are composed of a mixture of sand, silt, clay and organic matter. Both the clay and organic matter particles have a net negative charge.

SAR - Sodium Adsorption Ratio (SAR) Sodium adsorption ratio is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

The below shells and deposits are all bound forms of water minerals - what we referred to previously; as cations, elements, minerals, TDS, TSS, Ec – the same things you see in your water and soil analyses.

pH (SU)	EC (dS/m)	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Ni (ppm)	NO ₃ -N (ppm)	PO ₄ -P (ppm)	SO ₄ -S (ppm)	B (ppm)
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Figure 1 – Shells, Calcium; phosphate, silicate, carbonate – Calcite, Caliche, iron silicate, more shells, struvite, iron oxide, hematite, magnetite – all capable of being solubilized by ion exchange into drinkable and high-grade

nutrition with WaterSOLV™. BUT – we have seen cases where biofilms block acids access, and that's one aspect of where the WaterSOLV™ BC can play a role.

Caliche is a very dense soluble form of calcium that is readily converted to available nutrition by WaterSOLV™ Curative.

What happens when we acidify these? They release bicarbonate – a gas, the bubbles. The elements dissolve into the water and become drinkable.

Acids, Sustainability, Solubility and Size

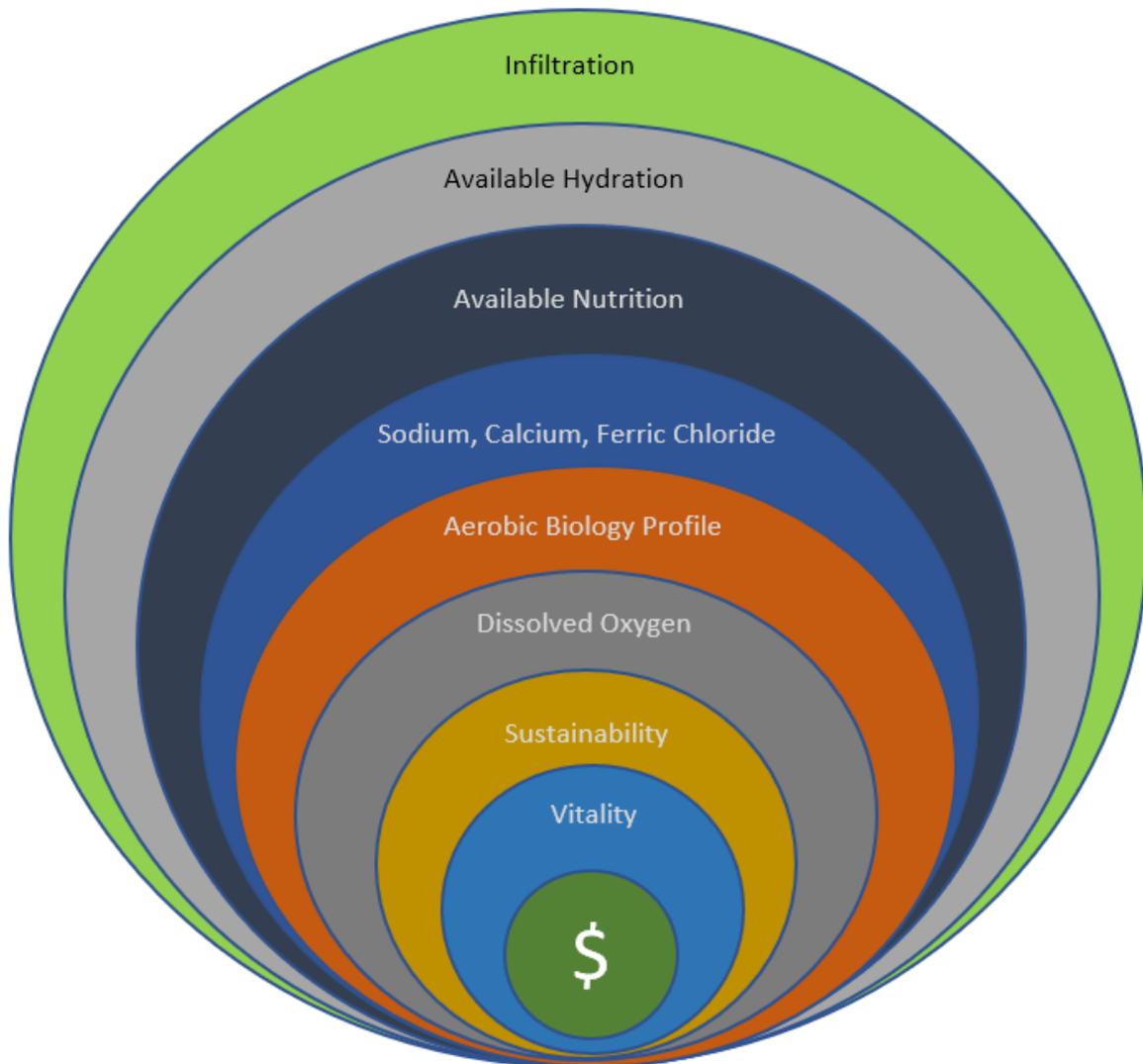
You can recover from the accumulation of insoluble salts throughout your soil. Insoluble salts are referred to as evaporative salts, cementation, hardpan, we can't get water down (usually, could be bio also), and what we HCT call bound nutrition. But it takes a stronger acid than sulfuric or N-pHuric. What we mean by stronger is not a lower pH but something that has the power to disassociate the bonds and prevent them from re-forming, better than what we are already experiencing isn't working, more acid and a lower ph. Scientific proof it isn't working; both calcium and sulfate (gypsum) are building in the soil, and calcium is deficient in the tissue.

