Sustainable Agriculture forum

with Dr Arden Andersen Ph.D.D.O.

2017

Sep 25 - 27

Workbook

Fraser Coast REGIONAL COUNCIL

INVEST Fraser Coast now is the time

Soils & Agronomy Laboratory Course

- Australia
- September 25-27, 2017
- Arden Andersen, D.O., M.S.P.H., Ph.D.

Who is Arden Andersen

- Physician
  - GP, Occupational Medicine, Aerospace Medicine
  - Doctor of Osteopathic Medicine (US), Bachelor of Science in Agriculture, Masters of Science in Public Health, Ph.D. in Ag Biophysics
- Agricultural consultant/teacher
- Farm heritage from Michigan – dairy
  - Initial degree in agriculture – teacher
  - Exchange student near Bant, NOP, NL

Event Schedule; Day 1

- Farming-Food-Human Health Link
- Holistic Mindset
- Definitions
- Health-Disease Continuum
- Basic Sciences
- Field Assessment: Graham Shepherd/Michael McNeill Models; Visual Soil Assessment Score Card

Day 2

- Male/Female Fertilization
- Basic Nutrients/Functions
- Micronutrients
- Sap Testing – HortiNova Model
- Beginning Programs

Day 3

- Programs
- Glyphosate/GMO Issues
- Problem Solving
- Post Test
- Human Health Discussion Q & A

Key issues to take away

- Produce better quality/quantity of food
  - To do this one must understand photosynthesis
  - Understand that nutrition is the foundation of photosynthesis, subsequently all else
    - Determines how fertilizer converts to yield
    - Determines health of plant
    - Determines pressure of weeds, disease and insect pests
    - Key to male-female dynamics
    - Understanding nutrition starts with calcium
- Field observation, timing, execution

Key Question?

- What, in your operation, are you not doing today, but if you could do it, would fundamentally revolutionize your business?
- Equally important, potentially what are you presently doing today on your farm that legitimately threatens the viability of agriculture/food production on planet earth?

Australian Issues

- Plant breeding and variety selection per climate and disease pressure; linkage mapping, crown rot (Fusarium pseudograminearum) $80 million in north and frost susceptibility ($400 million/yr.) in wheat; longer coleoptile (dwarfs adopted to reduce lodging) for deeper planting in dry weather; weed suppressing wheat varieties to compete with herbicide resistant weeds

Australian Issues

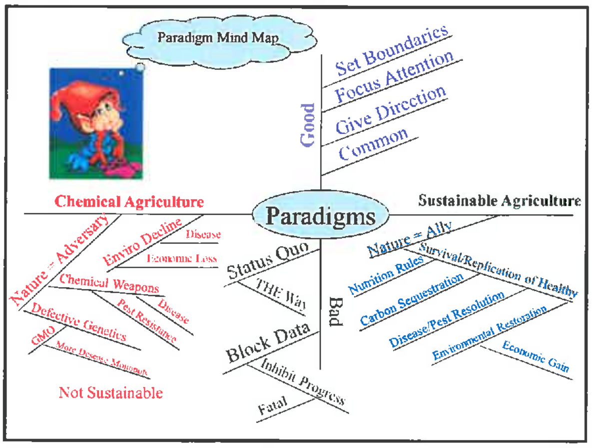
- 67% AU soils are affected by 'transient' salinity; root architecture, root lesion nematodes; Yellow Spot(pyrenophora tritici-repentis) costs $212 million/yr. with $150 million in fungicide use; late maturity alpha-amylase(cool temp shock) and black point (rain early/middle grain development with heat), sclerotinia stem rot in canola ($80/Ha Prosaro fungicide costs) – need Fall bio-program; herbicide carry-over for years in the soil;

Australian Issues

- powdery mildew in wheat and barley – blumeria fungicide resistance testing dPCR (digital polymerase chain reaction); wheat rust;
- Soil health, moisture retention, world pricing and competition
- Consumer buying trends: gluten and diary free, whole grain, ancient grains, non-GMO

Paradigm Video

- The Business of Paradigms 21st Century Edition
- In order for one to change their actions, he must first change the way he thinks
  - In this case this starts with understanding basic sciences



The Green D-evolution

- A lot of "green" for special interest groups
- A lot of "green" for chemical medicine
- A lot of "green" for politicians
  - Democrats and republicans – no difference
  - From Johnson to Obama federal policies toward alternative (to chemical) medicine and agriculture are identical; Trump seem more anti-environment
- A lot of "green" for chemical farmers
- A lot of "hollow" calories for consumers
- A lot of fat to transport – how much greenhouse gas is that emitting?

Rudolph Steiner 1922

- Dr. Ehrenfried Pfeiffer asked Rudolph Steiner in 1922 why so few people took on the holistic teachings of Steiner and others and Steiner replied,
  - "This is a problem of nutrition. Nutrition as it is today does not supply the strength necessary for manifesting the spirit in physical life. A bridge can no longer be built from thinking to will and action. Food plants no longer contain the forces people need for this."

What is the quality of your product?

- What is your crop brix?
- What is it's nutrient density?
- What are the heavy metal levels?
- What is the ORAC value?
- How does it taste, ship, store, and look?
- Is your farm a part of the problem or a part of the solution to climatic change?
  - The real issue of climatic change is toxicity
    - Destruction of the air, water, soil and food quality

More on Present-Day Ag

- Polluted or contaminated large percentage of lakes, streams and underground aquifers
- Created huge dead zone in golf of Mexico at the mouth of the Mississippi River
- Lost over 50% of top soil
- Continue erosion at or greater rate than 1930's
- Created uncountable resistant pathogens both in animal and human environments
  - Latest 4th generation cephalosporin antibiotic was not approved for vet use because of the resistant human pathogen E. coli organisms, already a problem, would develop additional resistance to all previous cephalosporin's.
    - » Food Quality, August/September 2006.

Global Climate Change

- *Priority One* by Allan Yeomans
  - CO2 increase over past Century
  - Major ocean currents are/have changed
  - Weather extremes abound
  - Carbon sequestration is a vital need
    - Remove airborne CO2
    - Increase water holding capacity
    - Tolerate droughts and floods
    - Reduce erosion and nutrient leaching

This really works!

- Hi Arden,
- I thought this might warm your heart. I was on Slim and Janina Slee's dairy farm (1000 cows) yesterday on the SI. They attended the Dunedin course 5 years ago and went back to the farm to dig. They found bricks for spade squares, no worms and grass brix of 3 at the highest. They implemented a lime, traces, humates program and have added effluent and created a lime slurry program. Over the years their brix has grown from 2 to 5 to 8 and yesterday the average was 11 with a high of 14. They're my biggest Dr Paul remedies client and have stopped using antibiotics. They're making it work on a large scale. They're stoked. So am I.
- This is a photo of their 5 year old daughter Sydney learning to use a refractometer. Phyllis Tichinin, Hawks Bay, New Zealand 11/08/12

Then there are the conventionally produced crops

- Illinois Dept. of Ag Sept. 20, 2012 Livestock Health Advisory: A facility may introduce aflatoxin-contaminated ingredients, i.e., ingredients containing more than 20 parts per billion (ppb) aflatoxin, directly into commercial channels based upon the following **maximum levels** in accordance with the Food and Drug Administration Compliance Policy Guide 683.100:
- - 300 ppb for corn intended for finishing (i.e., feedlot) beef cattle;
- - 200 ppb for corn intended for finishing swine of 100 pounds or greater;
- - 100 ppb for corn intended for breeding beef cattle, breeding swine, or mature poultry;
- - 20 ppb for corn, peanut products, and other animal feeds and feed ingredients, but excluding cottonseed meal, intended for immature animals;
- - 20 ppb for corn, peanut products, cottonseed meal, and other animal feeds and feed ingredients intended for dairy animals, for animal species or uses not specified above, or when the intended use is not known.

Bird's Eye View Pioneers

- Steiner – energy and mineral
- Albrecht – soil mineral and animal health
- Reams
  - Reams saw the "big picture" though he could not explain it in acceptable terms so he invented his own terms – "anion" and "cation"
- Chaboussou/Callahan
  - Insects only attack "sick" plants - recycling
- Tainio – energy, mineral and biology

What is "bird's eye view"?

- Holistic – yes and what does that mean?
  - Start with health outcome plant and work backward to what allows health to occur
  - First have to define "health"; thus, health, pre-disease, and disease
  - Establish methods/standards of evaluation
    - Must know where you reside
    - Must know if/when inputs move you up/down
      - If nitrogen application greens the crop, is the crop healthier or sicker? What is your definition of "green"? What is your definition of "healthier" or "sicker"?

Bird's Eye View

- Outcome regardless of methods employed
  - **Health** – maximum brix, mineralization, nutrition, taste, yield to genetic potential, free of disease/parasites autonomously
  - **Pre-Disease** – "appears healthy" due to artificial control of disease/parasites, disease waiting to happen, accepted yield, mineralization, nutrition, brix - majority of crop production today including organic production
  - **Disease** – recycling of deficient/defective systems unable to provide needed nutrition/sustenance for consumer

Health

Sustainable living system taking in adequate energy equal to or greater than energy is being lost; strong immune system able to protect the organism from all predatory threats: at the top of Maslow's Hierarchy

Pre-disease

Declining system balance, weakening immune system unable to sufficiently protect the organism from predators and inherent internal degradation: loosing energy faster than replacing it

Disease

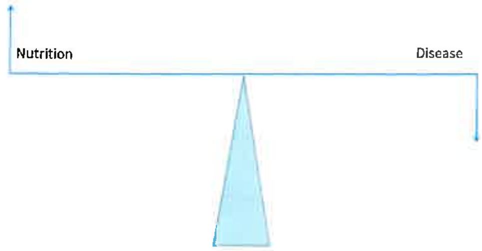
Sufficient system imbalance that recyclers appear; question is whether they will prevail or will the system sufficiently regenerate: loosing energy much faster than replacing it if at all

Death

Recycle carbon, hydrogen, oxygen and nitrogen via microorganisms

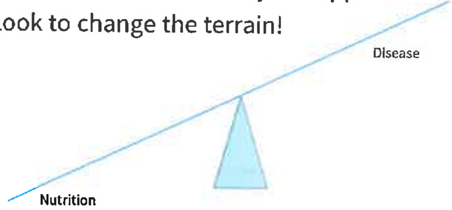
Nutrition v. Disease

- Balance of Nature



Time Management

- One can spend eternity looking to ID every disease organism associated with a given condition. These are only the opportunists.
- Look to change the terrain!



What are our standards of health?

- Simplest field test: Brix
- Observation of or lack of symptomology
- Test weight or bulk density
- Mineral and nutritional testing
- Visual characteristics
  - Uniformity, optimal shape, structure, color…
    - Calyx on fruit, dent on corn, shape on pears/apples…
- Yield
- Storability

Above all …

- Farming is about producing food for people.
- Health is about nutrition.
- Brix/nutrient density are the ultimate and final judge/determinant of food quality.
- Finally, farming is about delivering nutrients, via food, to the consumer table.
  - All else is just rhetoric
  - Farming this way, by default, solves the other issues so often debated in various groups

5 of 7 Paradigm Shifts

- Listen to the consumer
- Insects, diseases and weeds are due to environmental and nutritional circumstances created by farmer
- Brix level of sap as first measure of quality
- History and physical exam are 90% of diagnosis
- Calcium is king and most all of you have a deficiency at least functionally in your soils and crops

1st paradigm shift…

- Listen to the consumer
  - Taste, eating experience
  - Nutritional value
  - Pesticide free
  - Environmentally compatible
  - Genetically clean
    - NON-GMO

The consumer is not the problem

- Reality: Too few farmers realize the true value of the farm, the significance of the food they produce and the consequences that food creates in society.
- Farmers are quick to complain that consumers fail to appreciate what goes into producing "food" and that food is the foundation to a stable country

Purpose of Farming

- Produce food and fiber for human consumption, health and survival
  - May have animal intermediates
    - Meat, milk (still issues), eggs
- Provide comprehensive nutrition
  - Growth and development
  - Prevention and recovery from illness, trauma
- Sustainability of human life requires sustainability of farming, which requires comprehensive **nutrition**.

Food and Fiber

- Not vanity items like telephones, TV's, cars, stereos, furniture, etc.
- Food and fiber are fundamental basic needs that determine the health and wellbeing of people
  - Whatever they contain – nutrients and toxins – directly determines the quality of life we can attain
    - Health, both physical and mental
    - Productivity, both physical and mental
- Medicine and agriculture are intimately connected

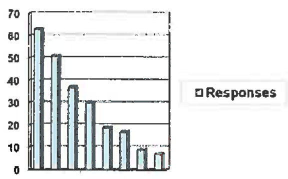
The Consumer Rules

- And why shouldn't they
  - It's food that they are buying
  - "Taste remains a critical issue in the market and customers will always raise this issue first."
  - "Japan would prefer a minimum brix level to reduce any poor tasting fruit as our customers are still finding brix variability…"
    - » New Zealand Kiwifruit Journal July/August 2006
  - "We had to change or lose the Japanese market." "…performance in Japan was not up to expectations. (T)he new Zespri policy this year was designed so only the best fruit would go to Japan, the co-op's premium price market."
    - » The New Zealand Farmers Weekly, July 24, 2006, p.9.
    - » The NZ kiwifruit industry resisted, in the past, differentiating fruit according to brix value because too many growers would not meet the standard. Now there is no choice, the consumer has spoken with their Yen, Euros and Dollars.

Market Drivers

- **Prefer to have fewer chemicals in food – 63%**
- **Better for me/my family – 51%**
- Better for the environment – 37%
- Prefer the taste of organic – 30%
- Looked better than the non-organic – 19%
- Item was on sale – 17%
- First time buyer and wanted to try it – 9%
- Only choice available – 7%

- 17% of 1,200 or 204 respondents – The Packer's Fresh Trends 2002 report – Vance Publishing Co.



Nutrient Outcome over Farming Procedure

- Organic food production disallows GE
- Organic disallows synthetic pesticides
- Organic production is a procedural status
- Farmers can become certified organic by doing nothing: organic by neglect
- International organic certification is highly suspect and becoming tainted
- The KEY: Nutritional Outcome

2nd Paradigm Shift

- Insects, diseases and weeds are due to environmental and nutritional circumstances created by farmer
  - These circumstances are correctable
- Insects, diseases and weeds are NOT due to a deficiency of chemical weapons or because the farmer has not killed them by some other means

Current Mindset on Pests...

- Everyday the farmer arises out of bed in the morning and goes to war, wondering what he/she is going to "have" to kill today and by what means.
- This is the "warring mentality" or paradigm of the "green revolution"
- It spreads death and destruction everywhere in the wake of its path

Francis Chaboussou who authored the concept of "trophobiosis"

- "First, we need to overcome the idea of 'the battle': that is, we must not try to annihilate the parasite with toxins that have been shown to have harmful effects on the plant, yielding the opposite effect to the one desired. We need, instead, to stimulate resistance by dissuading the parasite from attacking.
- This implies a revolution in attitude, followed by a complete change in the nature of research. ... we need a deeper understanding of the relationship between the 'conditioning of the plant' and proliferation of the parasite."
  - P.209

Role of potassium, calcium, magnesium and phosphorus on disease resistance by Volker Romheld

- An adequate nutritional status of distinct mineral nutrients (e.g. K, Ca and micronutrients) can improve resistance/tolerance to diseases and pests. **Under high disease pressure, plants often require a higher nutritional status** because of disease damage. An adapted crop and 5 fertilization management (including rhizosphere management) can support plants in their effort for disease resistance. In particular, negative interactions with some agrochemicals such as distinct herbicides (e.g. glyphosate) that block the plant's own defense mechanisms have to be considered much more carefully in relation to plant, soil and ecosystem health in the future.
- Institute of Plant Nutrition, University Hohenheim, Stuttgart, Germany, fone: 49-711-459-3714 / 3504, e-mail: roemheld@uni-hohenheim.de

Plant Nutrition Basics

- Three different types of reactions as nutrient supply increases:
- I) A "balanced nutritional status" will result in the lowest overall disease and pest incidence and is an ideal situation for a farmer. Such a balanced nutrient supply will ensure optimal growth and yield, while being optimal for plant resistance (Type I). This relationship can be shown for bacterial stem rot or bacterial wilt of tomato.

Plant Nutrition Basics

- ii) High susceptibility to many fungal diseases induced by obligate parasites (e.g. powdery mildew, leaf blotch or *Puccinia spp) or* pests will only be found at excessive rates of N (Type II).
- iii) In contrast to obligate parasites, the facultative parasites are suppressed with increasing nutrient (N) supply and result in an opposite relationship between growth and disease susceptibility (Type III).

Insect reality…

- Insect behavior is deliberate and designed to eliminate weak, deformed, nutritionally deficient/unbalanced plants
- Insect pests avoid healthy plants!

Insect Science…

- Francis Chaboussou: Trophobiosis
  - Nutrition Theory
    - Insects attack only sick plants having incomplete proteins, free or fragmented nutrients which insects are able to digest
  - *Sante des Cultures, Une Revolution Agronomique*, Paris, 1985, ISBN: 2-7066-0150-7
- Philip S. Callahan: Tuning Into Nature

Healthy Crops by Francis Chaboussou

- Chaboussou cites nearly 300 peer reviewed journal articles substantiating the fact that insects do not attack healthy plants, only plants with an imbalance of nutrition particularly with **free nitrogen, amino acids and reducing sugars**.
- Insects and pathogens seek soluble, free nutrients which corresponds to a state in the plant of the inhibition of protein and complex carbohydrate synthesis. This state of susceptibility in the plant corresponds to nutritional deficiency or imbalance caused by negligent fertilization or by insecticides, herbicides and fungicides.
- "… numerous organophosphates inhibit protein synthesis (in plants). This is the cause of the plant's increased susceptibility, not only to sucking insects,… but also to diseases, fungal and otherwise…" p.55
- "… in this case (as in all other cases where the plant's resistance is undermined) the parasite proliferates where protein breakdown predominates in the host plant's metabolism." p. 48

Healthy Crops
by Francis Chaboussou

- **"...a plant will only be attacked when its biochemical state corresponds to the nutritional (trophic) needs of the parasite in question." "...soluble nitrogen compounds are the main nutritional factors promoting the development of the various infections."** p. 31

The identification of *PAD2 as g-glutamylcysteine synthetase highlights the importance of* glutathione in plant disease resistance

- ***"The GSH deficiency of pad2 did not only lead to enhanced susceptibility towards Pseudomonous brassicae and P. syringae but also caused enhanced susceptibility towards a number of* necrotrophic pathogens including *Botrytis cinerea, Alternaria brassicicola and Plectospaerella cucumerina. Thus, GSH is identified as an important component of general* disease resistance in Arabidopsis (brassica - thale cress)."**

  - Vincent Parisy1, Benoit Poinssot1, Lucas Owsianowski1, Antony Buchala1, Jane Glazebrook2 and Felix Mauch1 1Department of Biology, University of Fribourg, Switzerland 2Department of Plant Biology, University of Minnesota, USA

Why do we use sugar in foliar sprays?

- **An oligosaccharide (OS) has been shown to induce resistance in grapevine** (*Vitis vinifera*) against *Plasmopara viticola (downy mildew) under greenhouse conditions.* ***Spray application*** **reduced the severity of the disease by 70-80 %.** However, the efficacy of the treatment appeared to be influenced by the age of the leaf, old leaves being more resistant to the disease than the young ones. **Following OS application, foliar tissues underwent significant ultrastructural and biochemical modifications, detectable only after inoculation with the pathogen. These included H202 production at the infection site, the deposition of phenolic compounds-enriched material and the formation of structural barriers that appeared to prevent pathogen development and sporulation in foliar tissues.** Our observations suggest that in grapevine OS act rather like a priming agent than a true elicitor.

  - Trouvelot S1., Allègre M1., Joubert2, J.-M., Pugin A1, Daire X. *Cytological aspects of elicitor-induced resistance against Plasmopara viticola in grapevine* 1 1 UMR INRA-Université de Bourgogne - CNRS Plante Microbe Environnement. Dijon. France 2 Laboratoires Goëmar SA, St Malo, France

The Myth of Nitrogen Fertilization for Soil Carbon Sequestration

- Intensive use of N fertilizers in modern agriculture is motivated by the economic value of high grain yields and is generally perceived to sequester soil organic C by increasing the input of crop residues. This perception is at odds with a century of soil organic C data reported herein for the Morrow Plots, the world's oldest experimental site under continuous corn (*Zea mays L.)*. **After 40 to 50 yr of synthetic fertilization that exceeded grain N removal by 60 to 190%, a net decline occurred in soil C despite increasingly massive residue C incorporation…**
- S. A. Khan,* R. L. Mulvaney, T. R. Ellsworth, and C. W. Boast University of Illinois J. Environ. Qual. 36:1821–1832 (2007). doi:10.2134/jeq2007.0099

Food toxicity starts on the farm

- Scientific studies have linked the toxins, called advanced glycation end products (AGEs), with inflammation, insulin resistance, diabetes, vascular and kidney disease, and Alzheimer's.
- AGEs are a group of compounds formed from the non-enzymatic reaction of **reducing sugars with the free amino groups** of proteins. They are also produced when meat products are sterilized and pasteurized.

Fundamental Concept of Nutrition

- Every living organisms has its needed diet to be healthy and reproductive
  - Would you feed a pig's diet to a cow?
  - Would you feed a goat's diet to a pig?
  - Would you feed an adult's diet to a baby?
- Insects, bacteria, fungi, and viruses are no different.
  - They feed on only those things that sustain them and allow for procreation. They do not have the digestive enzymes necessary to digest complete/complex proteins and carbohydrates. They need simple sugars and amino acids and nitrogen compounds.

Pesticides and Nutrition

- Pesticides and especially herbicides may be more to blame than misguided fertilization for the development of various parasites, due to the inhibition of protein synthesis caused by these chemicals. Chaboussou, p. 162
- Various fungicides cause proliferation of nematodes, particularly on strawberries and onions. p. 153
- Proliferations of parasites on cereal crops result from an alteration of the plant's metabolism by the use of chemical pesticides. Most often these are herbicides, but insecticides and fungicides can also be involved. So too can chemical fertilizers. p. 152

Insects and Nitrogen

- Levels of amino acids and amides in the roots of nematode-infected plants are always higher (from 17% to 316%) than those in healthy plants (Hanks and Feldman, 1963). ... especially since the intensive use of herbicides began.
- Fertilizers, particularly those over-rich in nitrogen, lead to an increase in damage caused by parasites.
  - Chaboussou, p. 153

Plant "Resistance"

- Loss in plants of 'resistance' to insects and desease can be explained through the availability of improved nutrition for the parasites. This occurs through inhibition of protein synthesis, as well as through enrichment of the tissues with soluble substances (amino acids and reducing sugars).

Root exudation (bleeding) of organic compounds from cotton, wheat and apple with different Zn levels

Zn Treatment	Amino acids	Sugars	Phenolics
	($\mu g\ g^{-1}$ root $6h^{-1}$)		
		COTTON	
-Zn	165	751	161
+Zn	48	375	117
		WHEAT	
-Zn	48	615	80
+Zn	21	315	34
		APPLE	
-Zn	55	823	350
+Zn	12	275	103

Cakmak and Marschner, 1988, J. Plant Physiol.

Significance of plant exudates?

- Plant/root exudates are the foods/attractants for insects and diseases.
- Plant nutrient deficiencies result in more "free" food/attractant for the insects/diseases.
- Correct the plant nutrient deficiencies and you correct the insect and disease problems.

Aphids, Mites, etc.

- "Leaf analysis has shown that where aphid development is greatest, the most notable biochemical changes are in the ratios of free amino acids."
- "The aphid population increases as the levels of non-proteic nitrogen increase."
- Speaking of pesticides 2-4D, DDT and others:
  - "As a result of the alteration of the foliage by the pesticide, the aphids are likely to reproduce much earlier. From July to November, the result is the appearance of an additional generation of aphids when they are fed on foliage treated with mevinphos."

Healthy Plants, p. 118-121.

Aphid as a vector for virus

- Miller and Coon (1964) researching aphid behavior and virus infection in crops concluded the following:
  - If the aphids, presumed to be vectors, gravitate towards plants already infected with viral diseases in preference to healthy ones, to what extent are they responsible for the initial infection?
  - Aphids like all insects seek plant tissue enriched in soluble nitrogen, particularly free amino acids and reducing sugars.
    - Chaboussou, p.127

Sap Testing NovaCropControl

- Sap analysis of total nitrogen, nitrate nitrogen and ammonia nitrogen.
- Aphids attack the plant when the percent of nitrate nitrogen to total nitrogen in the sap reaches 55%.

Pesticide Effect

- Maxwell and Harwood (1960) are perhaps the first to have looked at the relation between plant fecundity (ability to reproduce) and physiology on the one hand, and the effects of pesticides on the other.
  - Leaf analysis has shown that where aphid development is greatest, most notable is the rations of free amino acids; increases in free alanine, serine, and glutathione.
  - DDT causes increases in tissue non-proteic nitrogen and disaccharides eight to fifteen days after application.
  - As a result of the alteration of the foliage by the pesticide, the aphids are likely to reproduce much earlier; the result is the appearance of an additional generation of aphids when they are fed on foliage treated with mevinphos.
    - Chaboussou, p. 120, 121

Apple Scab

- Williams and Boone (1963) recorded that susceptible varieties to Venturia inaqualis, contain asparagine levels of 1.969 (an amino acid necessary for the growth of pathogenic fungi), while the resistant variety on has 0.756.
- Regarding the genetics of varieties:
  - The gene can only express itself in relation to other factors in the environment.
  - Genetic factors are only one element and their action can be thwarted by a whole series of others, most importantly by the effects of chemical pesticides.
    - Chagoussou, p. 82

Entomology According to Callahan

- Insects tune into the radio and infrared signals in their environment to seek, identify, track and home in on their mates and foods.
- Ammonia emitted from soils acts as an amplifying signal pump for the signals coming of sick crops making them more easily detected by nature's garbage crew

Consider the new paradigm…

- Many chemical weapon advocates will insist that insect pests do attack healthy plants, they have seen it.
  - What is there definition of "healthy"?
  - Would they say that professional athletes are healthy? Probably the model of health!
  - Then how do they explain away the fact that professional athletes have a lower life expectancy than the standard population?
  - OHHH! But they may use drugs or performance enhancement chemicals. And for what are the chemical weapons used in agriculture?

The real issue in Ag is quality of the product produced for human consumption

- USDA data shows up to 38% decline
  - Protein, Ca, vit. C, P, Fe, riboflavin
    - ABC News March 1, 2006 by Megan Carpenter
  - 43 foods 1950 – 1999
    - Davis, Epp and Riordan; JACN, Vol. 23, No. 6, 669-682 (2004)
  - Fe, Zn, Cu, Mn, Se
    - Average 63% decline 1941 – 2001
      - Huling, December 15, 2001

DID YOU KNOW? Our food today is LESS NUTRITIOUS than before WWII!

- Mineral Depletion in Food 1940-1991

Vegetables	Fruits
Lost **76%** of their copper	Lost **19%** of their copper
Lost **49%** of their sodium	Lost **29%** of their sodium
Lost **46%** of their calcium	Lost **16%** of their calcium
Lost **27%** of their iron	Lost **24%** of their iron
Lost **24%** of their mag	Lost **15%** of their magnesium
Lost **16%** of potassium	Lost **22%** of potassium

- David Thomas, Analysis of UK *Composition of Foods 1940 – 1991. Nutrition and Health 2003, Vol 17, pp. 85-115* from *The Composition of Foods*, Ministry of Agriculture, Fisheries and Foods and the Royal Society of Chemistry
- Considering the amazing technological advancements in plant breeding, genetic engineering, conventional precision farming practices, how is it possible that all this technological advancement has actually reduced food nutritional value?

Mineral Depletion 1960's

- "Spectrometer analyses of over 4,000 grain samples taken in 11 midwest states over just the last four years indicate an unmistakable decline in trace minerals…"
- "The average copper content in all the corn analyses… 2.56 ppm… but for the last year 1968 was less than 0.82 ppm…a drop of approximately 70 percent"
- "The hog man may notice that his animals are quite nervous…magnified if the animal is put under any stress…animals being loaded into a truck for market began to shake and quiver and had trouble standing"
- National Hog Farmer, Swine Information Service, No. E25, 1968.

Disease Toxins Now Common

- Fusarium toxins are now common in all glyphosate sprayed crops and crops grown on soils having been sprayed with glyphosate at any time in the past.
- Fumonisin – heart failure in pigs; esophageal cancer in humans
- Vomitoxin – animals go off feed
- Zearalenone – estrogen-like effects; precocious puberty in males and females

Disease v. Health

- Why do women get yeast infections after antibiotics? Does the drug have yeast spores?
  - No! The antibiotic kills off the good bacteria!
  - It is the same in the soil and on the plants.

Chemicals cause fungal disease

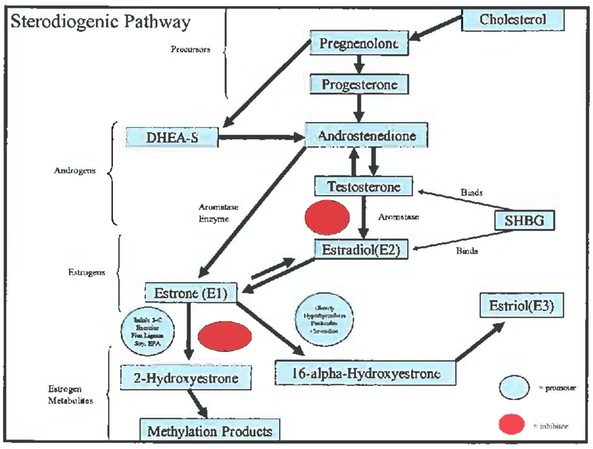
- "We have observed an impact of organo-chemicals on the development of fungal diseases in apple trees and grapevines, … Dithiocarbamic acid used over four years to control Phytophthora in potatoes also provokes an increase of other diseases, especially viroses."
- Chaboussou, p. 112.

Herbicides: War on weeds

- Farmers have been brainwashed to believe that fertile soils grow weeds and their domesticated crops equally well
- Farmers believe that weeds detract from their crop, steal water and nutrients and ruin the “clean techno-farm” image
- Name one herbicide, just one since 1950 that has solved the weed problems in farming.

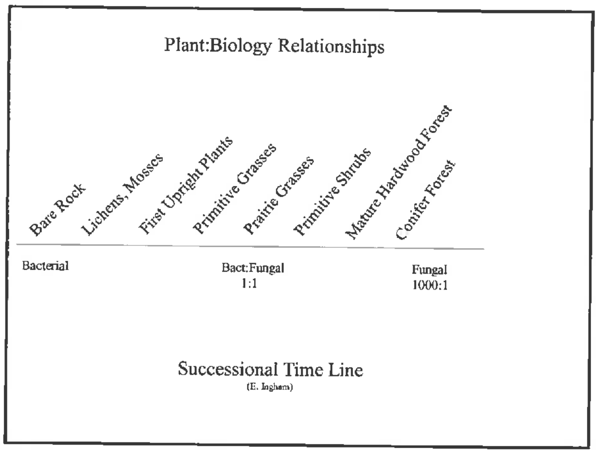
There’s more…

- Roundup inhibits steroidogenesis by disrupting steroidogenic acute regulatory (StAR) protein expression – blocks progesterone production; pesticide-induced infertility/hormone disruption
  - RR crops are the most common GM crops
- Insecticides: Organochlorine Lindane and Organophosphate Dimethoate directly inhibit steroidogenesis
  - Walsh, et al. Environ Health Perspect 108:769-776 (2000) by NIH grant HD17481 and T32-HD07271



Weed Reality...

- Domesticated crops have a higher evolutionary order than do weeds
- Crops have different desired rhizosphere microbial communities than do weeds
- Weeds indicate the soil has been converted to a lower, more primitive evolutionary environment



Weeds are NOT equal to crops

- Consider Scandanavian geo succession studies and greenhouse studies on microbes and weeds
- Pennanen, Taina, Rauni Strommer, Annamari Markkola, Hannu Fritze, Microbial and Plant Community Structure Across a Primary Succession Gradient. Scandinavian Journal of Forest Research. 16:1: 37-43, January 2001
- Batten, Katherine M., Kate M. Scow and Erin K. Espeland, Soil Microbial Community Associated with an Invasive Grass Differentially Impacts Native Plant Performance, microbial Ecology, SpringerLink, June 27, 2007

To Review:Reduce herbicide costs

- Ohio Ag Research & Devel Ctr (OARDC)
  - Soil biology indirectly prop to insect pressure
    - More egg masses/pressure on conv fert corn
  - Soil bio-active carbon indirectly prop to broadleaf pressure
  - C:N indirectly prop to broadleaf pressure
    - Improved bio-active carbon to N from 25:1 to 75:1 reduced broadleaf weeds as much as 75%
    - Grass weeds not affected as much
    - My Note: Seen often in organic programs – the calcium issue is not adequately addressed because pH is used as the indicator for calcium applications. Calcium is the key to controlling grass weeds.

Ohio research continued…

- Summary: more bio-carbon
  - Less broadleaf weed pressure
  - Less insect pest pressure
- Grass weeds didn't show this change
  - Ohio State still uses pH to determine calcium needs
    - My Note: Seen often in organic programs – the calcium issue is not adequately addressed because pH is used as the indicator for calcium applications. Calcium is the key to controlling grass weeds.

Carbon Sequestration: Humus

- USDA National Soil Tilth Laboratory
  - No-till corn residue conversion into humus is equal to benefit if residue **completely removed**
  - 8000 lbs. of corn residue from 180-bu. Yield
    - 80 lbs. N; 30 lbs. P; 190 lbs. K
    - Residue mass nearly 2X weight of roots
  - No-till system residue leaches or oxidizes into
    - NO, CO2 and other compounds lost to the enviro.
      - » AgriEnergy Resources Fall 2006 Newsletter

Weed susceptibility is nutrition based

- Effect of soil pH on herbicide activity

Soil pH (top 1 in)	Fall Panicum(lb/ac)
5.6	1517
6.4	820
6.9	749
7.2	349

- *atrazine 1 lb/A, cyanazine 2 lbs/A
- Crop Production Systems. Lee Schweitzer, Dept. of Agronomy, Purdue University 2012/2013

3rd paradigm shift…

- Brix level of sap as first measure of quality
  - Check sap of leaf, petiole and fruit
  - 12 brix 24/7 is the minimum goal for the plant sap

Brix History: http://en.wikipedia.org/wiki/Brix

- The Balling scale was developed by German chemist Karl Balling. It refers to the **concentration of a sucrose solution**, as the weight percentage sucrose at 17.5°C.
- The Brix scale was originally derived by Antoine Brix by recalculating Balling's scale to a reference temperature of 15.5°C. The Brix scale was subsequently recalculated again, and now uses a reference temperature of 20°C. Brix can be approximated as 261.3*(1 - 1/g), where g is the specific gravity of the solution at 20°C.
- The Plato scale which measures in Plato degrees is also a refinement of the Balling scale. It uses a reference temperature of 17.5°C and a slightly different modulus, with the approximation 260*(1 - 1/g), where g is the specific gravity of the solution at 17.5°C.
- The three scales are often used interchangeably since the differences are minor.
- Brix is primarily used in fruit juice, wine making and the sugar industry.
- Plato is primarily used in brewing.
- Balling still appears on older saccharimeters, and is still used in the South African wine industry.

- **Brix is used in the food industry for measuring the approximate amount of sugars in fruit juices, wine, soft drinks and in the sugar manufacturing industry.** Different countries use the scales in different industries; in the UK brewing is measured with specific gravity X 1000, European brewers use Plato degrees, and US industries use a mix of specific gravity, Brix, degrees Baume and Plato degrees.
- For fruit juices, one degree Brix is about 1-2% sugar by weight. This usually correlates well with perceived sweetness.
- Since Brix is related to the concentration of dissolved solids (mostly sucrose) in a fluid it is therefore related to the specific gravity of the liquid. Because the specific gravity of sucrose solutions is well known, it can also be measured by refractometers.

- **When a refractometer is used**, It is correct to report the result as "refractometer dried substance" (RDS). One might speak of a liquid as being 20 °Bx RDS. This is a measure of percent by weight of TOTAL dried solids and, although not technically the same as Brix degrees determined through a specific gravity method, renders an **accurate measurement of sucrose content since the majority of dried solids are in fact sucrose.** When an infrared Brix sensor is used, it measures the vibrational frequency of the sugar molecules, giving a Brix degrees measurement. This will not be the same measurement as Brix degrees using a density measurement because it will specifically measure dissolved sugar concentration instead of all dissolved solids.

First and foremost testing tool

- The refractometer
  - Test everything you get your hands onto
    - Plant sap
      - Leaf, stalk/stem, root, fruit
    - Milk
    - Fruits and veggies
  - Generally speaking (75%) the higher the brix the healthier the plant, the higher the yield, the fewer the insects and diseases, the higher the nutritional value.
    - 25% is operator error, dehydration, inappropriate test site
  - If you follow the Albrecht program, that is a great start from chemical to biological farming. If you stop there, you will hit a wall and will fail to get the brix readings to come up to 12 or above at the weakest point in the plant.

Refractometer and Food Quality

- Refractometer calibrated to % brix with refractive index of sucrose as the standard
- 12 Brix is the minimum desired level
- Sugar production is the fundamental purpose of photosynthesis
- 75% of the time, higher brix correlates to higher nutritional level in the plant/crop
  - 25% there is dehydration, operator error, abberancy purely in looking at brix of one part of plant: sweet corn ear v. stalk
- Learn some basic chemistry: H_2O is not H_2O_2 any more than CH_3OH is $(CH_3)_2OH$

Fundamentals of Brix

- Plant growth is about taking CO_2 and H_2O in the presence of a plant and sunlight and generating SUGAR, NOT protein, NOT fiber, NOT anything other than SUGAR, SUGAR, SUGAR.
- This SUGAR is then CONVERTED to everything you call "crop" and harvest.
- The lower the sugar the less the YIELD.
- Measure sugar with a refractometer and get a reading in BRIX.

The Brix Wimps

- There are a few vocal agronomists/consultants, particularly in the 'Albrecht-and-no-one-else' "churches" who discredit brix and its value in crop quality.
- As with EVERY measuring tool or method, operator error can be a factor in measuring brix.
- These folks, though possibly well meaning to a point, can't figure out how to get crop brix above minimal levels by sticking strictly to their narrow interpretation of Albrecht, so rather than heed the message, they insist upon killing the messenger.

SUGAR (REFRACTOMETER)
LITERATURE REFERENCES

AG JOURNAL 1952 pp. 610-614

CROP SCIENCE 1969 pp. 831-834

CROP SCIENCE 1970 pp. 625-626

CROP SCIENCE 1984 pp. 913-915

CROP SCIENCE 1988 pp. 861-863

CANADIAN JOURNAL OF PLANT SCIENCE 1964 pp. 451-457

CANADIAN JOURNAL OF PLANT SCIENCE 1972 pp. 363-368

PHYTO-PATHOLOGY 1966 pp. 26-35

4th paradigm shift…

- History and physical exam are 90% of diagnosis
- Soil test is only 10%
- Treat the patient, not the lab test

Physical Exam

- Mike McNiel, Ph.D.
- Graham Shepherd, Ph.D.
  - NZ soil quality audit
- Plus refractometer & penetrometer, weeds, diseases and insect pests
- We will do a soil audit at the end of the day

What is the quality of your product?

- What is your crop/milk brix?
- What is it's nutrient density?
  - What is the CLA/omega 3 value?
- What are the heavy metal levels?
- What is the ORAC value?
- How does it taste, ship, store, and look?
- Is your farm a part of the problem or a part of the solution to climatic change?
  - The real issue of climatic change is toxicity
    - Destruction of the air, water, soil and food quality

5th paradigm shift...

- Calcium is king and most all of you have a deficiency at least functionally in your soils and crops
- Key to yield
- Key to disease, insect pest and weed issues
- Key to foliar feeding success or failures
- Key to getting potassium into the plant

Outcome is what counts!

- High Brix plant matter and milk
- 1940 or better nutrient levels
- No pest, disease, or weeds to KILL
- Yields consistently greater than norm
- Cost per unit of production less than norm
- Premier taste, shelf life, shipping, storability
- Carbon sequestration, environmental reclamation
- Humane, clean, profitable, sustainable production
- Those who can will, those who can't will talk, talk,..

Procedure guarantees NOTHING

- Food is about nutrition
- Nutrition is about substance, about brix, about proper fertilization/nutritional management of the crop.
- Organic certification is procedural. It only means something (aside from non-GMO) if the farmer has applied nutritional practices that raise crop brix and NATURALLY reduce/eliminate weeds, diseases & insect pests.

Accountability

- The "green revolution" perpetuating the pseudo-science of chemical N-P-K farming is being held accountable for 6 decades of environmental degradation, pollution, food adulteration/nutrient decline along with all its direct and indirect costs to society
- Real science is vindicated and we can now get on with the business of real food production and solving this long list of challenges, all readily solvable with biological management methodologies

Norman Uphoff, PhD

- Professor of Government and International Agriculture; Program Leader for Sustainable Rice Systems, Cornell International Institute for Food, Agriculture and Development (CIIFAD); Director of Graduate Studies, Field of International Development; Core Faculty, Cornell Institute for Public Affairs (CIPA), Acting Director, Spring 2007
- *Envisioning 'Post-Modern Agriculture' A Thematic Research Paper,* Cornell University, March 2007 http://www.wassan.org/sri/documents/Post_Modern_Agriculture_March07.pdf
- "Post-modern agriculture (biological agriculture) is not anti-science, …it is the most modern agriculture because it builds carefully and creatively on advances in scientific knowledge particularly in the disciplines of biology, ecology, and microbiology."
- "We should give more attention to the biological aspects of soil systems… and rediscover the potentials of synergy and symbiosis."
- "Use of agrichemicals for crop protection has resulted in a chemical treadmill where increased use does not result in an overall reduction in pests and diseases"

Uphoff, 2007

- "Instead of always requiring more inputs to achieve more outputs, it is possible to produce more outputs with fewer or reduced inputs, by tapping into the power of biology."
- "Many of the economic advantages that larger farms currently enjoy come more from *economies of size* than from true economies of scale. This means that their profitability derives more from their market (bargaining) power than from true factor-use efficiency.
  - *Envisioning 'Post-Modern Agriculture' A Thematic Research Paper* Cornell University, March 2007

David Pimentel, PhD 1997

- "Pesticide use in US has gone up 10 fold since WWII, total crop losses in America due to insect damage went up from 7% to 13%."