REMEMBER – The evaporative salts of the strong acids are not dissolved by strong acids. If you want to know more about the plusses and minuses of sulfurous acids, you can we've made comparisons available for you online at our website – www.hctllc.com – direct link; <https://www.hctllc.com/sulfurous>

How is it a product that is just 34% acid, can be used at 1/10th the volume of a 93% sulfuric acid and break down more bound nutrients and a higher pH, at an equivalent cost and without the need for gypsum? Lets' rephrase that. How can two, 265-gallon totes of an acid product – 550 gallons, outperform a tanker of 93% sulfuric acid, 5,500 gallons, at the same or lower overall cost, while improving soils and crop conditions – AND SUSTAINABLY?

- A. Convert the cation to NOT re-crystallize, taking the place of the bicarbonate exchange site. This makes what would become scale, re-hydratable nutrition (and of a higher-grade nutrition, the amino acid glycolate, +++). We do not have to reacidify the evaporative salts in the soil to make them available nutrition, we just rehydrate them.
- B. We harvest the existing bound nutrients in the soil.
- C. By improved infiltration of water and availability of hydration and available nutrition, we have enhanced growth rate, volume, health, heat tolerance, less stress, less evaporation so less water and loading of water elements.
- D. We incorporate the biology, chloride salts, sodium and oxygen aspects, chemically. It's a fine-tuned system making water a better solution of – minerals, metals, microbes and chloride salts.

The Rings to Nutritional Vitality and ROI



For optimum crop vitality, it begins with Infiltration- getting water and nutrition to the root zones. The roots have to have available hydration and available nutrition. With that we need to make sure we have managed the chloride salts including sodium, as they are extremely soluble and readily available in water if concentrated in the soil. Another factor we need to rule out is bio-films as they can block the flow of everything. Our soil must contain dissolved oxygen for the water for the plant. What we do with our total program has to have positive effects for years to come. Such practices will provide crop vitality, optimum yields and likely a positive Return on Investment.