5 Paradigm Shifts

- Listen to the consumer
- Insects, diseases and weeds are due to environmental and nutritional circumstances created by farmer
- Brix level of sap as first measure of quality
- History and physical exam are 90% of diagnosis
- Calcium is king and most all of you have a deficiency at least functionally in your soils and crops

6th Paradigm: pH

- Most university agronomy professors and many farmers believe that pH is the determinant of calcium presence/need.
- It is not, never was, never will be the measurement of calcium.
- pH does influence solubility of minerals
- pH is negative log of hydrogen ion concentration
  - Not negative log of calcium ion concentration

What is the real issue for pH?

- pH affects the oxidation state of the metal ions, and, thus their bioavailability
- Plant and animals need cations in the reduced state and anions in the oxidized state for the most part
  - Fe^{+2} v. Fe^{+3}
  - Cr^{+3} (nutritive) v. Cr^{+6} (carcinogenic)
- Low pH tends to reduce the oxidation state while alkaline pH tends to raise the oxidation state
  - In nature this is modulated by microorganisms and root exudates especially organic acids
  - Problems with mineral acids (carbon burn) and excessive tillage (oxidation)

Actually a 7th Paradigm Issue

- Belief by the bio-farmer that he cannot get by without herbicides, insecticides, etc. though he prides himself on using "less" and the belief by organic farmers that they must settle for less yield and higher input cost.
  - Its still about nutrition
    - The bio-farmer has more improvement to make
    - The organic farmer needs to learn the first 5 paradigms
    - Both need to get back to basics, again…
      - Calcium, carbon, biology
  - Can't never did anything; trial ways to eliminate herbicides.

New Paradigm of Farming…

- Apply scientific protocol:
  - Chemistry – proper mineralization
  - Physics – proper tillage and energetics
  - Microbiology – quality biologicals/inoculants
  - Common sense
  - Management Execution
- To begin the transition in thought, farmers really need to understand the consequences of their actions or inactions. Farmers produce FOOD FOR PEOPLE!

Why Biological/Sustainable?

- First and Foremost: Consumer Demand
- It is just good ag; good science
- Better P & L statements
  - Better farm autonomy/independence
  - **Better human/environmental health**
    - **By default addressses climate change and greenhouse gas**
  - Better lifestyles
  - Long term sustainability in $$ and yields
- We are here for our children and grandchildren and their children's children

The Future of Farming

- Variable costs of growing corn between 2002 and 2006 have increased 33%
- Fertilizer is projected to increase 52% over this time period; 2012 costs continue to increase due to cost of oil
- Univ. of Illinois trials show comparisons of N requirements for conventional v. biological programs
  - Conv corn on corn 1.23 lbs./bu
  - Bio corn on corn 0.58 lbs./bu
  - Conv corn on beans 0.95 lbs./bu
  - Bio corn on beans 0.37 lbs./bu

"The Myth of Nitrogen Fertilization for Soil Carbon Sequestration"

- "What we learned is that after five decades of massive inputs of residue carbon ranging from 90 to 124 tons per acre, all of the residue carbon had disappeared, and there had been a net decrease in soil organic carbon that averaged 4.9 tons per acre. Regardless of the crop rotation, the decline became much greater with the higher nitrogen rate," said Khan.
- November/December 2007 issue of the Journal of Environmental Quality.

Soil Physics: Bio-Activity

- USDA National Soil Tilth Laboratory - Dr. Jerry Hatfield
- Cure compaction: increase soil bio-activity
  - Tillage delays compaction/moves it to next season
  - Must allow aggregates to re-form
  - Must build soil biology first
    - Manure; residue mgmt w/added biologicals; crop rotations with small grains; cover crops for better tilth and CO2 capture

Soil Carbon and Nitrogen in NZ and UK

- Studies in both UK and NZ find the same trend as at University of Illinois even in pasture based systems
  - Modern farming practices of high nitrogen use have and continue to erode soil carbon and nitrogen levels in spite of purported conservation measures and contrary to what agricultural "experts" have espoused and continue to claim.
  - Schipper, L.A., et al, Global Change Biology (2007) 13, 1-7.

Farming for the Consumer!

- People can live without computers, cars, TV's, telephones – conveniences only of modern day life, but no person can live without food, nor have health without food with full nutrition.
- Read *The Agenda* by Michael Hammer
  - We are in a "consumers" economy

MAP for Success Massive Action Plan

- Take inventory: Where you are and what you have.
  - Survey the site, test the soil, commodity testing, etc.
- Define your goal
  - Where are you going? What do you want to build?
- Design your plan
  - Blueprint
    - Foundation, framing, finishing, personnel
  - Bill of materials
- Execute: Put the plan into action
- Evaluate, Amend and Re-execute

What to do???

- Can it be corrected?
  - Absolutely, positively, YES!!!
- How?
  - Similar to the AA 12 step program only called
    - Pesticide Anonymous – PestAnon
      - Acknowledge there is a problem
      - Seek counsel with God
      - Find a sponsor – tutor, helper, consultant and study
      - Take inventory
      - Set goals
      - Draw up a plan

7 - 12 Step Program

- Soil test/plant test/commodity test/water test
- Get recommendations, review and study
- Apply nutritional materials and maintain appropriate cultural practices - execute
- Monitor, retest soil/plants, adjust on the run
  - Refractometer
- Meet your customers
- Give thanks to God, enjoy the harvest and start again at the beginning

It is a lifetime commitment

- It is a daily commitment
  - Pesticides Anonymous
  - No different than any other addictive condition
  - The withdrawal period is the worse time
    - 3 to 5 years

Logic: Linear or Nonlinear

- Your logic determines how you think and work through problem solving exercises.
- Common and conventional logic today in
  - medicine/agriculture is linear or reductionistic. Whole = sum of its parts, nothing more.
- Nature is nonlinear or holistic, meaning the whole is greater than the sum of its parts.
  - your problem solving logic must also be nonlinear or holistic. Whole > sum of parts
    - Cake is more than just flour, sugar, eggs, water
    - Life is more than chemical analysis.

Conventional Thought...

- The *MODEL* – Standards
  - Food & fiber production are a war
  - Nature is the adversary
  - Insect, disease & weed pests are perceived as *normal* – wrath of God
  - Soil is inanimate
  - Nature is random, unintelligent & flawed
  - Humankind knows a better way...

Conventional Thought...

- The *LOGIC* – Standards application
  - Reductionistic – The whole equals the sum of its parts and nothing more, period.
  - Linear – based upon straight line, invitro observation and principle
    - If the result is not politically correct, change it or claim its science is flawed.
    - **What you get out is only equal to or less than what you put in** – purely entropic
  - If all else fails, get a BIGGER HAMMER!

Real World Thought…

- The *MODEL* – Standards
  - Food & fiber production are a part of Nature. Peaceful coexistence is the rule.
  - Nature is the guide and guardian.
  - Insect & disease *pests* are Nature's garbage collectors. Weeds are Nature's soil caretakers.
  - Soil is *living* and *dynamic*, analogous to the ruminant digestive system.

Real World Thought…

- Model continued…
  - Nature is ordered, intelligent, and perfect.
  - Nature is the example to follow – ideal model of plant, soil, and animal characteristics – here you will find the answer.

Real World Thought…

- The *LOGIC* – Science application
  - Holistic – the whole is greater than the sum of its parts
  - Non-linear – keyed to tuning, based upon harmonics and in vivo observation and function
  - Energetics is the fundamental basis of all physiology, animate or inanimate
  - When all else fails, think, apply common sense and find the cause

Model & Logic Summary

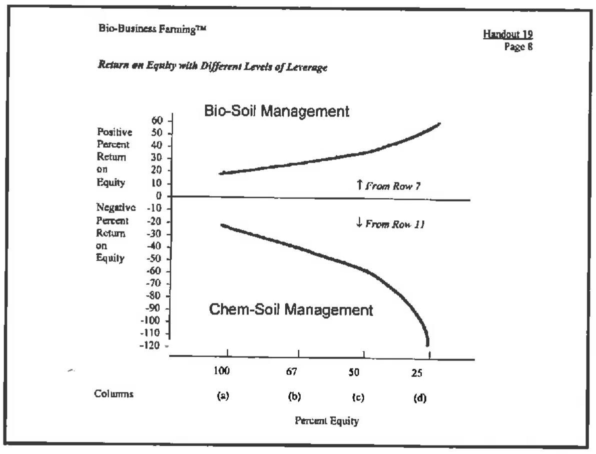
- Conventional System
  - Linear
  - Single variable based – relativity
  - No harmonics – pigeon hole logic
  - Driven system – forced effects
    - More fertilizer, more poison, bigger equipment
- Messenger oriented – symptoms (insects pests, diseases, weeds) rule
  - Externalized EM fields

Model & Logic Summary

- Real World System
  - Non-linear
  - Multiple variables – life – Whittaker Math
  - Harmonics prevail
  - Functioning system – effects flow naturally
- Message oriented – causes are key – **nutrition**
  - Internalized EM fields – information fields
    - » Kaznacheyev, Devyatkov, Popp, Callahan, Becker

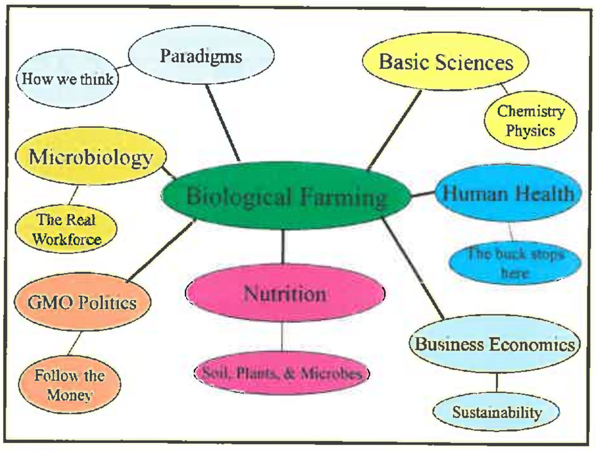
Bio-Business Connection

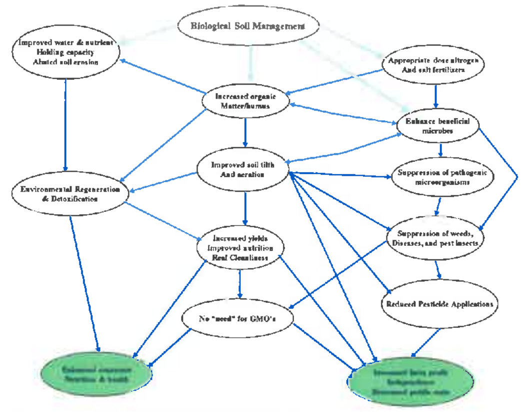
- Soil/Crop Mgmt.
  - Effectiveness: do the right thing
    - Mineralization, inoculation
  - Efficiency: do the thing right
    - Correct mineral mix, critters, application, placement, timing
- Focus on the right things First, then work on doing them rightly/better
- Biological Soil/Crop Mgmt. Is **effective** management



What is *biological farming*?

- Combining the best of chemistry, physics, biology, and microbiology with sound farm management practices.
- Addressing and solving weed, disease and insect pest problems at their root causes rather than merely masking the symptoms with poisonous chemicals.
- Maximizing yield, quality, food nutrition and profit potentials





Evaluating Soil Quality

Michael McNeill, Ph.D.

Ag Advisory, Ltd
222 E. Call St., Algona, IA 50511
515-295-5513

T Graham Shepherd
Landcare Research, NZ

Soil Quality Test Kit

- Soil Quality Test Kit Guide
- Kit tests to be measured in the field
  - Soil respiration
  - Infiltration
  - Bulk density
  - Soil pH, EC, and nitrate
  - Slake test
  - Earthworms

Field Kit

- Water Infiltration – cylinder with timed water
- Temperature - thermometer
- pH – soil and sap
- EC – soil and sap
- CO_2 – Solvita Soil Life kit
- Slaking – dipping soil clods in water
- Texture – soil ribbons in hand, soil classification
- Structure – visual of particles
- Brix – plant sap
- Compaction – penetrometer
- http://soils.usda.gov/sqi/assessment/test_kit.html

Soil Testing

- Mining Assay
  - Chemical components of parent material
  - Applies to mining operations, industrial extraction
- Conventional CEC Soil Test
  - Chemical components via extracting agent
  - Good for seeing reserve status
  - Annual testing
- Reams/Morgan Extract Test
  - Chemical components associated with Biology
  - Good for seeing functional status/cash flow
  - Variable testing per crop need
  - We are using Perry Ag Labs

Reams based upon Morgan Test

- There are more than 10 different extraction procedures used for estimating available soil P in the European Union (Tunney *et al.*, 1997). **In Ireland, the Morgan P test (Morgan, 1941) has been used for almost 50 years, although it is the only country in Europe to use this test.** A change was made from the Morgan test and other reagents to the Olsen test (Olsen *et al.*, 1954) in 1971 for England and Wales and in 1983 for Northern Ireland (Stevens, 1983). In the Netherlands recalibration of current fertilizer recommendations based on 0.01 M calcium chloride ($CaCl_2$) (Houba, Novozamsky and Temminghoff, 1994) is being investigated (Tunney *et al.*, 1997). One of the objectives of the present study was to compare the results of these three procedures for measuring soil P concentrations.
- The **Morgan test provided the best estimate of P availability** to grass in terms of grass DM yield and P uptake in the grass DM over 6 harvests compared to the Olsen and $CaCl_2$ tests.
- Irish Agriculture and Food Development Authority, http://www.teagasc.org/research/reports/environment/4366/eopr-4366.htm

Functional Nutrient Basics

- Calcium 2000 to 4000 units/area
- Phosphate 200 to 400 units/area
- Potash 200 units/area (1:1 P:K)
- Magnesium 285 to 570 units/area
  - (7:1Ca:Mg)
- NO_3 40 units/area
- NH_4 40 units/area

- Must have microbio to maintain these 24/7

CEC and Reams Testing

Standard CEC	Reams Test
70% Ca	2000+
10% Mg	285+
P/P2O5	200/400+
4% K	200+
1% Na	20-70ppm+
NH4/NO3	40+/40+
Conductivity	200-800uS

Other Testing Options

- Texas Plant & Soil Lab, Edinburg, Texas 956-383-0739; www.txplant-soillab.com; K. Chandler
- CO2 and water extraction for soil testing
- Recommendations according to soil test correlated to physical soil characteristics, crop, stage of growth and desired outcome
- Include biological product in programs
- Petiole to predict root availability and future
- Leaf to predict what has been used to date

Functional Field Quality

- Refractometer readings at 12 brix or above at weakest point 24/7
- Must consider field conditions and performance factors like insect activity for true reading
- Only those who are unable to affect crop brix readings discredit its value

Reams Testing

- **No number is perfect unless ALL numbers are perfect.**
- **Treat the *patient* NOT the lab numbers**

Testing Bullets to remember

- CEC is reserve evaluation
- Reams is functional/cash flow evaluation
- No number is perfect unless all are perfect
- Soil test presence of nutrients does not ensure plant sufficiency
- As humus increases, increase foliar application of micronutrients
- **History and physical exam are 90% of the answer**

Soil Testing System/Method

- There is much debate and rhetoric about soil testing methods/labs.
- I currently use Perry Ag Labs for both the CEC and the "Reams" test.
- The key is that we need some type of CEC test to measure "reserve" nutrient levels and some type of test to represent "cash flow" nutrient levels – meaning those that reflect visual/physical characteristics in the field/paddock.
  - Results in the field are the only true goal and measure.

Building the Soil

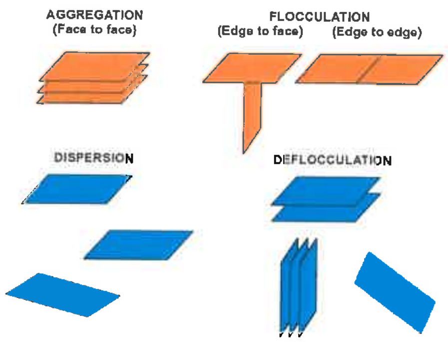
- Every farmer can build a house.
  - Use the same common sense to build an energy system in the soil.
- Lay the foundation
- Construct the framework
- Fill in the holes

Lay the foundation

- ***First***, soil test using the Reams
  - (functional or "cash on hand") and Albrecht (reserve) tests.
- Apply ***appropriate*** calcium and
  - base nutrients and possibly paramagnetic material.
- Keep biology in mind. May add
  - biological product.

Strong Foundations Hold Firm

- Foundation: *calcium*, base
  - minerals and paramagnetic forces initiate ordering - amount of energy collected
  - Calcium ~ capacitor component
  - Mineral ~ circuitry/antenna
  - Capacitor + antenna ~ Potential
    - EM structure
  - Calcium deficiency ~ grass weeds
  - Need early in season for growth
  - 100 lbs-kg/ac-ha 20um fine $CaCO_3$ with carbon
  - 1 – 10 lbs-kg/ac-ha 1 – 5 um fine $CaCO_3$ with carbon



Put a frame on the foundation

- Framing ~ Nutrient ratios, trace
  - elements - allows us to tap/plug into the EM grid (receptacle for the appliances - plants)
- P:K imbalance ~ broadleaf
  - weeds, low brix, insect problems
  - **If P is functionally deficient so is Ca, Mg, K, ...**
- Ca:Mg imbalance ~ compaction
  - or lack of soil structure

Construct the Framework

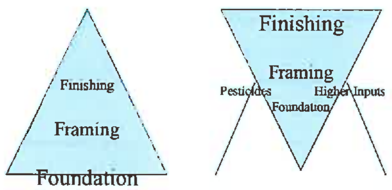
- Nutrient ratios come into line as
  - the biological component of the soil prospers. Any management act that promotes biological integrity is appropriate, from products to cultural practices.
- Food, water, oxygen, comfort

Fill in the holes

- Humus formation is the ultimate
  - goal at this stage. This may require specific trace elements, compost, biological products, foliar sprays, carbohydrates, etc.
- Foundation, framing, finishing
  - are all included at every step of management/crop production.

Bio Ag v. Conventional Ag

- BioAgr Conventional Agr



Farm Program

- Organic program: apply 10 ton of chicken and feedlot manure; 5 ton of gypsum; salt problem
  - Fruit is small, brix 6 to 8, full of insect pests and significant fungal disease
  - Spray with copper sulfate and sulfur weekly
  - Crop produces alternate years
- Conventional program: 300 units N, 5 ton gypsum; salt problem
  - Fruit is larger, pithy, brix 6 to 8, no insect pests due to several insecticide sprays, fungus tolerable but problem
  - Spray weekly with sulfur and fungicides
  - Crop produces alternate years
- Any net difference for the consumer?

Attention to Detail

- Finishing ~ Humus complex
  - allows us to regulate, store and transform tapped energy.
- Humus deficiency ~ instability
- The way to build humus is through carbon sequestration done via residue management
  - One cannot leave this to chance
    - Inoculate
    - Remember O2, H2O, food, comfort

Science Application Bullets:

- Calcium: foundation- father of nutrients
- Phosphate: escort-mother of nutrients
- Humus: bonding-family unit
- Consider: O2, H2O, Food, Comfort

A Team Approach

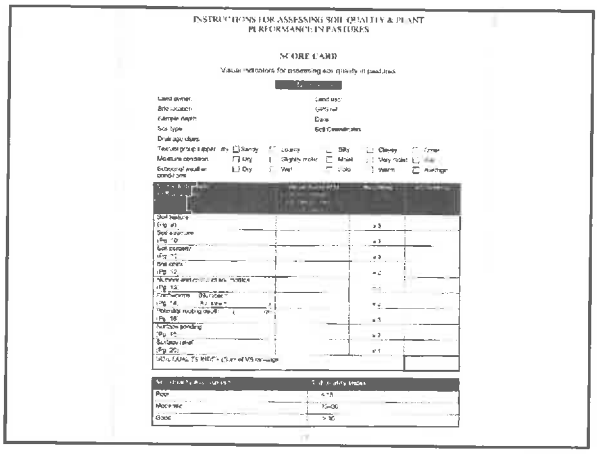
- Architect ~ God
- Contractor ~ Humankind
- Carpenters ~ Microbes/plants

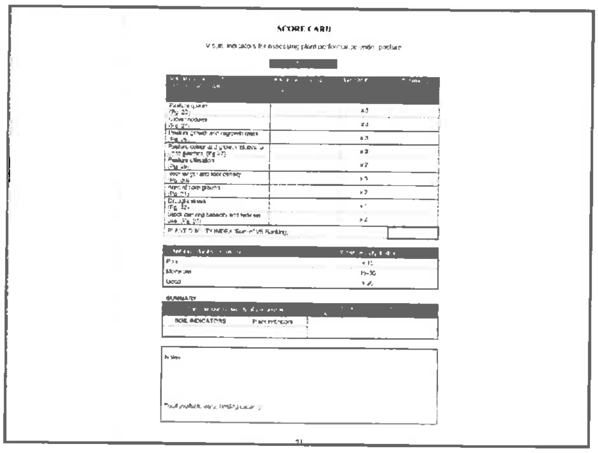
Outcome Rules: It's what we eat!