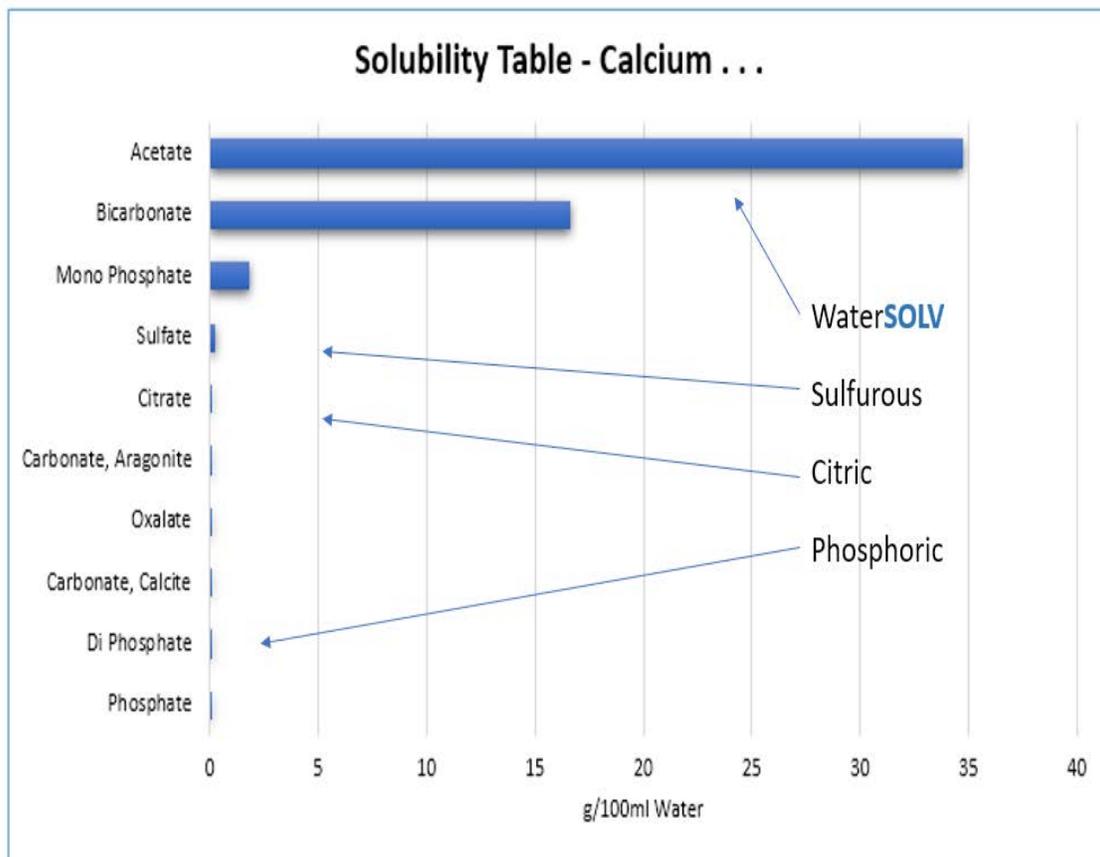
What acids are capable of working the most efficiently?

We can sequester the charge of the cations using any acid and sulfuric. Sulfuric acid has been the mainstream in the industry because there was not a better alternative, until now. But as growers begin to experience the declines and learn about the options, they're becoming more aware being at what we refer to as them at the end of the thread or the end of the rope.

We treat about the entire Arizona Nursery markets sulfuric acid with our program, successfully and for years.

The art, is the prevention of the cation from re-adsorbing the bicarbonates and forming scale, along with the other attributes. It works! At this link, <https://www.hctllc.com/sulfurous> - is why we would not recommend sulfurous acids, – nor will it remediate soils effectively - these items are NOT addressed in the industry or in your water and soil analyses. Namely there is a much better and sustainable solution that also incorporates the biology and oxygen.

The Solubility of Various Calcium Derivatives



Note how insoluble calcium sulfate is.

This represents water that was saturated with Calcium Carbonate (CaCO₃ – Lime) crystal (calcite) as far as it could go, and then analyzed. The 1% additive was HCT’s base chemistry. Note that at pH values of 2.7 and 1.5, the acidified water had stopped dissolving the scale. This is caused by saturation, like only being able to dissolve a small amount of sugar in ice tea. Yet you can dissolve lots of salt in water, but not nearly as much sugar. That 1% additive increased the dissolving capacity of the acid 13%. But more important it will prevent those dissolved minerals from reforming as scale and has converted them into a high grade, always hydratable nutrient. One of the points here is you can’t drive pH lower and solubilize minerals if you are already at saturation. This is the situation when we’re adding calcium and sulfate when it is already saturated in our soils.

Water Analysis of a Saturated Descaling Solution

Will not dissolve any more scale yet pH is below 3.0
 Why? – Saturation, like sugar into tea.

Parameter	HCl 10%	HCl 9% 1% Additive	Variance
pH	2.7	1.5	N/A
Calcium	7,950	9,140	13%
Magnesium	85	90	6%
Calcium Hardness	19,800	22,800	13%
Magnesium Hardness	351	371	5%
Total Hardness	20,200	23,200	13%
TDS	33,700	34,600	3%

Will more sugar dissolve in iced or hot tea? What about scale in water?

Irrespective of the pH!

The perception in agronomy is the lower the pH, without plant damage, the more soluble the nutrients in water for our plants to uptake. Technically there is a chart that shows how much sulfuric acid by % is necessary to reduce the alkalinity to achieve a specific pH.

Acidified, the solubilization of minerals and metals in soils will be broken down and available for the plant to uptake. We can agree to that as long as the minerals and metals are in solution and in a drinkable state by the plant. But also, the media, the soil, has to be in a condition that allows for the flow of water and the nutrients until the plant drinks them. Hopefully we do not have biology or biofilms blocking their access which we never look for in conventional agronomy. Nor do we look at the FATE of what we put onto the ground including food sources for bad bacteria, sodium chloride products and excessive N and or sulfur or sulfate. Acidified N in excess of near 20 ppm blocks oxygen flow. Sulfate is food source for sulfate reducing bacteria like iron and manganese are food sources for bacteria as well. Both iron and manganese bacteria can produce massive amounts of slime which is impervious to acids and chlorine.

Do roots chase nutrition, or do they chase hydration?

They chase hydration at any pH and if we hydrate them too much pathogens can become a problem.

That's why we address both pathogens along with minerals, metals and chloride salts.

Several things happen here with this acidified water;

- A. Some of the nutrient rich water makes it to the root zone and is taken in by the plant (SODIUM)
- B. Most of the nutrient rich water evaporates to dryness in the soil, absorbs bicarbonates, and forms micro crystals – scale.
- C. As the soil scaling process repeats itself year over year, about the third year the farm manager gets concerned and starts applying more resources to the soil. At the same time nothing is getting better, costs are increasing, the soils tend to turn anoxic, more acid, more calcium and sulfate, more analyses, humic acid, fulvic acid, phosphoric acid, organic matter, tilling, all the while chloride, sodium calcium and potassium and sulfur levels build in the soils and the crops continue to get worse.
- D. Nobody is looking at the tissues for the deficit of oxygen
- E. More nitrogen, acid, gypsum and heavy acids to push the sodium away from the root zone.
- F. The lack of rain exacerbates the presence of dissolved oxygen in the soil to the plant uptake.

Several Videos that show pH values are not a valid resource, most the time, in agronomy.

Bio-films block acidification;