- Organic approach
  - Must follow NOP guidelines
- Biodynamic approach
  - Must follow BD guidelines
- Biological/Sustainable approach
  - Use what is most appropriate to get the job done: mineralized food, profitability, joy
  - Some zealots will insist that one cannot use synthetic fertilizers and get living, healthful foods
    - They probably cannot but what is impossible in one paradigm is the rule in ours!

Treat the patient, not the lab test

- 90% of the diagnosis is from H & P
  - Regardless of the soil, tissue and sap tests, make fertilizer decisions based upon what is seen in the field; what are the physical symptoms/conditions that need to be addressed?
  - So many consultants/farmers just don't get this
    - Get out of the mindset of using fertilizers/bios like pesticides
      - And sometimes we need to to get a crop, but address the underlying cause of the problem while getting the yearly crop
      - See the big picture; the hole picture
  - What nutritional deficiencies are seen
  - What deficiency characteristics are seen
    - Hollow stems, tear drop stems, low brix, insects...
    - Is the crop maturing or dying
    - Growth v. fruiting?
  - Feed the crop, not the test report





Revised soil Quality score Card combine VSA with M. McNeill SQA

Visual/Measured Indicators Of Soil Quality	Soil Score Card Visual/Measured Score(VS/MS) 0=Poor Condition 1=Moderate Condition 2=Good Condition	Weighting	VS/WS Ranking
Soil texture (Pg. 9)		X3	
Soil structure (Pg. 10)		X3	
Soil porosity (Pg. 11)		X3	
Soil color (Pg. 12)		X2	
Number and color of soil mottles (Pg. 13)		X2	
Earthworms (Number=) (Pg. 14) (Av. Size=)		X3	
Potential rooting depth (Pg. 16)		X3	
Surface ponding (Pg. 18)		X2	
Surface relief (Pg. 20)		X1	
Penetrometer value		X3	
Soil temperature		X1	
Water infiltration time (1st=)(2nd=)		X3	
Soil EC		X1	
Soil pH (1:1 water:soil)		X1	
CO2 evolution (24 hour)		X2	
SOIL QUALITY INDEX (Sum of VS rankings)		Possible Total 66	
Soil Quality Assessment Poor Moderate Good		 <20 21-40 >40	

Australian Oat Crop

- FEED ANALYSIS SEPTEMBER 2004

	SUPERPHOSPHATE	TNN FCMP	
Dry Matter	24.14%	24.29%	1%
Moisture	75.86%	75.71%	0%
Nitrogen	1.53%	2.57%	68%
Crude Protein	9.57%	16.05%	68%
Digestible Protein	6.47%	13.27%	105%
Gross Energy	16.13 MJ/Kg	17.05 MJ/Kg	6%
Digestible Energy	12.91 MJ/Kg	14.43 MJ/Kg	12%
Metabolizable Energy	10.27 MJ/Kg	11.9 MJ/Kg	16%
Net Energy Nem	6.06 MJ/Kg	7.43 MJ/Kg	23%
Net Energy NE1c	6.1 MJ/Kg	7.49 MJ/Kg	23%

- Average Nutrient Increase Whilst Using TNN FCMP 40%

Leongatha, Vic., Grazing Property, TNN Industries

Feed Analysis Comparison Alfalfa

		Conv.	Biological
Crude Protein	% of DM	23.73	21.98
Acid Deterg Fiber	% of DM	29.70	29.61
Neut Deterg Fiber	% of DM	49.19	41.94
Cell Wall Digest	**% NDF**	**59.96**	**65.18**
In Vitro DM Dig	**% of DM**	**80.31**	**85.40**
Non Fiber Carbo	**% of DM**	**16.03**	**25.30**
Rel Feed Value	Index	124.0	146.0
Rel Forage Qual	Index	145.2	191.3
Calcium	% of DM	0.56	1.16
Nitrate Nitrogen	PPM	240.0	54.0
Iron	PPM	76.00	121.0
Manganese	PPM	55.00	129.0

- *Analab Inc., Fulton, Illinois: AgriEnergy Resources Fall 2006

Alfalfa Feed Analysis continued

- Over 100% increase in calcium
  - Ca:K improved from 1:6 to 1:2.2; 1:1.2 goal
- 40% less potassium
- 20% higher Relative Feed Value
- 32% higher Relative Feed Quality
- 24.8% higher YIELD
- Increase in all amino acids; 75% more methionine and 60% more lysine
- Increase in all vitamin levels; 214.8% higher vitamin A (beta carotene)

Alfalfa Trial Program

- Foliar Program v. no foliar for control
  - 2 gal AER SP1 (liquid bio extract) (20 ltr/ha)
  - 2 gal Drammatic ONE Liquid Fish
  - 2 gal Foundation (traces, nutrient pkg, K_2SO_4)
  - 2 gal Chilean Nitrate
  - 18 gal tank mix (180 ltr/ha)
    - Applied May 10, 2006; Tested May 23
    - Greenberg Farms, Stratford, Wisconsin

Plant Physiology

- Photosynthesis
  - Plant takes water and carbon dioxide in the presence of sunlight and manufactures sugar
    - Must have complete nutrition for this process to occur
  - This sugar is them metabolized half used for fuel to run the "plant factory" and half used for the manufacture of crop
  - This is your YIELD
    - Brix measures what you have available to make yield

Chaboussou

- "It seems that, in both animals and plants, susceptibility to disease is the result of metabolic problems."
- "It is no accident that, in exploring these issues of resistance and protection of the plant, we find ourselves face-to-face with the phenomenon of nutrition."
    - pp. 208 - 209

Nutrients and Functions

- Nutrients are the building blocks of all life
- Each nutrient has a function or many functions important to the health and survival of the organism

Nutrition is comprehensive

- Perhaps as many as 60 or more elements are involved in healthy plant growth. 16 elements are typically considered essential for plant growth.
  - carbon, hydrogen, oxygen, nitrogen, phosphorous, sulfur, potassium, calcium, magnesium, copper, zinc, molybdenum, boron, iron, silicon, and manganese. Additionally cobalt, chlorine, sodium, nickel, iodine and vanadium have been found essential for plant growth in certain plants.
- "With a solution containing 26 elements, Hoagland and Snyder obtain strawberries which are much more vigorous and more resistant to Oidium (powdery mildew) and red spider mites than with a solution containing only 12 elements." (Chaboussou)
- Fundamental goal of nutritional management is *protein synthesis*.
  - The relationships between plant and parasite are primarily nutritional in nature.
  - Predominance of protein synthesis increases the plant's resistance or 'immunity' to disease and parasite attack.
  - Predominance of protein breakdown increases the plant's susceptibility to disease and parasite attack
    - This process is accelerated/exacerbated by the foliar/soil, especially multiple times, application of pesticides, especially herbicides. (Chaboussou)
- Carbon, Hydrogen, and oxygen compose much of the dry matter in plants are obtained from water and carbon dioxide via photosynthesis.

Chelation

- Chelation comes from the Greek word chele, meaning claw. The chelating agent, often an organic molecule, captures the metal ion encircling the metal. Think of how a herd of buffalo will encircle its young to keep it away from predators.
- Metalloenzymes include porphyrin rings in hemoglobin and chlorophyll. Many microbial species produce water-soluble pigments that serve as chelating agents, termed siderophores.

Chelation cont.

- Pseudomonas secrete pyocyanin and pyoverdin that bind iron. E. coli produce enterobactin (iron chelator/scavenger), perhaps the strongest chelating agent known.
- Most metal complexes in nature are chelated, e.g. with a humic acid or a protein. Thus, metal chelates are relevant to metal nutrition in soil, plants and microorganisms.
- Chelation is used for bioremediation by selectively removing toxic metals such as cesium 137 from radioactive

Chelated minerals

- Amino acid metal chelates enhance metal absorption in the stomach or similar environments by preventing insoluble complexing.
- Ethylenediaminetetraacetic acid (EDTA) is a very stable synthetic chelator. It may not easily give up the mineral, is not readily used by plants and animals so it randomly chelate and strip another mineral from the body.

Chelate tidbits

- Tetracycline family of antibiotics chelate Ca2+ and Mg2+ ions.
- EDTA is a strong antioxidant – note preference for Fe(III) over Fe(II).
- K2EDTA is an anticoagulant.
- EDTA is used to clean up root canal drill
- Phosphonates are chelating agents used for descaling boilers and herbicides.
- Rust removal products are iron chelators.

Chelating dynamics

- Metal hydroxide complexes tend to precipitate out of solution. As pH goes up, more metal hydroxides are formed and precipitate. Prevent this through the use of auxiliary complexing agents such as ammonia, tartarate, citrate, or ethanolamine, however the metal stays in solution and can continue to react. You have a competition between the metal-complexing agent and Metal-EDTA complex. The Kf for the metal-EDTA complex must be many orders of magnitude larger than the Kf for the metal-auxiliary complex agent so that the EDTA can remove the metal from the complexing agent.
  - http://www.bhsu.edu/Portals/91/AnalyticalChemistry/StudyHelp/LectureNotes/Chapter13.pdf

Chelation

- Think of a fuse in any circuit; the appliance in question only works with the fuse present
- For the circuit to be correct, the fuse must be the right configuration and the right size in amperage
- In nature this equates to the right metal in the right electrochemical state (reduced or oxidized)

Chelating process

- Think of a magnet and various types of metal shavings on the table. Different types will be attracted to the magnet depending upon it magnetic susceptibility.
- Nutrients will be chelated at different strengths - magnetic susceptibility/magnetic attraction to the chelating agent

Main function of biology?

- Chelation of minerals
- Break down organic materials –disassemble toxins or form new ones
- Pesticides are chelating agents – year after year the farmer applies more and more effectively altering the bio-environment

Plant use of chelates

- When grown in an iron -deficient soil, roots of graminaceous plants (grasses, cereals, rice) secrete siderophores into the rhizosphere. On scavenging iron(III) the iron –phytosiderophore complex is transported across the cytoplasmic membrane using a proton symport mechanism.
- The iron(III) complex is then reduced to iron(II) and the iron is transferred to nicotianamine (*an iron, zinc, copper, nickel chelator synthesized by nicoti nanamine synthase using SAMe as a co-factor*), which although very similar to the phytosiderophores is selective for iron(II) and is not secreted by the roots. Nicotianamine translocates iron in phloem of all plants.
  - http://en.wikipedia.org/wiki/Siderophore

Biochelators

- To fight bacterial infection, the immune system produces a protein called siderocalin to sequester and inactivate enterobactin. Antibiotics are metal chelators thus deactivating enzymes key for the target microbe to function or survive. Quinolones (Cipro) targets topoisomerase (Mg) so the bacteria DNA can't coil and thus replicate properly.

Microbiology…

- Two major issues
  - Disease
  - Plant Growth
- Nutrition is also key to determining which microorganisms dominate
- Oxygen, Water, Food, Comfort

Microbiology 101…

- Plants, ideally, do not absorb those compounds which are characteristic of soil outside the rhizosphere but rather they absorb metabolic products of the rhizosphere.

Microbiology 101…

- Environment determines who lives and who dies
- Microorganisms are critical to all live
  - Plants to humans
- Need complete foodweb per Ingham
  - Introduction of pure cultures of individual antagonists does not guarantee control of disease pathogens.

Microbiology 101…

- Bacteria
- Fungi
- Flagellates
- Amoebae
- Ciliates
- Nematodes
- Algae

Applied Microbiology…

- Inoculation
  - Packaged products are mostly bacterial
    - Spore formers
  - Some spore forming fungi
    - Mycorrhiza
  - Compost – must be true and tested
  - Compost tea – fresh, aerobic, and tested
  - Never assume "nature" will take care of the inoculation or that if you simply appropriately tend the soil then the desired microbiology will magically appear/return!

Microbial Succession

- Pennanen, Taina, Rauni Strommer, Annamari Markkola, Hannu Fritze, Microbial and Plant Community Structure Across a Primary Succession Gradient. Scandinavian Journal of Forest Research. 16:1; 37-43, January 2001.
- Showed that the succession from bare rock to mature forest starts with bacteria and progresses fungi dominated system as is contended by Dr. Elaine Ingham

Weed-Microbiology Connection

- Batten, et al demonstrated in replicated greenhouse studies, that if one artificially imposes a microbial community into a soil, it will result in the invasion of subsequent plant species compatible with the "new" microbial population. Reported in Microbial Ecology, SpringerLink, June 27, 2007.

Microbial solubilization and immobilization of toxic metals: key biogeochemical processes for treatment of contamination

- **Microorganisms play important roles in the environmental fate of toxic metals** with a multiplicity of physico-chemical and biological mechanisms effecting transformations between soluble and insoluble phases. Such mechanisms are important components of natural biogeochemical cycles for metals and metalloids with some processes being of potential application to the treatment of contaminated materials.
  - FEMS Microbiol Rev. 1997 Jul;20(3-4):503-16.

Applications of free living plant growth-promoting rhizobacteria

- Department of Biology, University of Waterloo, Waterloo, Ontario, Canada, N2L 3G1.
- **Free-living plant growth-promoting rhizobacteria (PGPR) can be used in a variety of ways when plant growth enhancements are required.** The most intensively researched use of PGPR has been in agriculture and horticulture. Several PGPR formulations are currently available as commercial products for agricultural production. Recently developing areas of PGPR usage include forest regeneration and phytoremediation of contaminated soils. As the mechanisms of plant growth promotion by these bacteria are unravelled, the possibility of more efficient plant-bacteria pairings for novel and practical uses will follow. The progress to date in using PGPR in a variety of applications with different plants is summarized and discussed here.
  - **Lucy M, Reed E, Glick BR Antonie Van Leeuwenhoek. 2004 Jul;86(1):1-25 .**

Research advances in plant growth-promoting rhizobacteria and its application prospects]

- Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang. hujiangchun@yahoo.com.cn
- The study of plant growth-promoting **rhizobacteria will provide possible methods to overcome the difficulties in controlling soil borne plant diseases.** PGPR can colonize in rhizosphere at high population density, **inhibit plant pathogens and deleterious microorganisms there, and promote crop growth and its yield.** More importantly, some PGPR strains applied as biocontrol agents can make treated plant produce induced systemic resistance (ISR), and thus, increases plant overall health. In recent two decades, the researches of PGPR in abroad are very active, and many PGPR products have been applied successfully. In our country, more attention should be paid to the study of the basic theory and application of GPPR and the industrialization of PGPR products.
- Hu J, et al. Ying Yong Sheng Tai Xue Bao. 2004 Oct;15(10):1963-6.

Fungal production of citric and oxalic acid: importance in metal speciation, physiology and biogeochemical processes.

Department of Biological Sciences, University of Dundee, UK.

- The **production of organic acids by fungi has profound implications for metal speciation, physiology and biogeochemical cycles. Biosynthesis of oxalic acid from glucose** occurs by hydrolysis of oxaloacetate to oxalate and acetate catalysed by cytosolic oxaloacetase, whereas on citric acid, oxalate production occurs by means of glyoxylate oxidation. Citric acid is an intermediate in the tricarboxylic acid cycle, with metals greatly influencing biosynthesis: growth limiting concentrations of Mn, Fe and Zn are important for high yields. **The metal-complexing properties of these organic acids assist both essential metal and anionic (e.g. phosphate) nutrition of fungi, other microbes and plants**, and determine metal speciation and mobility in the environment, including transfer between terrestrial and aquatic habitats, biocorrosion and weathering. Metal solubilization processes are also of potential for metal recovery and reclamation from contaminated solid wastes, soils and low-grade ores. Such 'heterotrophic leaching' can occur by several mechanisms but organic acids occupy a central position in the overall process, supplying both protons and a metal-complexing organic acid anion. Most simple metal oxalates [except those of alkali metals, Fe(III) and Al] are sparingly soluble and precipitate as crystalline or amorphous solids. **Calcium oxalate is the most important manifestation of this in the environment and, in a variety of crystalline structures, is ubiquitously associated with free-living, plant symbiotic and pathogenic fungi.** The main forms are the monohydrate (whewellite) and the dihydrate (weddellite) and their formation is of significance in biomineralization, since they affect nutritional heterogeneity in soil, especially Ca, P, K and Al cycling. The **formation of insoluble toxic metal oxalates, e.g. of Cu, may confer tolerance and ensure survival in contaminated environments.** Adv Microb Physiol. 1999;41:47-92.

Mycorrhizae – glomalin: Soil Superglue

- USDA Agriculture Research Service soil scientist Sara E. Wright has discovered a unique fungal protein that may be the primary glue that holds soils together.
- She named the gooey protein "glomalin" for Glomales, the scientific name for the group of common root- dwelling fungi that secrete the protein through hairlike filaments called hyphae. The fungal hyphae are found worldwide on the roots of many plants. Glomalin sloughs off of the hyphae and finds its way into soil.
  - http://www.ars.usda.gov/research/publications/publications.htm

Microbes PLUS Nutrition

- Mycorrhizae fungi:
  - 50% colonization w/moderate chemcial fertilizer
    - 100 grams dry weight roots per plant plus 50 grams of mycorrhizae per plant biomass
  - 70% colonization w/no fertilizer
    - 40 grams dry weight roots per plant plus 28 grams of mycorrhizae per plant biomass
  - Need > 40% colonization
  - Moderate fertilization maximizes results

Microbiology Notes

- Keep in mind that though the beneficials may eat the same or similar carbon and nitrogen materials, they do so in different environments (aerobic v. anaerobic) resulting in very different by-products (humus v. alcohols, aldehydes, salts)

Bio-Active Soil…

- Check soil pH with equal parts water and soil by volume
- Check soil pH with 0.1 Molar solution of KCl
- If the pH difference is greater than 0.3 the soil is poorly bio-active because the ions are poorly bound or "free" in low bio-active soils

Microbial Labs

- Soil Food Web Institute Pty Ltd

Send samples to 80 Faulkner Rd, Wyrallah,NSW 2480.

Phone 02-6622-5150

Microbiology Labotories Australia

P O Box 230, Melrose Park, S A. 5039

Phone 08-7324-5088

Microorganism function

- Ultimately microorganisms have two functions
  - Recycle debris
  - Chelate minerals for plant utilization
- They also provide food for other organisms

End Day One

- Farming to feed people FOOD
- Holistic mindset – thinking processes\
- Health is all living systems is about nutrient density/balance
- Field Assessment – Visual Soil Assessment

Day 1 Review

- Paradigms and how we think determines ability to see a problem and its solution
- Weed, disease and insect pests are manifestation of nutrient/biology imbalance/deficiency NOT pesticide deficiency
- Visual Soil Assessment: compaction, water infiltration, smell, tilth, what's growing and its brix

Calcium

- Cell division/elongation
- Cell wall binder – pectates
- Disease and parasite resistance
- Affects chromosome structure/gene orientation
- Activates several enzymes: 2nd messenger
  - Amylases, ATPases, phospodipases
- Cell balancer between acids/bases
- Regulation of membrane ion selectivity:K/Na
- Primarily extracellular except membrane
- Limited phloem translocation:
  - from old leaves to developing tissues

Communicating with calcium

- All living cells use a network of signal transduction pathways to conduct developmental programs, obtain nutrients, control their metabolism, and cope with their environment. A major challenge for cell biologists is to understand the "language" of these signaling systems. In plant cells, the list of messengers used by signaling pathways includes Ca +2 , lipids, pH, and cyclic GMP (cGMP). However, no single messenger has been demonstrated to respond to more stimuli than has cytosolic free Ca ion.
- The Plant Cell, Vol. 11, 691–706, April 1999, www.plantcell.org

Calcium functions

- **Calcium as a Secondary Messenger**
  Calcium also plays a role in the plant very similar to a hormone in the regulation of various cell functions. One such function is in the **regulation of the protein pump that regulates the uptake and movement of nutrients into the root and throughout cells within the plant.** This process is called facilitated diffusion and is the means by which the majority of all nutrients are taken into the plant. In this process calcium stimulates the enzyme calmoldulin, which activates the protein pump that is involved in this process of nutrient uptake. Also auxin-regulated cell elongation seems to require Ca2+ as a secondary messenger. (*Marschner*).
- …the Ca^{2+} level required for growth under heat stress exceeds that required for growth under normal temperatures. Total foliar mass and leaf area were essentially unaffected by Ca^{2+} level under control temperatures. Under heat stress, leaf area was reduced to about 5% of the control at 5 and 25 μ*M* Ca but to only 70% of the control at 125 and 600 μ*M* Ca. Likewise, total foliar mass was reduced under heat stress to about 30% of the control at 5 and 25 μ*M* Ca but **total foliar mass was greater under heat stress than control conditions at 125 and 600 μ*M* Ca.** (Dept of Hort, U of Wisc-Madison on potatoes)

Calcium signal schematic

- Signals originate from the external medium, ER, mitochondrion, chloroplast, and vacuole and can be localized or global, cytosolic, nuclear and perinuclear, or chloroplastic. Red arrows indicate the principal Ca^{2+} fluxes. See the text and Table 1 for discussion and references.