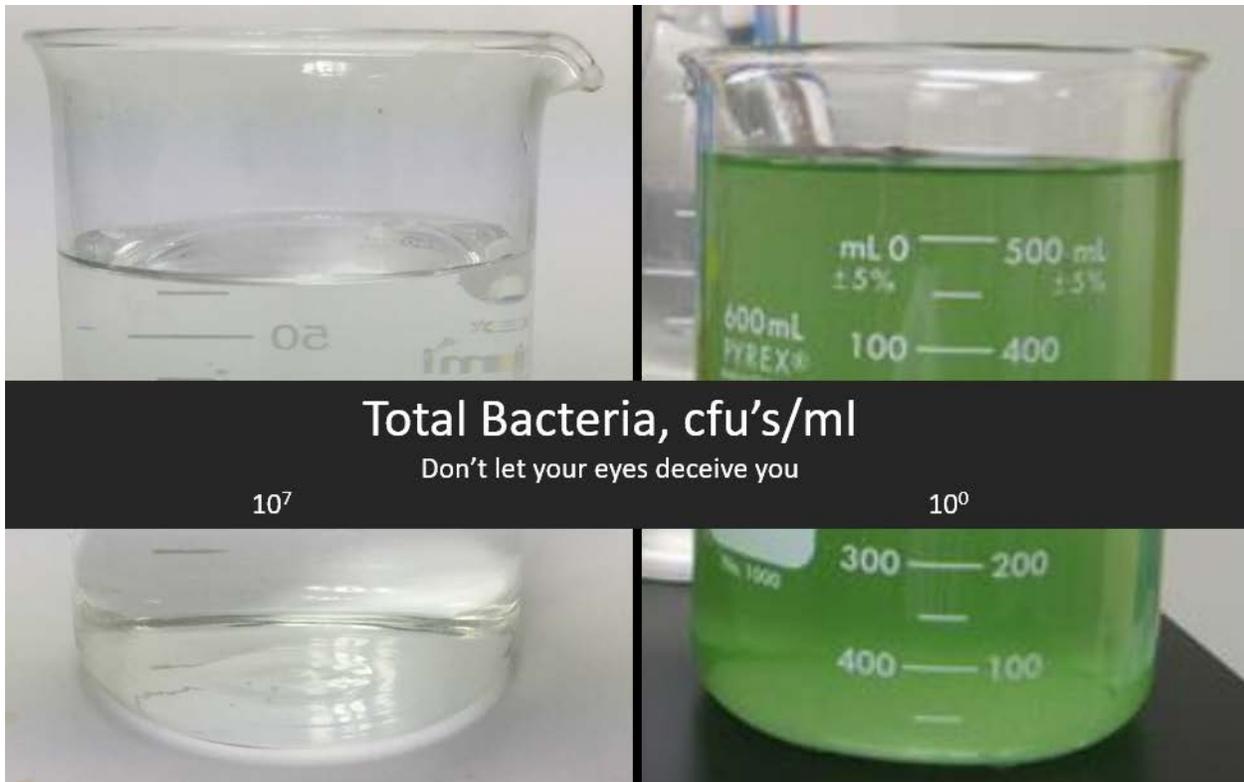
<https://youtu.be/qiQrgb8cTsc>

Zero pH does not burn skin;

https://www.youtube.com/watch?v=3GHBXHwpj00&feature=emb_logo

Biology

We believe crystal clear water is good, green brackish water is bad. This clear water was substantially more loaded with bacteria than the bad looking green water. The clear water could sustain bacteria and biofilms, the green water would not. Don't let the visual appearance of the water fool you.



Here are two peroxide products after they were reacted with calcite (calcium carbonate). It's pretty clear which product would have the greatest chance of putting calcium through the plant into the tissue.

Peroxide + Glycolic/Amino Acid + Calcite	Peroxide + Glycolic/Amino Acid + HCT's Solutions + Calcite
	
PROBLEM	SOLUTION
	WaterSOLV™ BC

References of Interest

1. USDA – NRCS – National Agronomy Manual – February 2011 - (190–V–NAM, 4th Ed., February 2011)
 - a. 503.8 Relationship Between soil pH and Nutrient Availability (see Figure 6)
 - b. 503.31 Managing nutrient losses
 - c. 504.02 Crop water requirements
 - d. 504.03 Irrigation water and plant growth
 - e. 504.07 Irrigation related agricultural salt problems - Application of irrigation water
 - f. 508.01 Soil structure - (g) Salt-affected soils – Sodicty
Dispersion, the release of individual clay platelets from aggregates, and slaking, the breakdown of larger aggregates in smaller aggregates, lodge in soil pore spaces, reducing permeability and decreasing porosity, which leads to soil crusting and poor tilth. Adding gypsum to the soil surface or even to irrigation water can effectively avoid or even alleviate problems with reduced infiltration rate and seedling emergence (through crusted soil). A sulfur source can also be added to enhance acidification of the soil. For soils already saturated with calcium (carbonate), the addition of gypsum or sulfur is ineffective in treating sodicity. Increasing organic matter levels by continuous cropping, residue management, establishing tolerant plant species and removing excess water is more sustainable.
2. Soil, Water and Plant Characteristics Important to Irrigation – North Dakota State University, December 2017
3. Saturation Paste Extract - CALCIUM, MAGNESIUM, SODIUM, AND SAR - AAS or ICP-AES Method – S-1.60
4. EXTRACTABLE POTASSIUM, CALCIUM, MAGNESIUM, AND SODIUM - Ammonium Acetate Method - S - 5.10
5. Western Coordinating Committee on Nutrient Management (WERA-103). - SOIL, PLANT AND WATER REFERENCE METHODS - FOR THE WESTERN REGION 1 – 2013 - 4th Edition - Dr. Robert O. Miller - Dr. Ray Gavlak - Dr. Donald Horneck

18 Essential Elements for Plant Growth

Table 503–8 Eighteen essential elements for plant growth, and the chemical forms most commonly taken up by plants

Element	Symbol	Form Absorbed by Plants
Carbon	C	CO ₂
Hydrogen	H	H ⁺ , OH ⁻ , H ₂ O
Oxygen	O	O ₂
Nitrogen	N	NH ₄ ⁺ , NO ₃ ⁻
Phosphorus	P	HPO ₄ ²⁻ , H ₂ PO ₄ ⁻
Potassium	K	K ⁺
Calcium	Ca	Ca ²⁺
Magnesium	Mg	Mg ²⁺
Sulfur	S	SO ₄ ²⁻
Iron	Fe	Fe ₂ ⁺ , Fe ₃ ⁺
Manganese	Mn	Mn ²⁺ , Mn ⁴⁺
Boron	B	H ₃ BO ₃ , BO ₃ ⁻ , B ₄ O ₇ ²⁻
Zinc	Zn	Zn ²⁺
Copper	Cu	Cu ²⁺
Molybdenum	Mo	MoO ₄ ²⁻
Chlorine	Cl	Cl ⁻
Cobalt	Co	Co ²⁺
Nickel	Ni	Ni ²⁺

Functions of Essential Elements in Plants

Table 503–10 Functions of essential elements in plants

Essential element	Function in plant
Carbon, hydrogen, and oxygen	<ul style="list-style-type: none"> • Directly involved in photosynthesis, which accounts for most of plant growth: $6\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow 6\text{O}_2 + 6(\text{CH}_2\text{O}) + 6\text{H}_2\text{O}$
Nitrogen	<ul style="list-style-type: none"> • Found in chlorophyll, nucleic acids, and amino acids • Component of protein and enzymes, which control almost all biological processes
Phosphorus	<ul style="list-style-type: none"> • Typically concentrated in the seeds of many plants as phytin • Important for plant development including: <ul style="list-style-type: none"> — development of a healthy root system — normal seed development — uniform crop maturation — photosynthesis, respiration, cell division, and other processes • Essential component of Adenosine Triphosphate (ATP), which is directly responsible for energy transfer reactions in the plant Essential component of DNA and RNA, and phospholipids, which play critical roles in cell membranes
Potassium	<ul style="list-style-type: none"> • Found in ionic form in the cell, rather than incorporated in structure of organic compounds • Responsible for: <ul style="list-style-type: none"> — regulation of water usage in plants — disease resistance — stem strength • Involved in: <ul style="list-style-type: none"> — photosynthesis — drought tolerance — improved winter-hardiness — protein synthesis • Linked to improvement of overall crop quality, including handling and storage quality