Calcium transport schematic

- Energized transport systems are represented as blue circles. ACA1, ACA2, and ACA3 are Arabidopsis Ca^{2+} ATPases that have been localized to the membranes shown. The direction of Ca^{2+} pumping for ACA1 is hypothetical. ACAx refers to a plasma membrane ATPase that has been identified biochemically but not at a molecular level. BCA1 is a *Brassica oleracea* Ca^{2+} ATPase that localizes to the vacuolar membrane. CAX1 is a Ca^{2+}/H^{+} antiporter from Arabidopsis, probably located at the vacuolar membrane. Red squares represent Ca^{2+}-permeable ion channels, identified through electrophysiological approaches. None has been identified yet at a molecular level. BCC1, *Brionica* Ca^{2+} channel; $InsP_3R$, putative $InsP_3$ receptor; RyR, putative ryanodine receptor, activated by cADPR; SV channel, slowly activating vacuolar channel; VDCC2, voltage-dependent Ca^{2+} channel 2; VVCa channel, vacuolar voltage-gated Ca^{2+} channel. See text for further discussion and references.

Another calcium dependent enzyme helps protect mitochondria from ROS damage

- Annual Review of Plant Physiology and Plant Molecular Biology
  Vol. 52: 561-591 (Volume publication date June 2001)
  (doi:10.1146/annurev.arplant.52.1.561)
- PLANT MITOCHONDRIA AND OXIDATIVE STRESS: Electron Transport, NADPH Turnover, and Metabolism of Reactive Oxygen Species
- **Ian M Møller** Department of Plant Physiology, Lund University, Lund, Box 117, S-221 00 Sweden;
- Plant Biology and Biogeochemistry Department, Risø National Laboratory, Building 301, P.O. Box 49, DK-4000 Roskilde, Denmark; e-mail:ianmaxmoller@risoe.dk k
- **The production of reactive oxygen species (ROS), such as O2 and H2O2, is an unavoidable consequence of aerobic metabolism.** In plant cells the mitochondrial electron transport chain (ETC) is a major site of ROS production. In addition to complexes I–IV, the plant mitochondrial ETC contains a non-proton-pumping alternative oxidase as well as two rotenone-insensitive, non-proton-pumping **NAD(P)H dehydrogenases** on each side of the inner membrane: NDex on the outer surface and NDin on the inner surface. Because of their **dependence on Ca2+, the two NDex** may be active only when the plant cell is stressed. Complex I is the main enzyme oxidizing NADH under normal conditions and is also a major site of ROS production, together with complex III. The alternative oxidase and possibly NDin(NADH) function to limit mitochondrial ROS production by keeping the ETC relatively oxidized. Several enzymes are found in the matrix that, together with small antioxidants such as glutathione, help remove ROS. The antioxidants are kept in a reduced state by matrix NADPH produced by NADP-isocitrate dehydrogenase and non-proton-pumping transhydrogenase activities. When these defenses are overwhelmed, as occurs during both biotic and abiotic stress, the mitochondria are damaged by oxidative stress.

Calcium counters nitrogen

- Tejerina et al. (1978) Influence of fertilizer on *Erwina carotovora* pathogenesis. Proc. IV. Int Conf. of Plant pathogenic Bacteria, pp. 607-615.
  - "A high level of Ca is able to counterbalance the effect of nitrogen…"
  - Excess of nitrogen correlated to pathogenesis of viruses, bacterial & fungal disease, and insect pests

Calcium

- Symptoms:
  - blossom-end rot, bitter-pit in apples, death of root tips, die-back of terminal buds, premature shedding of flowers and buds
- **Nature's detoxifier**
  - **Key for countering heavy metals**
  - **As calcium goes up, nitrogen need goes down**
- **Growth Energy**

The Essential Role of Calcium Ion in Pollen Germination and Pollen Tube Growth

- A pollen population effect occurs whenever pollen grains are grown in vitro. Small pollen populations germinate and grow poorly if at all, under conditions which support excellent growth of large pollen populations. The pollen population effect is overcome completely by a **growth factor obtained in water extracts of many plant tissues. This factor is shown to be the calcium ion**, and its action confirmed in 86 species representing 39 plant families. Other ions (K+, Mg++, Na+) serve in supporting roles to the uptake or binding of calcium. The high requirement of calcium (300-5000 ppm, as Ca (NO3)2-4 H20, for optimum growth) and low calcium content of most pollen may conspire to give calcium a governing role in the growth of pollen tubes both in vitro and in situ. It is suspected that ramifications of this role extend to the self-incompatibilities of plants and to the curious types of arrested tube growth distinguishing, for example, the orchids. A culture medium which proved its merit in a wide variety of pollen growth studies included, in distilled water, 10% sucrose, 100 ppm H3BO3, 300 ppm Ca (NO3)-4H2O, 200 ppm MgSO4-7H2O and 100 ppm KNO3.
- James L. Brewbaker, Beyoung H. Kwack
  American Journal of Botany, Vol. 50, No. 9 (Oct., 1963), pp. 859-865

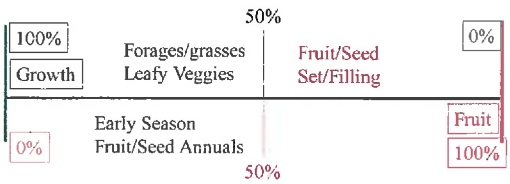
Bacterial Disease and Calcium

- Fireblight: Erwinia amylovora: The invasion of the cortical tissues in apple shoots is correlated with the quantity of organic nitrogen/inorganic nitrogen.
- Erwinia carotovora bacteria in beans:
  - Certain combinations of N, K, Ca, and Mg were able to render the bean completely resistant to the bacteria.
- A high level of Ca is able to counterbalance the effect of nitrogen.
  - p. 69-71

Breakthrough: Energy Mgmt.

- **Crop growth v. fruiting is energy determined and manageable**
- Energy mgmt. Begins with the basic building project: foundation, framing, finishing
- Calcium is the primary base against which we react other materials to release energy
- Calcium is the key to successful foliar spray
  - Must have adequate calcium to get all other nutrients assimilated and functional
  - Must have phos for calcium to be functional

Fruit v. Growth Continuum



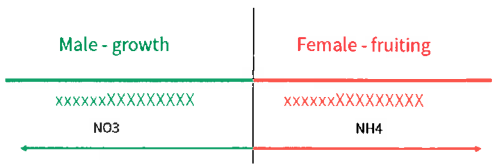
Calcium –
CaO>Ca(OH)2>CaCO3
Potassium
Nitrate N (NO3)
Chlorine
Testosterone

S>SO4
Phosphorous
Acids incl. vinegar
Ammonium N (NH4)
All other nutrients
Estrogen

Male v. Female

- The goal is to maintain the hormonal and energy "gender" in the soil and plant that results in the desired outcome.
  - Vegetative = male
    - Remember every cell replicates needing full nutrition and some degree of "female" to replicate
  - Fruiting = female
    - Remember every cell must grow needing full nutrition and some degree of "male" to grow

The Continuim of Veg v. Fruit



Fertilize to maintain the balance between growth and fruiting According to the crop being grown and the timing of the Growth stage. If one dominates inappropriately, you get bolting Seed undesirably in forages; you get small seed/fruit in grains And treefruit and vegetables.

Sources of Calcium: add carbon

- Limestone – CaCO3, most common
  - Aragonite, oyster shells, "Coral Calcium"
- Calcium Oxide – dehydrated, careful, heat
- Calcium Hydroxide – hydrated, special uses
- Calcium Sulfate – gypsum, soil conditioner
- Dolomite – poor calc., use for magnesium
- Soluble Salts:
  - Cal Chloride, Cal. Nitrate, Cal AmmNit, Cal Organic Acids
- Calcium Phosphate – less soluble
- Bone Meal, Beet Lime, Paper Mill Lime
- Calcium Lignosulfonate – "organic"

Glyphosate and crop nutrition

- significantly reduce Ca concentrations of grain. The deviations for variants with treatment vary in the range 15-50% relative to blank (untreated).
- **Some aspects of plant breeding and obtaining agricultural products on technogenous contaminated lands**
- Lilia N. Oulianenko, Stanislav V. Krouglov & Alexander S. Filipas
- *Russian Institute of Agricultural Radiology and Agroecology, 249020, Obninsk, Kaluga Region, Russia*

Phosphorus

- Phosphorus is part of nucleic acids and phospholipids (the basic molecule of cell membranes). As part of the adenosine phosphates (ATP, ADP and AMP) the phosphate group takes part in energy transduction. Intermediary metabolism includes phosphorylation, the addition of phosphate groups from ATP to carbohydrates and their intermediary products. In the light dependent photosynthesis ATP is made then used in the Calvin cycle in the production of hexose sugars. As ATP is constantly made and used within cells there is a constant conversion of inorganic phosphate to organic forms and visa versa. (Street & Öpik, 1984)
- A shortage of phosphorus means a breakdown of the **transmission of energy in plants** and as such prevents growth.
  - Fruiting Energy

Phosphorous

- Escort via ATP
  - Recycled as usher in a church
- Some is consumed

Sources of Phosphate

- Soft Rock Phos – best long term, food qual.
- Rock Phos – watch Fl, Cd, best cultured
- Acid Phosphates: always add carbohydrate
  - Super phos, triple super phos
  - Monoammonium (preferred), diammonium
  - Phos Acid – caution, ties up Ca, good in foliars
- Bone meal – caution with current Mad Cow
- Liquid Fish – excellent
- Microrrhizae fungi – activate and transport
- Oats – activate phos in soil

Phosphate Tidbit

- Alkaline phosphate fertilizers have a beneficial effect against viral diseases. By promoting maturity, they bring forward the sated of resistance in the plant brought about by age.

The role and use of phosphorus in pasture and cropping

- Tim Jenkins, Biological Husbandry Unit, Lincoln University, NZ
- Superphosphate does provide fast P availability easily leading to times of excess P which may increase plant susceptibility to pests and diseases; also can adversely affect soil biology, reducing the level of VAM; very prone to surface runoff; increases cadmium release
- Improve phosphorus efficiency
  - Promote good root structure and depth
  - Take care of soil structure, lime and improve OM levels
  - Improve soil biological activity for nutrient recycling
  - VAM enhancement for nutrient access at 7 cm v. 1 mm

  - OrganicNZ, March/April 2007

Potassium

- Regulatory mechanism
  - Photosynthesis, energy metabolism, starch synthesis, nitrate reduction, sugar degradation, carbohydrate/sugar translocation, protein synthesis
  - Size and number of fruit set
- Potassium is an essential mineral for plants yet its role is not fully known.
  - Most common cation of protoplasm
  - Maintain cell turgor and movement
  - Opening/closing of stomatal guard cells
- "The only known metabolic role for potassium is as an activator of some enzymes (photosynthesis), but other elements which act as enzyme activators are required in micronutrient quantities only. The affinity of proteins for potassium is, however, low, so that fairly high potassium concentrations may be needed to make potassium-enzyme complexes."Street and Öpik (1984)
- Potassium deficiency's most common symptoms are yellow edges and tips of leaves (Roberts et al, 1993).
- Growth Energy

Potassium tidbits

- If potassium is in excess in early season, this can depress primordial seed/kernal formation due to absolute or functional calcium deficiency caused by the excess potassium.
- Verticillium wilt in potatoes is closely correlated to the nitrogen form present:
  - NH4SO4 suppresses potentially
  - CaNO3 increases potentially
    - Calcium nitrate can be very helpful if sufficiently countered with NH4+

Sources of Potassium

- Potassium Sulfate – excellent
- Potassium Chloride – avoid like the plague
- Potassium Nitrate – very soluble
  - Double growth energy
- Potassium Hydroxide – caustic, caution
  - Make hot mixes, clean
- Organics – best if composted
  - Sawdust – cure for 30 days and compost first
  - Rice hulls, tobacco stems, pecan hulls, cotton burr ash
  - Straw, hay, manures

KCl v. K2SO4

- Leaching losses   Rainfall in inches-cm
-           10-4 20-8 50-20 75-30 100-40
- K source   % K Lost
- KCl   17   75   91   91   94
- K2SO4   0   15   53   79   79
- K3PO4   0   0   0   18   33
- Sartain, 1988, Great Salt Lake Mineral Corp.

Glyphosate and crop nutrition

- glyphosate treatments significantly
- decreased concentration of K both in the straw and in grain.
- **Some aspects of plant breeding and obtaining agricultural products on technogenous contaminated lands**
- Lilia N. Oulianenko, Stanislav V. Krouglov & Alexander S. Filipas *Russian Institute of Agricultural Radiology and Agroecology, 249020, Obninsk, Kaluga Region, Russia*

Nitrogen

- The most important uses of nitrogen are as part of proteins and nucleic acids, the key molecules of life. Amino-acids form chains which inter-link several to form proteins. Anything that includes protein includes nitrogen therefore it will be found in almost all cell structures.
- Nitrogen also forms part of many pigments and co-enzymes. It is part of the porphyrin rings which are the basic structure of electron carrying and exciting mechanisms such as chlorophyll and cytochromes.
- Potent electrolyte
- Protein = nitrogen X 6.25 or 6.4
- NO_3 – Growth Energy; NH_4 – Fruiting Energy

Protein, not nitrogen

- Protein synthesis, i.e. the assembly of polypeptide chains from their amino acid constituents, occurs on the ribosomes. The information specifying the amino acid sequence of the polypeptide chain is contained in mRNA molecules.
- Gene expression occurs almost exclusively *via* the synthesis of proteins.
- Protein synthesis is a complex, energy requiring, multi-enzymic process
- Plant protein is manufactured in the chloroplast, mitochondria and cytosol
  - *The Molecular Biology of Plant Cells.* H. Smith, UNIVERSITY OF CALIFORNIA PRESS

Protein, cattle and ammonia

- If dietary protein is too high, gut microbes are overwhelmed and the ammonia will be spilled into the blood, converted to urea in the liver and excreted in the urine, milk and breath.
- The type of dietary protein fed will determine how much ammonia is produced and consequently, the concentration of MUN (milk urea nitrogen).
- According to Ontario Dairy Herd Improvement (DHI), the normal range for MUN concentration is between 10–16 mg/dl.
- So, pasture operations have a problem with urea in the urine leaching into the environment; solve it by improving the diet, grass brix level
- In Ontario, the 2003 price was $0.25 per test per cow.
- MUN's will be lower in the morning.
  - http://www.omafra.gov.on.ca/english/livestock/dairy/facts/03-117.htm

Sources of Nitrogen

- Manures – best if composted, check chems
- Compost – best source applied
- Air – 78% N, biological fixation
- Urea – must be clean, converted to NH4
- Nitrates – used for growth
- Ammonias (NH3, NH4, NH4OH)
  - Used for fruiting, must dilute with water
- Fish, Seaweed – good organics
- Sludge – compost, check metals
- Always add carbohydrate

Insect Bait

- US Patent 7048918
- University of Florida Research Foundation, Inc. (Gainesville, FL
- Includes amino acids and sugar

Nitrogen and Pests

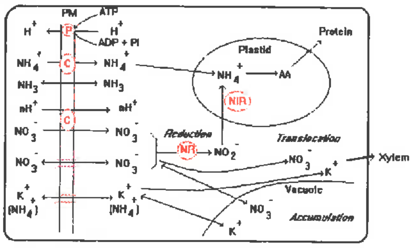
- "Influence of *Prokelisia* Planthoppers on Amino Acid Composition and Growth of *Spartina alterniflora*". Journal of Chemical Ecology. Vol. 23, No. 2. February 1997, pp.303-321.
- "Phloem feeding by *P. dolus* (planthopper) reduced the concentrations of -aminobutyric acid, isoleucine, leucine, lysine, threonine, and valine in *S. alterniflora* leaves (Smooth Cordgrass, perennial deciduous grass especially in estuarine salt marshes). In contrast, glutamic acid was the only amino acid that increased in plants fed upon by planthoppers, and this increase was only observed in plants in the high N-fertilizer treatment. Planthopper feeding reduced the total concentration of amino acids tested, and the concentration of essential amino acids."
- Point: pests seek out appropriate sources of food rich in amino acids under high nitrogen fertilization programs

Biochem of Fertilizer

- Final farm products:
  - Fats, proteins, carbohydrates
- Most common fertilizer
  - Nitrogen
    - Nitrate
    - Ammonia
    - Urea
- Lets look at how the plant deals with nitrogen

Nitrate uptake and reduction

Nitrate and ammonium transport



Scheme of proposed transport mechanisms for nitrate (nitrite) and ammonium at the plasmalemma of a plant cell. PM = plasma membrane (plasmalemma); (P) = proton pump (H^+ ATPase) acting mainly in charge balance; (C) = carrier protein; ╪ = channels, serving for pH and charge balance.

The **nitrate uptake system of higher plants** consists of a constitutive, low affinity transport system (LATS) (possibly a carrier system or an anion channel), and an inducible, high affinity transport system (HATS) **regulated by cellular energy supply**, and by intracellular nitrate consumption, and whose activity depends on the proton electrochemical gradient. The latter system is regarded as an H^+/anion co-transport carrier mechanism that produces transient plasmamembrane depolarization upon addition of nitrate. The depolarization is counteracted by the plasmamembrane H^+-ATPase (Ullrich, 1992). The plasma membrane proton ATP-ase is induced by nitrate (Santi et al, 1995).

In addition to the nitrate uptake system, **plants have an inducible nitrate efflux system, requiring both RNA and protein synthesis**. The efflux system, however, has a much slower turnover rate than the uptake system (Aslam et al, 1996).
Nitrite is also transported by two systems, of which the low-affinity system may play a greater role than in nitrate uptake. In some, but not in all cases, the high-affinity system has been shown to be identical with that of nitrate transport, by uptake competition studies as well as voltage changes (Ullrich, 1992).
Movement of nitrite from the cytosol to the chloroplast appears to involve a proton-linked transport of nitrite. The rapid movement of HNO_2 across the chloroplast inner envelope would require some active proton transport from the stroma into the external space. The presence of an **H^+-ATPase on the chloroplast inner envelope** which pumps H^+ out of the stroma into the cytosol may fulfill this role (Shingles et al, 1996).

Ammonium ions are taken up by a saturable, but apparently constitutive, **carrier system** with high substrate affinity, **which may carry out ammonium** uniport **as long as H^+-ATPases restore Em**. The low-affinity component of transport is stimulated by high external pH and probably reflects diffusion of uncharged NH_3 across the lipid phase of the plasmalemma. Both the high affinity and low affinity ammonium transport systems appear to be constitutive (Kronzucker et al, 1996). In rice roots the K_m for ammonium uptake is about 32 μM (Kronzucker et al, 1996). A transient induction of the ammonium transport system (increased V_{max}) occurs upon exposure of rice seedlings to oxygen deprivation; this may occur in response to hypoxia-induced cytoplasmic acidosis (Kronzucker et al, 1998). Three ammonium transporters have been identified in *Arabidopsis* roots; constitutive, diurnally regulated, and starvation-induced (Gazzarrini et al, 1999).

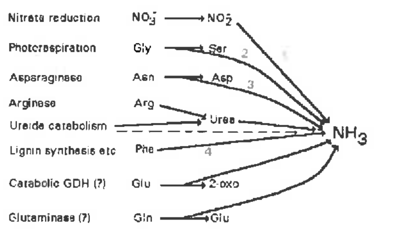
If ammonium enters the cell at high rates, it causes strong membrane depolarization and will block anion/H^+ co-transport. This may be the primary mechanism by which ammonium ions inhibit nitrate uptake (Ullrich, 1992). Alternatively competition between the nitrate uptake system and glutamine synthetase (GS) for ATP may in part account for ammonium inhibition of nitrate uptake (occurs only when GS is active) (Andriesse et al, 1989).

Butz and Jackson (1977) proposed that a nitrate reductase (NR) dimer that spans a unit membrane, plus an ATP-ase, is responsible for both nitrate transport and reduction. Antibodies against *Chlorella* nitrate reductase detect a protein in the plasma membrane of barley roots, and IgG fragments of these antibodies inhibited nitrate transport by barley roots (Ward et al, 1983).

The plasma membrane nitrate reductase represents a small fraction of the total nitrate reductase, it has a much low molecular weight than the cytosolic form of the enzyme, and does not appear to represent the inducible nitrate transporter or the inducible nitrate reductase; its role is presently unclear (Ullrich, 1992).

Warner and Huffaker (1989) deny a connection between NR and nitrate transport. Genotypes of barley lacking both the NADH-specific and NAD(P)H-NRs show the same kinetics of nitrate uptake as the wildtype (Warner and Huffaker, 1989). However, in these NR-deficient mutants there was still a trace of NR activity which could have been due to the low molecular weight plasma membrane form of the enzyme postulated to be involved in nitrate transport (Ullrich, 1992).

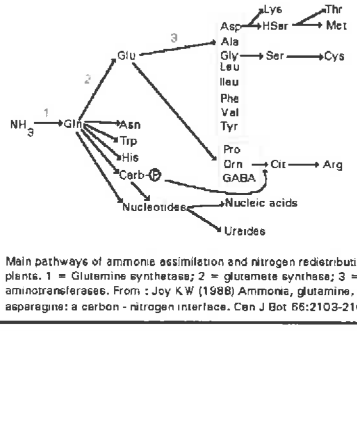
Ammonia Assimilation and Recycling
Pathways of ammonia production in plants



Metabolic reactions that produce ammonia in plants. Several are light-dependent (1. nitrite reduction; 2. photorespiratory metabolism) or light regulated (3. asparaginase; 4. phenylalanine ammonia lyase).

From : Joy KW (1988)

Ammonia Assimilation and Recycling
Main pathways of conversion of ammonia to amino acids



Main pathways of ammonia assimilation and nitrogen redistribution in plants. 1 = Glutamine synthetase; 2 = glutamate synthase; 3 = aminotransferases. From : Joy KW (1988) Ammonia, glutamine, and asparagine: a carbon - nitrogen interface. Can J Bot 66:2103-2109.

It is now recognized that in C_3 plants GS_1 is localized in the cytoplasm, but is present mainly in the phloem companion cells, and GS_2 is located in the chloroplasts.
Refixation of photorespiratory ammonium is mediated primarily by GS_2. Despite this efficient system for **reassimilating ammonium**, plants with normal activities of GS can lose ammonia to the atmosphere when grown on ammonium as sole N source. **Ammonia emission is greatly elevated when GS is inhibited with methionine sulfoximine**. Ammonia emission rates are also significantly increased in barley mutants with reduced GS activity (47 to 66% of wildtype) (Mattsson et al, 1997).
The photorespiratory N cycle requires an important metabolic interplay between mitochondria and peroxisome. Thus, the reduction of serine in the peroxisomes to glycerate (via hydroxypyruvate) requires reducing equivalents (NADH) provided by the mitochondria via the malate:oxaloacetate (OAA) shuttle. In this shuttle, OAA is reduced in the mitochondrial matrix by NADH generated during glycine oxidation. The malate generated in the mitochondria is then transported to the peroxisome where malate is use to regenerate OAA and provide the NADH required to sustain serine reduction to glycerate (Raghavendra et al, 1998).

References

Givan CV, Joy KW, Kleczkowski LA 1988 A decade of photorespiratory nitrogen cycling. Trends Biochem. Sci. 13: 433-437.
Lea PJ, Blackwell RD, Joy KW 1992 Ammonia assimilation in higher plants. In (K Mengel, DJ Pilbeam eds) "Nitrogen Metabolism of Plants", Clarendon Press, Oxford, pp 153-186.
Mattsson M, Hausler RE, Leegood RC, Lea PJ, Schjoerring JK 1997 Leaf-atmosphere NH_3 exchange in barley mutants with reduced activities of glutamine synthetase. Plant Physiol. 114: 1307-1312.
Raghavendra AS, Reumann S, Heldt HW 1998 Participation of mitochondrial metabolism in photorespiration. Reconstituted system of peroxisomes and mitochondria from spinach leaves. Plant Physiol. 116: 1333-1337.

•Plant GSs are inhibited by a number of synthetic and naturally occurring compounds:

- **•tabtoxinine-beta-lactam, a toxin produced by several disease-causing pathovars of *Pseudomonas syringae* (Langston-Unkefer, 1997).**
- **•methionine sulfoximine (MSX) (see e.g. Lea et al, 1989; Stewart et al, 1980)**
- **•glufosinate (phosphinothricin) [the active ingredient of "Basta" and several other herbicides used worldwide] (Hoerlein, 1994). This compound is produced as part of the tripeptide L-phosphinothricyl-L-alanyl-L-alanine by *Streptomyces* sp. Phosphinothricin acetyltransferase (PAT) confers "Basta" resistance in plants (Hoerlein, 1994).**

http://www.hort.purdue.edu/rhodcv/hort640c/ammonia/am00030.htm

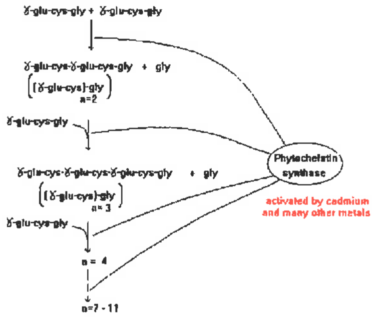
Glutamine is the primary amino acid made from ammonia or into which ammonia is bound. If the glutamine manufacturing enzyme GS is inhibited, ammonia is left free in the plant to cause damage and go off into the air. Per Callahan, free ammonia amplifies the signals of "sick plant" attracting pest insects to the plant.

Ag-Medicine Connection

- Glutamine in humans:
  - 50% of muscle AA pool
  - Fuel for intestinal cells and immune cells
  - Combats catabolic effect of cortisol (stress) thus muscle wasting
  - Recycle ammonia
- Made by Glutamine-Synthetase
- *Conditionally essential* amino acid

» Flex, October 1996; p. 58.

Phyto
Chela
tins



Phytochelatins…

Glutathione serves as a precursor of peptides, known as phytochelatins, which are composed of two or more repeating gamma-glutamylcysteine units with a terminal glycine residue; (gamma-glutamylcysteine)$_n$-gly, where n = 2 to 11 (Steffens et al, 1986; Reese and Wagner, 1987). The enzyme responsible for the synthesis of these peptides is known as phytochelatin synthase (Rauser, 1990; 1995). **Phytochelatins (PCs) play an important role in the detoxification of certain heavy metals (particularly cadmium) in plants** (Rauser, 1990; Howden et al, 1995ab; Rauser, 1995). These peptides appear upon induction of plants with metals of the transition and main groups (Ib-Va, Z = 29-83) of the periodic table of elements (Zenk, 1996). In *Rubia tinctorum* phytochelatins (class III metallothionein) are induced by many metal ions, but only a few (Ag, Cd and Cu) were bound to the PCs that they induced (Maitani et al, 1996). These peptides are induced in all autotrophic plants so far analyzed, as well as in certain fungi (Zenk, 1996). Phytochelatin synthase (PC synthase) (glutathione gamma-glutamylcysteinyltransferase or gamma-glutamylcysteine dipeptidyl transpeptidase) [EC 2.3.2.15] is a constitutive enzyme that is activated by cadmium and other metal ions (Rauser, 1995). It catalyzes the following reaction: gamma-Glu-Cys-Gly + (gamma-Glu-Cys)$_n$-Gly-->(gamma-Glu-Cys)$_{n+1}$-Gly + Gly.

Note that glutamine is a part of this protein, therefore, certain herbicides can interfere with phytochelatins and, consequently, toxic metal protection.

Cadmium toxicity effects on growth, mineral and chlorophyll contents, and activities of stress related enzymes in young maize plants (Zea mays L.)

- According to the relationship between the POD activity and the Cd content, a **toxic critical value was set at 3 mg Cd per kg dry matter in the 3rd leaf and 5 mg Cd per kg dry matter in the 4th.** Anionic POD were determined both in root and leaf protein extracts; however, no changes in the isoperoxidase pattern were detected in case of Cd toxicity. Results show that in contrast with growth parameters, the measurement of enzyme activities may be included as early biomarkers in a plant bioassay to assess the phytotoxicity of Cd-contaminated soils on maize plants.
  - Lagriffoul, A. et al.Plant and Soil. Springer Netherlands, Vol. 200, No. 2, March, 1998, p. 241-250.

Nitrogen Summary: The Drug of Choice in Chemical Farming

- Nitrogen is component of every cell, every amino acid, protein, nucleic acid
  - Must be combined with carbohydrate
  - Only utilized as NH2 molecule
  - All forms, NO3, NH3/4, Urea
    - Must be converted to NH2 form
  - Stored as glutamine
    - Glutamine is component of other amino acids
      - Phytochelatins/metallothionine

Nitrogen Summary …

- Nitrogen utilization/status is the key
  - The intensive agriculture used to increase yields is based on chemical fertilizers, especially nitrogenous fertilizers and pesticides – practically all of them nitrogenous and chlorates. As we have seen in this work, the parasites then follow one after another in an inevitable cycle. (Chaboussou)
  - It is the state of proteolysis which sensitizes the plant to it parasites – virus, bacteria, fungus, insect. (Chaboussou)
  - Free nitrogenous compound accumulation calls in the disease and parasite organism
- Nitrogen compounds must be carried through to end product complete proteins
  - Sridhar (1975) established that a high level of soluble nitrogen in the leaves of rice promotes the spread of disease. … glutamine and asparagine levels increase. …high concentrations of nitrogen in the host provide the pre-requisites for the development of the parasitic fungus. The excess of soluble nitrogen in the plant tissue can result in part from a dis-equilibrium with the other elements, inhibiting the condensation of the amino acids into **insoluble proteins which are of no nutritional use to the various parasitic organisms**. (Chaboussou)

DMPP Study

- A field study was conducted to assess the effect of the nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP), applied at a rate of 1 kg ha-1, on nitrous oxide (N2O) emissions, forage production and N extraction from a grassland soil after cattle slurry applications in autumn and spring. Nitrous oxide emissions were measured daily or weekly using the closed chamber technique. DMPP efficiency after slurry application was lower in spring (16.7 C mean soil temperature) than in autumn (11.4 C mean soil temperature). Thus, DMPP was able to maintain soil mineral N in the ammonium form for 22 days and reduce cumulative N2O emissions by 69% in autumn, while in spring its effect on soil mineral N lasted for 7-14 days, reducing cumulative N2O losses by 48%. Furthermore, application of DMPP after slurry did not decrease biomass yield or N uptake.
- **3, 4-Dimethylpyrazole phosphate reduces nitrous oxide emissions from grassland after slurry application**
- by P Merino, S Menéndez, M Pinto, C González-Murua, J M Estavillo
- http://www.mendeley.com/catalog/3-4-dimethylpyrazole-phosphate-reduces-nitrous-oxide-emissions-grassland-after-slurry-application/

N-Ergize™

Keep the Nitrogen in your soil.

Reduce volatilization, denitrification, and leaching; and increase concentration of Nitrogen in the root zone. Managing Nitrogen loss delivers higher yields.

Guaranteed Analysis

CA-Dicyandiamine (DCDA), Ca-Monethanolamine, and proprietary ingredients 100% Derived From CA-Dicyandiamine (DCDA), Ca-Monethanolamine, and Proprietary Ingredients

Use Rates

Liquid Nitrogen •2 quarts per ton

Liquid Manure •3 oz. per 1,000 gallons

Dry Urea •3-4 quarts per ton. It is recommended to apply with a high-pressure nozzle.

Reasons to Use N-Ergize

- Reduce volatilization, denitrification, and leaching
- Increase concentration of N in the root zone
- Soil friendly –no nutrient loss or tie ups
- One formulation for dry, liquid UAN, and manure
- Does not require rain or tillage
- Begins working upon application
- No planting or crop restrictions
- Not a labeled pesticide
- Non-corrosive
- Odorless

How N-Ergize Works

Calcium polymer (Ca-Monethanolamine) reacts with Ammonia Carbonate producing Calcium Carbonate. Free-ranging Ammonia in the soil attracts the Calcium Carbonate creating a plant usable form of Nitrogen (NH_4^+). Polymers and NH_4^+ attach themselves to soil colloids reducing volatilization, denitrification, and leaching. Dicyandiamide (DCD) aids in reducing denitrification and leaching.

Reality: it works as a broad spectrum bacteriocide by killing the nitrous ammonous bacteria that denitrify nitrogen compounds

N-Ergize Glossary

1. Ammonium NH_4^+: Essential for the breakdown of plant protein and is the most important nitrogenous fertilizer for water plants.
2. Nitrite NO_2^-: Ester or salt of nitrous acid containing the nitrite (NO_2^-) ion. Nitrites are converted to nitrates (plant nutrients) by specific bacteria in the soil.
3. Nitrate NO_3^-: Inorganic nitrates are formed by bacteria and are an essential component of agricultural soil.
4. Denitrification: The microbiological process through which nitrogen is returned from the soil to the atmosphere
5. Leaching: When water carries nitrogen deeper into the soil beyond the reach of the plant roots.
6. Dicyandiamide (DCD): A nitrogen stabilizer used to reduce denitrification and leaching.
7. UAN: A fertilizer containing a solution of urea and ammonium nitrate in water.
8. Urea: A solid nitrogenous fertilizer with the highest nitrogen content. The standard crop nutrient rating is 46–0–0.
9. Urease: An enzyme present in the soil that reacts with urea, turning it into carbon dioxide and ammonia.
10. Volatilization: The process by which urea that has been converted to carbon dioxide and ammonia vaporizes into the atmosphere from the soil surface.

Other N-inhibitors

- N-Serve – nitrapyrin – most specific agent to kill nitrous ammonous bacteria (fertilizer)
- DMPP – dimethylpyrazole phosphate – very specific agent to kill nitrous ammonous bacteria (better for manure)

Carbon

- Element of Life
- Bio-active forms are key
- Carbohydrates
- Organic Acids
- Humus
    - Water holding capacity
    - CEC
    - Bio-food sources
    - Soil structure/aeration

Sources of Carbon

- Aerobic residue digestion – humus
- Compost
- Carbohydrates
  - Sugars, starches, humates, organic acids (fulvic…)
- Organic matter is carbon, but not necessarily humus nor, as such, does it benefit the soil by simply being present.

Pest and disease food

- A **reducing sugar** is a type of sugar with an aldehyde (R-CO) or ketone (R1R2CO) group. This allows the sugar to act as a reducing agent, for example in the Maillard reaction and Benedict's reaction. Reducing sugars include glucose, glyceraldehyde, lactose, arabinose and maltose. All monosaccharides which contain ketone groups are known as ketoses, and those which contain aldehyde groups are known as aldoses. Significantly, sucrose is not a reducing sugar. It is in fact known as a non reducing sugar.
- Reducing sugars are building blocks and desired foods of pathogens/pests
  - Maillard reaction – amino acid and reducing sugar reaction forming flavors and odors
  - Benetict's reaction – test using copper sulfate for presence of reducing sugars
  - Reducing agent – in a reduction-oxidation reacton that donates its electron(s), thus becoming oxicized itself; this is the browing one sees of a potato or apple after pealing
  - The more reducing sugars the faster the apple or potato will brown after pealing
    - We desire non-reducing sugars, complex carbohydrates

C:N

- Carbon to nitrogen ratio is key determinant to insect and disease attraction
- Soluble nitrogen and phosphorus compounds appear to have the greater power of attraction than sugars
- Key: organic nitrogens and insoluble sugars
- C/N balance is dependent on climate, soil, fertilization and – last but not least – the impact of pesticides.
  - Chaboussou, p. 20

Micronutrients with Dr. Huber and Ismael Cakmak

- Mineral Nutrition and Plant Disease
- Various trace minerals, deficiency deficiencies, interactions, valence states, crop ideosyncrocies
- Ex: flooded rice keeps Mn and Si reduced so plants can uptake

Microbially Induced Nutrient Deficiencies

Microbial Interaction	Effect on Plant Nutrition
Growth in soil or rhizosphere	Immobilize N, Fe, Mn, S thru or oxidation; increase availability of Fe, Mn, and S thru reduction
Root rots, damping-off root pruning	Immobilize, solubilize, absorption, uptake, distribution
Vascular wilts, leaf spots, blights	Translocation, distribution, sinks, metabolic efficiency
Viruses	Metab. efficiency, depletion, sinks
Fruit and storage rots	Sinks, distribution, nutr. reserves

Nutrients in Harvested Plant Materials (lb/a)

Crop	Component	Yield	N	P	K	S	Ca	Mg
Alfalfa	Hay	5.0 t	[illegible]	24	160	22	125	24
Apple	Fruit	12.5 t	68	22	100	22	18	11
Corn	Grain	3.3 t	109	22	26	10	3	10
Corn	Stover	3.3 t	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grapes	Fruit	6.5 t	100	18	85	15	115	20
Potato	Tubers	45 t	255	33	274	20	7	11
Soybean	Grain	2.0 t	289	25	79	13	10	10
Soybean	Residue	2.0 t	90	10	55	16	68	28
Wheat	Grain	2.2 t	84	19	24	5	2	10
Wheat	Straw	2.2 t	33	5	66	8	10	5

Nutrients in Harvested Plant Materials (lb/a)

Crop	Component	Yield	B	Cu	Fe	Mn	Zn	Mo/Co/
Alfalfa	Hay 5.0 t	0.07	0.07	0.9	0.45	0.45	Ni/Si/	
Apple	Fruit 12.5 t	---	0.07	---	0.07	0.07	Na/?	
Corn	Grain 3.3 t	0.45	0.06	0.13	0.06	0.13		
Corn	Stover 3.3 t	0.08	0.06	0.17	1.10	0.22		
Grapes	Fruit 6.5 t	0.12	0.09	0.65	0.12	0.15		
Potato	Tubers 45 t	0.07	0.10	0.9	0.20	0.10		
Soybean	Grain 2.0 t	0.08	0.07	0.70	0.08	0.07	+	
Soybean	Residue 2.0 t	0.04	0.02	1.30	0.70	0.39	+	
Wheat	Grain 2.2 t	0.07	0.06	0.50	0.15	0.22		
Wheat	Straw 2.2 t	0.02	0.03	0.17	0.29	0.09		

How Do We Get Better Nutrient Efficiency?

I. Better root system - Agronomy & genetics

A) More sustainable practices

B) Potential to reduce inputs by 20-40%

C) Potential to improve profits together with sustainability

II. Efficient supplementation (fertilization)

Crops Differ in Ability to Deal with Low Levels of Nutrients

- *Many forms exist for each essential mineral*
- *Some plant species OR CULTIVARS can use forms that are non available to others*
- *Some species and genotypes are more efficient than others*
  - *- Physiologically*
  - *- Root growth or configuration*

Differences in Crop Species and Cultivar Nutrient Uptake Efficiency

Weeds: 3 - 4 x better uptake than many crops

Nutrient	Plant: Pea and Wheat	Plant: Rye	Weeds	Difference
Mg	0.15	0.14	0.63	4 x
Cu	7.96	12.2	11.50	
Zn	23.2	48.1	41.30	
Ca%	0.50	0.66	2.15	4 x
B	8.1	6.2	23.70	3 x

Source: Bernard ESTEVEZ, Agr., 2004

Mn Sufficiency* Range for Agronomic Crops

Crop	Range	Crop	Range
Barley	25-100	Sorghum	6-190
Bean	20-100	Soybean	20-100
Canola	25-250	Sugar beets	26-360
Corn	15-300	Sugar cane	25-400
Cotton	25-350	Sunflower	[illegible]
Oats	25-100	Tobacco	26-400
Peanut	60-350	Tomato	25-35
Rice	150-800	Wheat, spring	25-100
Rye	14-45	Wheat, Winter	16-200

*Depends on: cultivar efficiency, growth stage, soil physical and biological environments, and climate. After Bennett, 1994; Mills and Jones, 1996

% Mineral Reduction in Roundup Ready® Soybeans Treated with Glyphosate

Plant tissue	Ca	Mg	Fe	Mn	Zn	Cu
Young leaves	[illegible]	[illegible]	7	[illegible]	NS	NS
Mature leaves	[illegible]	[illegible]	18	[illegible]	30	27
Mature grain	26	13	49	[illegible]		

Residual glyphosate?