Table 503–10 Functions of essential elements in plants—continued

Essential element	Function in plant
Calcium	<ul style="list-style-type: none">• Essential for cell elongation and division• Specifically required for:<ul style="list-style-type: none">— root and leaf development— function and cell membranes— formation of cell wall compounds• Involved in the activation of several plant enzymes
Magnesium	<ul style="list-style-type: none">• Primary component of chlorophyll and is therefore actively involved in photosynthesis• Structural component of ribosomes, which are required for protein synthesis• Involved in phosphate metabolism, respiration, and the activation of several enzyme systems
Sulfur	<ul style="list-style-type: none">• Required for the synthesis of the sulfur-containing amino acids cystine, cysteine, and methionine, which are essential for protein formation• Involved with:<ul style="list-style-type: none">— development of enzymes and vitamins— promotion of nodulation for nitrogen fixation by legumes— seed production chlorophyll formation— formation of several organic compounds that give characteristic odors to garlic, mustard, and onion
Boron	<ul style="list-style-type: none">• Essential for:<ul style="list-style-type: none">— germination of pollen grains and growth of pollen tubes— seed and cell wall formation— development and growth of new cells in meristematic tissue• Forms sugar/borate complexes associated with the translocation of sugars, starches, N, and P• Important in protein synthesis
Copper	<ul style="list-style-type: none">• Necessary for chlorophyll formation• Catalyzes several enzymes
Iron	<ul style="list-style-type: none">• Serves as a catalyst in chlorophyll synthesis<ul style="list-style-type: none">— development of enzymes and vitamins— promotion of nodulation for nitrogen fixation by legumes— seed production chlorophyll formation— formation of several organic compounds that give characteristic odors to garlic, mustard, and onion
Boron	<ul style="list-style-type: none">• Essential for:<ul style="list-style-type: none">— germination of pollen grains and growth of pollen tubes— seed and cell wall formation— development and growth of new cells in meristematic tissue• Forms sugar/borate complexes associated with the translocation of sugars, starches, N, and P• Important in protein synthesis
Copper	<ul style="list-style-type: none">• Necessary for chlorophyll formation• Catalyzes several enzymes
Iron	<ul style="list-style-type: none">• Serves as a catalyst in chlorophyll synthesis• Involved in many oxidation-reduction reactions during respiration and photosynthesis
Manganese	<ul style="list-style-type: none">• Functions primarily as a part of the enzyme systems in plants• Serves as a catalyst in chlorophyll synthesis along with iron• Activates several important metabolic reactions (enzymes)• Plays a direct role in photosynthesis
Zinc	<ul style="list-style-type: none">• Aids in the synthesis of plant growth compounds and enzyme systems• Essential for promoting certain metabolic/enzymatic reactions• Necessary for the production of chlorophyll, carbohydrates, and growth hormones
Molybdenum	<ul style="list-style-type: none">• Required for the synthesis and activity of nitrate reductase; the enzyme system that reduces NO_3^- to NH_4^+ in the plant• Essential in the process of symbiotic nitrogen fixation by Rhizobia bacteria in legume root nodules
Chlorine	<ul style="list-style-type: none">• Involved in:<ul style="list-style-type: none">— energy reactions in the plant— breakdown of water— regulation of stomata guard cells— maintenance of turgor and rate of water loss— plant response to moisture stress and resistance to some diseases• Activates several enzyme systems• Serves as a counter ion in the transport of several cations in the plant
Cobalt	<ul style="list-style-type: none">• Essential in the process of symbiotic nitrogen fixation by Rhizobia bacteria in legume root nodules• Has not been proven to be essential for the growth of all higher plants
Nickel	<ul style="list-style-type: none">• Component of the urease enzyme• Essential for plants supplied with urea and for those in which ureides are important in nitrogen metabolism

Terminology used to Describe Deficiency Symptoms

Table 503–11 Terminology used to describe deficiency symptoms

Term	Definition
Chlorosis	Yellowing or lighter shade of green
Necrosis	Browning or dying of plant tissue
Interveinal	Between the leaf veins
Meristem	The growing point of a plant
Internode	Distance of the stem between the leaves
Mobile	A mobile element is one that is able to translocate, or move, from one part of the plant to another depending on its need. Mobile elements generally move from older (lower) plant parts to the plant's site of most active growth (meristem)