Reduced:

Yield 26%

Biomass 24%

Factors Changing Plant Nutrient Needs

- Stage of plant growth
- Temperature
- Moisture
- pH
- Agricultural Chemicals
- Nutrients
- Microorganisms

Apparent conflict about required soil micronutrients

- **Manganese** for Field peas:
  - Mortvedt - Low needs
  - Karamanos - High needs
  - Wisconsin guidelines - in between
  - Wheat versus melons
- **Copper**
  - West Can.: 3.5 - 4.0 ppm
  - East Can.: 0.7 - 2.0 ppm

Macronutrients: Needs and Functions

Element	Needs	Constitutory functions	Physiologic functions
N	60-460	Proteins, AA, enzymes	Enzyme activation, photosynthesis
P	10-200	ATP, coenzymes, lipids sugar phosphates	Energy metabolism, Mo uptake, enzyme regulation
K	20-400	None known	Enzymes, photosyn., stomata, translocation
Ca	20-400	Middle lamella, cell walls, amylase, salts	Enzymes, pH reg, starch, membranes, organization
Mg	20-400	Chlorophyll, enzymes middle lamella	Enzymes, photosynthesis, energy metabolism
S	10-200	Proteins, oils, AA, vitamins, ferrodoxins	Enzymes, photosynthesis, e-transfer, regulation

The Physiological Role of

Mighty in Function

Micronutrients: Needs and Function

Symbol	Name	Need (ppm)	Some functions
B	Boron	4-100	Carbohydrate met, cell wall, pollen germ.
Co	Cobalt	Trace	Carbohydrate, N-fixation
Cu	Copper	5-15	Protein, sugar, pollination, defense-stress
Fe	Iron	20-50	Photosynthesis, energy, N-fix., ox-red
Mn	Manganese	18-50	Photos, ox-red, AA, energy, TCA, defense-stress
Mo	Molybdenum	0.5-1	Sugar, AA, N-fix., N-red.
Ni	Nickel	Trace	N-metabolism, germination, yield
Zn	Zinc	20-150	Respir, hormone, AA, ox-red, permeability, stress

Micronutrient Deficiency Symptoms

Micro	Symptom
B	Stunting, die-back, cracking, poor flowering, yellows
Co	Slow growth, poor nodulation
Cu	Stunting, yellow, rolled leaf, die-back, poor flowering, disease
Fe	Stunting, yellow, few nodules
Mn	Stunting, Interveinal yellow, leaf spots, malformed leaves
Mo	Stunting, interveinal yellow, mottling, necrosis, no nodules
Ni	Small leaves, slow growth, bud drop
Zn	Stunting, rosette, yellow, necrosis, twisting

Nickel

- Urease enzyme
  - Urea to NH_4 and CO_2
- Grain fill and seed viability
- Iron absorption
- Seed germination
- Nitrogen fixation
- Sources:
  - Trace mineral powders/liquids, fish, seaweed
  - 1-2.5gm/Ac. (2.5-6.25 gm/Ha) – glyphosate binds

Disease Effects Nutrition

- Availability
  Immobilization (sink, form)
  Nutrient balance
  Toxicity
- Uptake
  Root rots, blights
  Nutrient balance
- Distribution
  Wilts, plugs, sinks, necrosis
- Function
  Necrosis, toxins, plugging, viruses
- Loss
  Rots, blights, theft, sinks

Nutrient Mechanisms that Reduce Disease

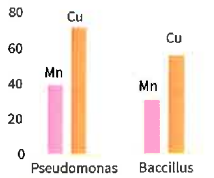
- Increased plant resistance
  Physiology, inhibitors
  Defenses - callous, cicatrix, etc.
- Disease escape, tolerance
  Increased root, leaf growth
  Shorter susceptible stage
  Compensate for disease damage
- Modify the environment
  Ph, other nutrients
  Rhizosphere biology interactions
- Inhibit pathogen activity
  Reduced virulence, survival
  Biological control and growth

Adversity Conditions for Nutrients

- Not present in soil
- Not available for plant uptake
  Valence state - antagonism
  Solubility, sequestered
- Soil conditions prevent uptake
  pH, Compaction,
  Temperature
- Plant health
- Management practices
  Tillage (no-till) stratification
  Glyphosate
- Adverse biological activity

Disease as a Symptom of Deficiency

- **Take-all: manganese (Huber)**
- **Stem melanosis, ergot, take-all: copper (Evans)**
- **Ergot, root rot fungi, damping-off: Mn, B, Cu (Comeau, Evans)**
- **Fusarium head blight: worse in low Copper (Franzen et al.)**
- **Verticillium wilt and common scab of potatoes: Mn**



Voss 2001

Nutrient	Soil Conditions Inducing Nutrient Deficiency
N	Leaching, low OM, residue burning, denitrification, microbial sinks
P	Acid, organic, leached & calcareous soils; excess liming
K	Sandy, organic, leached, eroded soils, intensive cropping
Ca	Acidic, alkali, or sodic soils
Mg	Low clay content, sodic low Mg soils
S	Low organic matter soils, high use of N and P
B	Sandy, acidic leached soils, alkaline soils with free lime
Cu	High pH, low organic soils
Fe	Calcareous soils, high P, Mn, Cu, or Zn; excess liming
Mn	Calcareous silt and clays, high organic matter, oxidative organisms
Mo	Highly podzolized soils, well drained calcareous soils, low pH
Zn	Highly leached acidic soils; well drained calcareous soils

Micronutrient bioassays ?
More research needed

Copper: Onion, Timothy, Fescue, Raygrass, ?

Boron : Chives, Alfalfa, Asparagus, sunflower ?

Manganese : Lebanese cucumber
Red clover selections

Maize = low Manganese okay
Melons = toxicity; wheat = deficiency

Molybdenum: ?
Problem is diffuse symptoms

Root Exudate Interpretation

- Cell integrity and nutrient metabolism is dependent upon mineral sufficiency.
- When mineral deficiencies occur, membrane integrity is lost and cells loose metabolic compounds – **hemorrhage it is called in medical terms**
- These intermediate metabolites are prime foods for insect pests and disease organisms – what these organisms home in on as food

Zn

Photosynthesis

Auxins...

Resistance to many diseases e.g. Rhizoctonia

Pollen viability

R to oxidation → E.g. Herbicide damage
Heat and drought
Flooding
Nitrogen applied
Copper foliar

Carbohydrate Metabolism

Membrane integrity

Zinc

- Growth regulator: auxin
- Synthesis of nucleic acids
- Enzyme activator
- Protein synthesis
- Dehydrogenase enzymes
- Convert simple to complex carbohydrates
- Symptoms:
  - Mottling, shorter internodes, rosetting, small terminal leaves, acute dieback of young twigs
- Sources:
  - Industry waste products – avoid, check heavy metals
  - Sulfates
  - Chelates
  - BioFermentation Zn preferred

B Mostly in small field patches. *But …*

Interactions:

High levels of calcium and potassium

Less available above pH 7.0

Needs research - lab tests are not reliable?

Bioassays useful if available

Source, Canola Council

Boron

- Sugar formation and transport
- Carbohydrate metabolism
- Reproduction and pollen vitality
- Cell wall formation
- Calcium uptake
- Symptoms:
  - Death of growing tips, leaf thickening and brittleness, flowers don't form, black heart of fruits/tubers
- Sources:
  - Chicken manure, Borax, BioChelates best
  - Careful: boron is a biocide also.

Chaboussou Tidbits for Boron

- Boron is only active in combination with magnesium, manganese, and molybdenum
- Beneficial effects of boron begin at flowering.
  - B/Zn ratios up to 47:1 in grapevines are necessary to ensure flowering.
  - Boron is key to plant resistance to disease
    - P. 81
  - Increasing doses of nitrogen fertilizers lead to decreased leave boron levels in cherry trees. p. 76

Manganese

- Key to seed quality/vitality
- Activator of many enzymes
  - Photosynthesis
  - Kreb's cycle esp. organic acids manufacturing
  - Oxidation-reduction, hydrolysis
- Don't use as EDTA with high iron
- Symptoms:
  - Interveinal chlorosis of young leaves
  - Reduced plant growth, leaf area
  - Reduced fruit/seed set and quality

Biological Transmutation

In the book Biological Transmutations by Professor C. Louis Kervan, published in 1980 (ISBN 0-916508-47-1)

Pg 94 "Manganese is used often by doctors who have found that a manganese deficiency caused some types of allergies. (It has been verified with the spectroscope that in 50% of all allergies the plasma has suffered a loss on Mn.) A prescription of 5 mg of Mn, taken twice a week for ten weeks, can cure asthma, hay fever, and other intolerances. Agronomist also widely use Mn to get rid of the bad effects of sea salt in the soil. (50 kg per 2 ½ acres make sowable dried-up fields which have been reclaimed from the sea.)

Pg 95 … a small reduction of Mn in the diet of female rats causes them to stop nursing. Male rats become sterile.

Very interesting since we now know that GM crops are severely deficient in Mn and allergies are skyrocketing….

Sources of Manganese

- Royal Jelly – worker bees feed to queen bee
  - Ideal source of Mn but not practical
- Sulfates – ok, best cultured
- Chelates –
  - EDTA, amino acids, organic acids
- BioFermentation Mn preferred

Cu

Lignin, cell wall formation

Resistance to ergot

Resistance to many other diseases

Pollen viability

Seedling vigor

Stem elongation

Cu problems:

Worst in:

Light soils

Organic soils

Soils with pH > 6.5

Copper

- Oxidation proteins for vit. C, A, & phenolics
- Nitrogen metabolism
- Electron transport in photosynthesis
- Elasticity
- Symptoms:
  - Necrosis of young leaf tips down along margins
  - Stunted growth
  - Wilting and eventual death of leaf tips

Copper, Nitrogen and Fungal Disease

- Copper deficiency creates an excess of nitrogen, which unleashes the disease. The ratio N/Cu changes from 35.0 in healthy rice to 54.7 in diseased rice, through a deficiency in copper.
- W.E. Ripper (7th British Weed Control Conference): a slight increase in nitrogen content in plants increases parasite attacks.
  - The same conclusion was reached at a symposium on integrated control in orchards (Bologna, 1972)
    - Total nitrogen levels increase after any treatment with chemical fungicides.
      - P. 75

Sources of Copper

- Sulfates
- Chelates
- BioFermentation Cu preferred
- Copper is also a fungicide. Be careful not to overuse, especially in organic programs and kill your beneficial fungi.
- Sul-Po-Mag July 15 – Sept 15 (Jan – Mar in So. Hemi) helps make copper available. 200 lbs./Ac, Kg/Ha once every five years for this purpose

Micronutrient interactions

B, Mn needed *in situ* for root tip elongation
deficit leads to drought-like effect, etc.

Effect on disease incidence - can be very high
Multiple diseases in interaction; root diseases ***

Deficits give pollen sterility:
Cu > Mn = B
leading to ergot in each case

Protection against drought, herbicide damage:
Zn, Mn, Cu, Mg, plus others (balance)

Factors Changing the Plants Nutrient Needs

- Stage of plant growth
- Temperature
- Moisture
- pH
- Agricultural Chemicals
- Nutrients
- Microorganisms

Reported* Effects of Nutrients on Disease

Mineral element	Disease is: Decreased	Increased	Variable	Total
Nitrogen (N/NH_4/NO_3)	168	233	17	418
Phosphorus (P)	82	42	2	126
Potassium (K)	144	52	12	208
Calcium (Ca)	66	17	4	87
Magnesium (Mg)	18	12	2	32
Manganese (Mn)	68	13	2	83
Copper (Cu)	49	3	0	52
Zinc (Zn)	23	10	3	36
Boron (B)	25	4	0	29
Iron (Fe)	17	7	0	34
Sulfer (S)	16	3	0	19
Other (Si, Cl, etc.)	71	6	8	85

*Based on 1,200 reports in the literature

Mineral Content of Caster Bean Leaves Relative to Susceptibility to Botrytis

(after Thomas and Orellana, 1964)

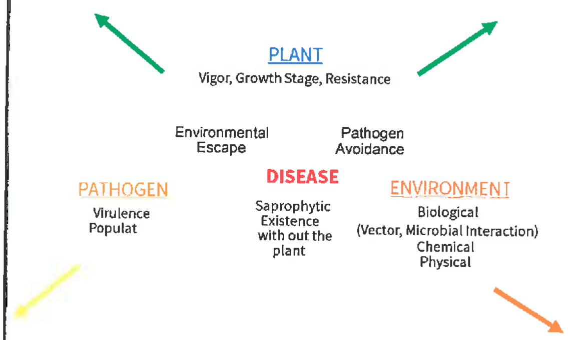
Cultivar	Ca	Mg	Na	K
Resistant	122	21	3.2	16.1
Susceptible	38	13	8.1	224.0

Factors Affecting N Form, Mn Availability and Severity of Some Diseases*

Soil Factor or Cultural Practice	Effect on: Nitrification	Mn Availability	Disease Severity
Low Soil pH	Decrease	Increase	Decrease
Green Manures(some)	Decrease	Increase	Decrease
Ammonium Fertilizers	Decrease	Increase	Decrease
Irrigation (some)	Decrease	Increase	Decrease
Firm Seed bed	Decrease	Increase	Decrease
Nitrification Inhibitors	Decrease	Increase	Decrease
Soil Fumigation	Decrease	Increase	Decrease
Metal Sulfides	Decrease	Increase	Decrease
Glyphosate	—	Decrease	Increase
High Soil pH	Increase	Decrease	Increase
Lime	Increase	Decrease	Increase
Nitrate Fertilizers	—	Decrease	Increase
Manure	Increase	Decrease	Increase
Low Soil Moisture	Increase	Decrease	Increase
Loose Seed bed	Increase	Decrease	Increase

*Potato scab, Rice blast, Take-all, Phymatotrichum root rot, Corn stalk rot

The Interaction of Three Factors Over Time Determines if a Disease will be Latent or Severe



Nutrient Mechanisms that Reduce Disease

- **Increased plant resistance**
  - Physiology, inhibitors
  - Defenses - callous, cicatrix, etc.
- **Disease escape, tolerance**
  - Increased root, leaf growth
  - Shorter susceptible stage
  - Compensate for disease damage
- **Modify the environment**
  - Ph, other nutrients
  - Rhizosphere biology interactions
- **Inhibit pathogen activity**
  - Reduced virulence, survival
  - Biological control and growth

Some Diseases Influenced by Magnesium

Plant	Disease	Causal agent	Mg effect
Bean	Root rot	*Rhizoctonia solani*	Decrease
Carnation	Wilt	*Fusarium oxysporum*	Decrease
Caster bean	Leaf spot	*Botrytis* spp.	Decrease
Cereals	Leaf/stem rusts	*Puccinia* spp.	Increase
Cotton	Bacterial blight	*Xanthomonas malvacearum*	Decrease
Cotton	Damping-off	*Rhizoctonia solani*	Decrease
Cotton	Root rot	*Phymatotrichum omnivorum*	Increase
Cotton	Wilt	*Fusarium oxysporum*	Decrease
Crucifers	Club root	*Plasmnodiophora brassicae*	Decrease
Grapevine	Die-back	*Eutypa lata*	Decrease
Maize	Southern leaf blight	*Bipolaris maydis*	Increase
Peanut	Pod rot	*Fusarium/Pythium/Rhizoctonia*	Increase
Pepper	Bacterial spot	*Xanthomonas vesicatoria*	Increase
Poppy	Downy mildew	*Peronospora arborescens*	Decrease
Potato	Gangreen	*Phoma exigua* var. *foveata*	Decrease
Potato	Soft rot	*Erwinia carotovora*	Decrease
Rice	Leaf spot	*Helminthosporium* spp.	Decrease
Rice	Panicle blast	*Pyricularia grisea*	Increase
Rye	Stalk smut	*Urocystis occulta*	Increase
Soybean	Root rot	*Rhizoctonia solani*	Decrease
Soybean	Twin stem	*Sclerotium* spp.	Increase
Tomato	Bacterial spot	*Xanthomonas vesicatoria*	Increase
Wheat	Flag smut	*Urocystis tritici*	Increase

Some Diseases Influenced by Sulfur

Host Plant	Disease	Effect of S
Cereals	Stem rust, stripe rusts	Increase
Cotton, tomato	Fusarium wilt, Verticillium wilt	Decrease
Crucifers	Club root	Decrease
Grape	Downy mildew, powdery mildew	Decrease
Maize	Leaf blight, Stewarts wilt	Decrease
Nicotiana glutinosa	Tobaco Mosaic Virus	Decrease
Peach	Armillaria root rot	Decrease
Peanut	Cercospora leaf spot	Decrease
Pine	Needle blight	Decrease
Potato	Common scab, late blight, stem canker	Decrease
Rape	Black spot, black leg, late leaf spot, Sclerotinia stem rot, Verticillium wilt	Decrease
Rhododendron	Bud Death	Decrease
Soybeans	Rhizoctonia root rot	Decrease
Sugarbeets	Ramularia leaf spot	Decrease
Turfgrass	Fusarium patch	Decrease
Wheat	Powdery mildew, sharp eye-spot	Decrease

Keys to Using Nutrition to Manage Disease

1. Genetics of the Plant
2. Nutrient Form or Availability
3. Rate Applied or Available
4. Method and Time Applied
5. Source of Element & Associated Ions
6. Integration with other practices

Some Diseases Decreased by NO_3-N & alkaline pH

Crop	Disease	Pathogen
Asparagus	Wilt	*Fusarium oxysporum*
Bean (*P. vulgaris*)	Chocolate spot	*Botrytis*
	Foot and hypocotyl rot	*Fusarium solani*
		Rhizoctonia solani
Beet	Damping-off	*Pythium* spp.
Cabbage	Club root	*Plasmodiophora brassica*
	Yellows	*Fusarium oxysporum*
Celery	Yellows	*Fusarium oxysporum*
Cucumber	Yellows	*Fusarium oxysporum*
Pea (*Pisum sativum*)	Damping-off	*Rhizoctonia solani*
Pepper	Wilt	*Fusarium oxysporum*
Potato	Stem canker	*Rhizoctonia solani*
Tomato	Gray mold	*Sclerotina* spp.
	Sclerotium blight	*Sclerotium rolfsii*
	Wilt	*Fusarium oxysporum*
Wheat	Eye spot	*Pseudocercosporella*
herpotrichoides		

Some Diseases Decreased by NH_4-N & acid pH

Crop	Disease	Pathogen
Bean *(P. vulgaris)*	Root rot	*Thielaviopsis basicola*
	Root knot	*Meloidogyne*
Carrot	Root rot	*Sclerotium rolfsii*
Corn	Stalk rot	*Gibberella zeae*
EggPlant	Wilt	*Fusarium oxysporum*
Onion	White rot	*Sclerotium rolfsii*
Pea	Root rot	*Pythium* spp.
Potato	Scab	*Streptomyces scabies*
	Wilt	*Verticillium dahliae*
	Virus	*Potato virus x*
Rice	Blast	*Pyricularia grisea*
Tomato	Southern wilt	*Pseudomonas*
solanacearum		
	Anthracnose	*Colletotrichum* spp.
	Wilt	*Verticillium dahliae*
	Virus	Potato virus x
Wheat	Take-all	*Gaeumannomyces*
graminis		

Nutrient Density of GMO & Non-GMO Corn, Iowa 2012

Nutrient	GMO	Non-GMO	Nutrient	GMO	Non-GMO
Glyphosate	13	0	Mn	2	14
Formaldehyde	**200**	**0**	Fe	2	14
Test Wt.	57.5	61.5	Zn	2.3	14.3
Brix	1	20	Cu	2.6	16
N	7	46	Co	0.2	1.5
P	3	44	Mo	0.2	1.5
K	7	113	B	0.2	1.5
Ca	14	6130	Se	0.6	0.3
Mg	2	113	Cl	10	1
S	3	42			

Medical Management Guidelines, Formaldehyde

- Concentration in GMO corn (Iowa) = 200 ppm
- Formaldehyde is highly toxic to all animals and absorbed well by the GI tract
  - It is carcinogenic, toxic, and allergenic
  - Contributes to reproductive problems
    - Drops sperm counts in men
    - Causes spontaneous abortion (miscarriage)
- EPA limit in air of new buildings = 0.016 ppm
- Maximum conc. in workplace = 0.3 ppm
- Maximum emis. from wood products = 0.09 ppm
- Symptoms at (0.5 - 3 ppm). Respiratory damage, Chronic fatigue, irritation, GI tract injury, cancer, Central nervous system, disrupts metabolism, Suppressed immune system, vomiting, genotoxic, Abdominal pain, ulceration, dizziness, death

Glyphosate in Human Urine (Urbanites) & Dairy Cows

City	No.	Male	Female
1	44	10.3*	6.1
2	22	16.0	2.7
3	19	60.1	8.3
4	22	23.5	13.8

*ppm glyphosate

Dairy	Glyp*.	Dairy	Glyp.
A	9	E	37
B	21	F	38
C	22	G	46
D	25	H	102

*ppm, herd average

Permitted in cereals, soybean, corn = 20 ppm
Permitted in alfalfa = 400 ppm Corn silage = 100 ppm
Toxicity to beneficial GI flora = 0.1 ppm
Long-term toxicity to liver, kidney, etc. tissues = 0.1 ppbillion
Long-term carcinogenicity = 0.1 ppb
Antibiotic to beneficial enteric bacteria = 0.1 ppm

REMEMBER

1. Nutrition is an integral part of efficient crop production
   A. Crop quality and quantity
   B. Disease control
2. Changes in the nutrient related interactions of the plant - environment - and pathogen affects disease
   A. Increase plant resistance and defense response
   B. Make the environment less conducive for pathogenesis
   C. Reduce virulence or survival of the pathogen
3. Nutrient rate, form, time, source and method of application are important principles for disease control
4. Integrate nutrition and cultural practices for optimum yield, disease control, over-all plant health and nutrient quality

Iron

- Iron is used in the synthesis of chlorophyll in a precursor to the completed form. Iron is also a part of many of the components of metabolism, namely cytochrome c, cytochrome oxidase and a variety of catalases. (James, 1973) This cytochrome has a similar shape to the chlorophyll molecule shown here but has iron instead of the magnesium. It is also part of iron-sulphur compounds, for example, quinones, these also carry electrons in the electron transform chain (Alberts et al, 1989).
- Necessary for photosynthesis, oxidation-reduction
- Nitrogen fixation (nitrogenase) and chromosome activity
- Symptoms:
  - Chlorosis in youngest leaves
  - Interveinal chlorosis
  - Stunted plants
  - Tip die-back

Sources of Iron

- Molasses – excellent organic source
- Sulfates
- Chelates
- Rusty water
- BioFermentation Fe preferred

Molybdenum

- Nitrate metabolism and reduction
  - Nitrate nitrogen reductase
- Nitrogen fixation
- Sulfur metabolism: Mo is enzyme activator
- Symptoms:
  - Stunted plants, reduced leaf area, older leaves mottled, leaf curl inward and die along the tips
- Sources:
  - Molybdenum glucoheptonate – preferred
  - BioFermentation – preferred
  - Chelates

Cobalt

- Nitrogen fixation
- Metal component of B12
- Sources:
  - Cobalt chelates
  - B12
- Soil Test: 0.3 ppm minimum

Inhibition of Ethylene Production by Cobaltous Ion by Oi-Lim Lau and Shang F. Yang