Mobility and Specific Deficiency Symptoms

Table 503–12 Mobility and specific deficiency symptoms

Essential element	Mobility	Deficiency symptoms and occurrence
Nitrogen	Mobile within plants: lower leaves	<ul style="list-style-type: none"> • Stunted, slow growing, chlorotic plants show chlorosis first • Reduced yield • Plants more susceptible to weather stress and disease • Some crops may mature earlier
Phosphorus	Mobile within plants: lower leaves	<ul style="list-style-type: none"> • Over-all stunted plant and a poorly developed root system show deficiency first • Can cause purple or reddish color associated with the accumulation of sugars • Difficult to detect in field
Potassium	Mobile within plants: lower leaves	<ul style="list-style-type: none"> • Commonly causes scorching or firing along leaf margins show deficiency first • Deficient plants grow slowly, have poorly-developed root systems, weak stalks; lodging is common • Seed and fruit are small and shriveled • Plants possess low resistance to disease • Deficiencies most common on acid sandy soils and soils that have received large applications of Ca and/or Mg
Calcium	Not mobile within plants: upper leaves and the growing point show deficiency symptoms first	<ul style="list-style-type: none"> • Poor root growth: Ca deficient roots often turn black and rot • Failure of terminal buds of shoots and apical tips of roots to develop, causing plant growth to cease • Most often occurs on very acid soils where Ca levels are low • Other deficiency effects such as high acidity usually limit growth before Ca deficiency apparent
Magnesium	Mobile within plants: lower leaves	<ul style="list-style-type: none"> • Leaves show a yellowish, bronze or reddish color while leaf show deficiency first veins remain green
Sulfur	Somewhat mobile within plants but upper leaves tend to show deficiency first	<ul style="list-style-type: none"> • Chlorosis of the longer leaves • If deficiency is severe, entire plant can be chlorotic and stunted • Symptoms resemble those of nitrogen deficiency; can lead to incorrect diagnoses

Table 503–12 Mobility and specific deficiency symptoms—continued

Essential element	Mobility	Deficiency symptoms and occurrence
Boron	Not mobile within plants: upper leaves and the growing point show symptoms first	<ul style="list-style-type: none"> • Reduced leaf size and deformation of new leaves • Interveinal chlorosis if deficiency is severe • May cause distorted branches and stems • Related to flower and or fruit abortion, poor grain fill, and stunted growth • May occur on very acid, sandy-textured soils or alkaline soils.
Copper	Not mobile within plants: upper	<ul style="list-style-type: none"> • Reduced leaf size leaves and the growing point show • Uniformly pale yellow leaves deficiency symptoms first • Leaves may lack turgor and may develop a bluish-green cast, become chlorotic and curl • Flower production fails to take place • Organic soils are most likely to be Cu deficient
Iron	Not mobile within plants: upper leaves show deficiency symptoms first	<ul style="list-style-type: none"> • Interveinal chlorosis that progresses over the entire leaf • With severe deficiencies, leaves turn entirely white • Factors contributing to Fe deficiency include imbalance with other metals, excessive soil phosphorus levels, high soil pH, wet, and cold soils
Manganese	Not mobile within plants: upper leaves show deficiency symptoms first	<ul style="list-style-type: none"> • Interveinal chlorosis • Appearance of brownish-black specks • Occurs most often on high organic matter soils and soils with neutral to alkaline pH with low native Mn content
Zinc	Not mobile within plants: upper leaves and the growing point show deficiency symptoms first	<ul style="list-style-type: none"> • Shortened internodes between new leaves • Death of meristematic tissue • Deformed new leaves • Interveinal chlorosis • Occurs most often on alkaline (high pH) soils or soils with high available phosphorus levels
Molybdenum	Not mobile within plants: upper leaves show deficiency symptoms first	<ul style="list-style-type: none"> • Interveinal chlorosis • Wilting • Marginal necrosis of upper leaves • Occurs principally on very acid soils, since Mo becomes less available with low pH
Chlorine	Mobile within plant, but deficiency usually appear on the upper leaves first	<ul style="list-style-type: none"> • Chlorosis in upper leaves symptoms • Overall wilting of the plants • Deficiencies may occur in well drained soils under high rainfall conditions
Cobalt	Used by symbiotic N-fixing bacteria in root nodules of legumes and other plants	<ul style="list-style-type: none"> • Causes nitrogen deficiency: chlorotic leaves and stunted plants • Occurs in areas with soils deficient in native Colorado
Nickel	Mobile within plants	<ul style="list-style-type: none"> • Symptoms and occurrence are not well documented but may include chlorosis and necrosis in young leaves and failure to produce viable seeds

Note: Information given above on nutrient mobility and deficiency symptoms is condensed. For more information, or for information on deficiency symptoms for a specific crop, see Bennett 1993; Horst 1995; Jones 1998; PPI 2003; or your State's Cooperative Extension Service publications.