- These data suggest that Co^{2+} inhibited ethylene production by inhibiting the conversion of methionine to ethylene, a common step which is required for ethylene formation by higher plants.
- **Co^{2+} is known to promote elongation, leaf expansion, and hook opening in excised plant parts in response to applied auxins or cytokinins.** Since ethylene is known to inhibit these growth phenomena, it is suggested that Co^{2+} exerts its promotive effect, at least in part, by inhibiting ethylene formation.
  - » *Plant Physiology* 58:114-117 (1976)

Sulfur

- Essential for oil formation
- Many amino acids and enzymes – cysteine/methionine
  - Photosynthesis
  - Nitrogen fixation
  - Active site of many enzymes
  - Cell membrane sulpholipids recognition
  - Thiamin, biotin and coenzyme A
  - Strong fruiting energy
- Symptoms:
  - Small/slender growth, delayed maturity, chlorosis, anthocyanin pigments form, **nitrate accumulation in petiole test (attract more insects)**
- Sources:
  - Ammonium Sulfate
  - Mineral Sulfates – Ca, K, Fe, Mn, Cu, Zn, …
  - Many amino acids
  - Elemental sulfur – avoid as nutrient sulfur, need SO4
    - » Insecticidal, fungicidal, **exhausts calcium**

Sulfur and Disease/Pests

- Sulfur is a 'plastic' element closely associated with protein synthesis
- Plants that are rich in nitrogen and poor in sulfur contain large quantities of free amino nitrogen, nitrates, and carbohydrates
- The leaves are able to absorb this elementary sulfur, because it is later found in the plant's proteins (Turrel and Weber, 1950) p. 183

Sulfur metabolism: Phos and Energy

- $SO_4^{=}$ is converted to phosphate-$SO_4^{=}$-anhydride bond in the compound APS catalysed by ATP sulfurylase and is the sole entry point for metabolism of $SO_4^{=}$
- $SO_4^{=}$ + MgATP ←-→ MgPPi + APS
- And eventually to cysteine and eventually methionine

Organic sulfur v. inorganics

- ***S*-Methylmethionine Plays a Major Role in Phloem Sulfur Transport and Is Synthesized by a Novel Type of Methyltransferase**
    - » Plant Cell, Vol. 11, 1485-1498, August 1999, Copyright © 1999, American Society of Plant Physiologists
  - Cobalt is the likely activator metal in the enzyme

Magnesium

- Chlorophyll molecule
- Coenzyme, nitrogen regulator
- Activates dehydrogenases and phosphate transfer enzymes. These enzymes are a vital part of an organism's metabolism so a deficiency can cause an energy deficiency if not totally efficient. (Street & Öpik, 1984).
- Magnesium, with calcium, is part of pectates that act as glue binding cellulose microfibrils together. (Fogg, 1963) This holds cell walls internally and also attaches adjacent cells to each other.
- Kinases need magnesium for activity. These transfer phosphoryl groups from ATP to an acceptor. One of the important kinases that do this is hexokinase which transfers a phosphoryl group from ATP to a variety of hexose sugars at the beginning of glycolysis. (Stryer, 1981)
- Sources:
  - Sul-Po-Mag, Epsom Salts, Chelates
  - Dolomite
  - BioFermentation Mg preferred

Silicon

- As a grass maize requires silicon for part of its structure, to provide it with rigidity. Silicon deficiency in grasses often leads to wilting, necrosis, and withering of leaves. (Street &Öpik, 1984) These symptoms were seen in the plants and assumed to be symptoms of a disease as it seemed to spread. None of the nutrient solutions or the growth medium contained silicon.
- Sources:
  - Potassium silicate
  - Horsetail grass extract

Conventional growing research creates experimental artifacts

- **The Anomaly of Silicon in Plant Biology by E Epstein**
- **Silicon** is the second most abundant element **in** soils, the mineral substrate for most **of** the world's **plant** life. The soil water, or the "soil solution," contains **silicon**, mainly as silicic acid, H_4SiO_4, at 0.1-0.6 mM-concentrations on the order **of** those **of** potassium, calcium, and other major **plant** nutrients, and well **in** excess **of** those **of** phosphate. **Silicon** is readily absorbed so that terrestrial **plants** contain it **in** appreciable concentrations, ranging from a fraction **of** 1% **of** the dry matter to several percent, and **in** some **plants** to 10% or even higher. **In** spite **of** this prominence **of silicon** as a mineral constituent **of plants**, it is not counted among the elements defined as "essential," or nutrients, for any terrestrial higher **plants** except members **of** the Equisitaceae. For that reason it is not included **in** the formulation **of** any **of** the commonly used nutrient solutions. The **plant** physiologist's solution-cultured **plants** are thus anomalous, containing only what **silicon** is derived as a contaminant **of** their environment. **Ample evidence is presented that silicon, when readily available to plants, plays a large role in their growth, mineral nutrition, mechanical strength, and resistance to fungal diseases, herbivory, and adverse chemical conditions of the medium. Plants grown in conventional nutrient solutions are thus to an extent experimental artifacts. Omission of silicon from solution cultures may lead to distorted results in experiments on inorganic plant nutrition, growth and development, and responses to environmental stress.**
  - Proceedings of the National Academy of Sciences, Vol 91, 11-17, Copyright © 1994 by National Academy of Sciences

Silicon cont.

- Deficiency symptoms:
  - Lodging in grains
  - Powdery mildew and/or grey leaf spot in cucurbits, grasses and small grains
- Grasses and monocots accumulate as much as 10% Si; dicots perhaps as low as 0.01% Si.
- Weathered soils such as Ultisols, Oxisols are often depleted of silicon. Histosols are naturally low in silicon.
  - Heckman, Joseph. Silicon in soil fertility and crop production. Crops & Soils magazine. Sept-Oct 2012. American Society of Agronomy

Si Sources

- Calcium silicate products (Wollastonite – mined)
- Steel mill slags (calcium magnesium silicate 30% Ca, 7% Mg, 12% Si)
- Potassium or sodium silicate solubles

Si-B-Ca

Chlorine

- Photosynthesis
- Water balance with K in the cell
- Disease resistance
- Sources:
  - Not to worry, you get enough from the air…

Chlorine Effects

- Chlorine has a tendency to reduce the synthesis of amino acids, especially proteins, and to promote the decomposition of proteins. These are properties which, at the same time , sensitize the plants to their various parasites, including viral diseases.

Chaboussou, P. 129

Sodium

- Electrolyte balance
- Sources:
  - Generally not needed to be added.
    - NaCl

Other mineral nutrients…

- Even though there is not a definitive understanding of many other nutrients in the functioning and health of plants, one must keep in mind the ultimate purpose of the harvested plant. **That purpose is food for humans and animals** even if just oil. Se, Co, Cr, Vn, I and many other nutrients must be present in the foods to have healthy consumers. Get them in the farming program and test to foods to verify their presence.

Outcome of nutrition is the key

- It is clear that the contamination of the soil, water, and seeds with **blast spores has no influence on the health of the plant when the plant's nutrition is well-balanced**. Even in susceptible varieties, the disease does not persist.
- Herbicides make rice susceptible to its parasites, and this is true of cereal plants in general. They do this by inhibiting protein synthesis… Just the opposite happens with a well-balanced fertilization. 'Well-balanced fertilization', is a common-place, it is never properly defined. We define it as **obtaining a maximum degree of protein synthesis**, especially during the more sensitive periods of the plant's physiological cycle, such as flowering. Chaboussou, p. 170

Presence v. Outcome

- The presence in the soil of one or another micronutrient is not sufficient: the plant must also be able to absorb this element.
  - Oxygen, water, food, comfort

Foundational Amino Acid: Methionine (methylation)

- **The specific features of methionine biosynthesis and metabolism in plants**
- **(*methionine / S-adenosyl methionine / plant development*)**
- **Stéphane Ravanel, Bertrand Gakière, Dominique Job, and Roland Douce** Laboratoire mixte Centre National de la Recherche Scientifique/Rhône-Poulenc (UMR041), Rhône-Poulenc Agrochimie, 14-20 rue Pierre Baizet, 69263, Lyon cedex 9, France
- Contributed by Roland Douce, April 13, 1998
- **Plants**, unlike other higher eukaryotes, possess all the necessary enzymatic equipment for *de novo* synthesis of methionine, an amino acid that supports additional roles than simply serving as a building block for protein synthesis. This is because **methionine is the immediate precursor of *S*-adenosylmethionine (AdoMet), which plays numerous roles of being the major methyl-group donor in transmethylation reactions and an intermediate in the biosynthesis of polyamines and of the phytohormone ethylene**. **In** addition, AdoMet has regulatory function **in plants** behaving as an allosteric activator of threonine synthase. Among the AdoMet-dependent reactions occurring **in plants**, methylation of cytosine residues **in** DNA has raised recent interest because impediment of this function alters **plant** morphology and induces homeotic alterations **in** flower organs. Also, AdoMet metabolism seems somehow implicated **in plant growth** via an as yet fully understood link with **plant-growth** hormones such as cytokinins and auxin and **in plant** pathogen interactions. Because of this central role **in** cellular metabolism, a precise knowledge of the biosynthetic pathways that are responsible for homeostatic regulation of methionine and AdoMet **in plants** has practical implications, particularly **in** herbicide design.
  - Vol. 95, Issue 13, 7805-7812, June 23, 1998

Vitamin	Sources	Role in Green Plant	Deficiency Symptoms in Man
Converted carotene* = A	Yellow vegetables, eggs, butter, liver oils	Pigment involved in phototropisms: possibly accessory pigment in photosynthesis	Night blindness
Thiamine = B_1	Yeast, whole grains, meat	Part of enzymes involved in respiration	Beriberi, a disease of the nerves
Riboflavin = B_2	Same as Thiamine	Part of enzymes involved in respiration	Skin ailments
Pyridoxine = B_6	Same as Thiamine	Part of enzymes involved in synthesis of amino acids	Fluid Retention, Elevated Homocysteine Neurological Problems
Niacin = Nicotinic acid	Same as Thiamine	Part of enzymes involved in respiration and photosynthesis	Pellagra
Ascorbic Acid = C	Fresh fruits (especially citrus) and vegetables	Participates in oxidation-reduction systems	Scurvy
Calciferol = D	Liver oils, eggs, almost all plants	None known	Rickets, defective growth of bones

Enhancement of symbiotic nitrogen fixation by vitamin-secreting fluorescent Pseudomonas

- Fluorescent *Pseudomonas* sp. strain 267 promotes growth of nodulated clover plants under gnotobiotic conditions. In the growth conditions (60 *M* FeCl3), the production of siderophores of the pseudobactin-pyoverdin group was repressed. **Plant growth enhancement results from secretion of B vitamins** by *Pseudomonas* sp. strain 267. This was proven by stimulation of clover growth by naturally auxotrophic strains of *Rhizobium leguminosarum* bv. *trifolii* and marker strains *E. coli* thi- and *R. meliloti* pan- in the presence of the supernatant of *Pseudomonas* sp. strain 267. **The addition of vitamins to the plant medium increased symbiotic nitrogen fixation by the clover plants.**
- Mieczys awa Dery o1 and Anna Skorupska. Plant and Soil, Vol.154, No. 2, July 1993.p. 211-217.

The effect of *Botrytis cinerea* infection on the antioxidant profile of mitochondria from tomato leaves

Importance of vit. C ...

- **Infection of tomato leaves with the necrotrophic fungus *Botrytis cinerea* resulted in substantial changes in enzymatic and non-enzymatic components of the ascorbate–glutathione cycle** as well as in superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), glutathione transferase (GST), and L-galactono--lactone dehydrogenase (GLDH) activities. In the initial phase of the 5 d experiment CuZn SOD was the most rapidly induced isoform (up to 209% of control), whereas later on its activity increase was not concomitant with the constant total SOD enhancement. **Starting from the second day *B. cinerea* infection diminished the mitochondrial antioxidant capacity** by decreasing activities of ascorbate peroxidase (APX), monodehydroascorbate reductase (MDHAR), dehydroascorbate reductase (DHAR) **as well as declining ascorbate and glutathione contents**. This was accompanied by dehydroascorbate (DHA) and oxidized glutathione (GSSG) accumulation that resulted in ascorbate and glutathione redox ratios decreases. The strongest redox ratio decline of 29% for ascorbate and of 34% for glutathione was found on the 3rd and 2nd days, respectively. Glutathione reductase (GR) induction (185% of control 2 d after inoculation) was insufficient to overcome the decreased antioxidant potential of glutathione. Changes in the ascorbate pool size were closely related to the activity of L-galactono--lactone dehydrogenase (GLDH). The activities of two glutathione-dependent enzymes: GSH-Px and GST were increased from day 1 to day 4. These results demonstrated that in *B. cinerea*–tomato interaction mitochondria could be one of the main targets for infection-induced oxidative stress.
    - Journal of Experimental Botany, Vol. 55, No. 397, pp. 605-612, March 1, 2004

Uptake of a microbially-produced vitamin (B12) by soybean roots

- Vitamin B12 (Cyanocobalamin) is one of the vitamins believed to be produced exclusively by microorganisms. Although soil is a rich source of vitamin B12, systematic study as to possible uptake of this vitamin by the plant roots is lacking. This study was undertaken to investigate, under water culture conditions, the uptake of [57Co]-cyanocobalamin by soybean (*Glycine max* (L.) Merr.). In the range of 10 to 3200 mol L−1, uptake of vitamin B12 was a linear function of the vitamin concentration in the nutrient solution. Depending on the vitamin concentration, **12 to 34% of the total absorbed vitamin was transported to the plant shoots, with proportionally more vitamin B12 transported at higher vitamin concentrations**. Aeration of the rooting medium with nitrogen gas significantly increased the total uptake and the percentage of vitamin transported to the shoots. Addition of respiration inhibitor dinitrophenol to the nutrient solution did not affect the total uptake or the partitioning of the vitamin. Root temperature (5–30°C) did not affect the total uptake but significantly altered the partitioning of the vitamin between the roots and the shoots. Foliar-applied vitamin B12 was not translocated to any considerable degree to other plant parts, indicating that phloem transport does not contribute to the distribution of this vitamin within the plant. It is suggested that adding manure (which is rich in this vitamin) to the soil could increase soil and thus plant content of vitamin B12. This could be of importance in raising the intake of this vitamin by people living by choice or necessity on vegetarian diets who are usually threatened by vitamin B12 deficiency.
    - http://www.springerlink.com/content/k6h3l6r51xw601j5/ Institute of Plant Sciences, Division of Agronomy, Swiss Federal Institute of Technology (ETH), ETH Zentrum, CH-8092 Zurich, Switzerland

B12 and Folic Acid

- **CHLOROPLASTS ARE AUTONOMOUS FOR *DE NOVO* METHIONINE SYNTHESIS AND CAN IMPORT *S*-ADENOSYLMETHIONINE FROM THE CYTOSOL***
- **Stéphane Ravanel , Maryse A. Block, Pascal Rippert , Samuel Jabrin, Gilles Curien, Fabrice Rébeillé, and Roland Douce**
- The subcellular distribution of Met and *S*-adenosylmethionine (AdoMet) metabolism in plant cells discloses a complex partition between the cytosol and the organelles. In the present work we show that *Arabidopsis* contains three functional isoforms of **vitamin B12-independent methionine synthase (MS), the enzyme that catalyzes the methylation of homocysteine to Met with 5-methyltetrahydrofolate as methyl group donor**. One MS isoform is present in chloroplasts and is most likely required to methylate homocysteine that is synthesized *de novo* in this compartment. Thus, chloroplasts are autonomous and are the unique site for *de novo* Met synthesis in plant cells. The additional MS isoforms are present in the cytosol and are most probably involved in the regeneration of Met from homocysteine produced in the course of the activated methyl cycle. Although Met synthesis can occur in chloroplasts, there is no evidence that AdoMet is synthesized anywhere but the cytosol. In accordance with this proposal, we show that AdoMet is transported into chloroplasts by a carrier-mediated facilitated diffusion process. This carrier is able to catalyze the uniport uptake of AdoMet into chloroplasts as well as the exchange between cytosolic AdoMet and chloroplastic AdoMet or *S*-adenosylhomocysteine. The obvious function for the carrier is to sustain methylation reactions and other AdoMet-dependent functions in chloroplasts and probably to remove *S*-adenosylhomocysteine generated in the stroma by methyltransferase activities. Therefore, the chloroplastic AdoMet carrier serves as a link between cytosolic and chloroplastic one-carbon metabolism.
    - J. Biol. Chem., Vol. 279, Issue 21, 22548-22557, May 21, 2004

Sources of Vitamins

- Organic Products –
  - Fish, seaweed, plant extracts
  - BioFermentation products
  - Manufactured vitamins
    - Use food grade, human or veterinary sources
      - Hoffman-LaRouche for example

Interesting Tidbits about Nutrition

- Caffeine lowers total nitrogen levels, particularly the soluble fraction and the DNA, while the protein fraction and the RNA increase in line with increases in the caffeine dose.
  - Net result is reduced aphid pressure
    - Chaboussou, p. 121, 122
- Misra and Sigh (1975) point out that there is no asparagine in healthy tissues (chrysanthemum), but that, sixty days after infection (virus), it is found in leaves of infected plants. p. 104

Most importantly…

- Water
- Oxygen

Plant Sap Testing

- Plant sap testing, perfected by HortiNova in The Netherlands, far exceeds the benefit of tissue testing.
- Sap testing tracks better with nutrient availability and functionality
- Sap testing tracks with insect and disease
- Done with old and new leaves every two weeks in high value crops
  - Express mail fresh samples to Holland

Calcium and Sap Testing

- Advancing Eco Agriculture (John Kempf) of Ohio has done the most to advance and verify plant sap testing in the US. (get their newsletter)
- Bitter Pit in apples is a common calcium problem, however, adding more calcium frequently does not solve the problem

Calcium Dynamics

- Sap testing revealed that potassium excess is the real culprit and the addition of chelated reduced manganese allows for the regulation of potassium and, subsequently, the uptake of calcium
- Certain varieties are more susceptible (Honeycrisp, Braeburn) (as are chili and bell peppers) and accumulate excessive potassium, thus blocking calcium. Manganese in 90% of these cases is the initial antidote.

Sap Analysis Interpretation

- Look at the sap analysis report
- Note there are two lines for each element
  - The top is referencing young leaves tested
  - The bottom is referencing old leaves tested
- Old leaves will act as reserves in time of need until exhausted
- Young leaves are rapidly growing and demand a lot of nutrition
- Testing both old and young paints a better picture of health/nutrient status

Sap Analysis Interpretation 2

- Our long standing belief is that nutrient deficiency is the greatest limiting factor in crop production. Perhaps of greater importance is nutrient excess and imbalance.
- The nutrient ranges have been determined by AEA according to actual field crop performance and brix levels. It does not correlate to tissue analysis ranges.

Sap Analysis 3

- Identify excess nutrient levels in the new leaves as they are the most rapid growing.
- On the worksheet, find the excess nutrient in the far left column and its antidote. Then determine if that antidote nutrient is deficient on the analysis report. If so check the yellow box – not the white box – for Mn on far left.
  - Example: K is excess, Mn is antidote and also deficient so check yellow box corresponding to Mn in far left column next to Phos as antidote.

Sap Analysis 4

- Titbits:
  - Proceed one nutrient at a time as budget permits.
  - Trace elements are key for foliars
  - If magnesium in old leaves is high and low in young leaves, most likely this reflects poor water movement because Mg is very mobile
  - Most commercial crops only photosynthesize about 10-15% of their genetic potential

Fertility Programs: Principles same; Logistics different

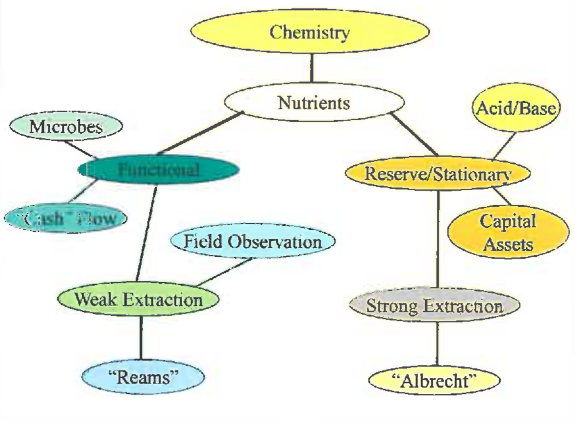
- Broad Acre - soil test and H & P
  - calcium, phosphate, potassium, sulfur, CHO, nitrogen, traces, fish, kelp, humic, bio-culture
  - Seed, soil, foliar, tissue test as needed
- Vegetable Crops - soil test and H & P
  - As above
  - Seed, soil, foliar, fertigation
- Tree/Vine Crops - soil test and H & P
  - As above

What have we learned so far?

- Current farming system is failing, ecologically, nutritionally, socially, financially
  - Chemical farming seeks solely to mask symptoms
- Human health depends upon/reflects agriculture
- To find solutions we must think differently
  - Think holistically, cause and effect
- Biological farming is a holistic model
  - It seeks solutions, not mere suppression of symptoms
- Biological farming is well founded on science
  - The literature abounds with indictment of chemical agriculture and support of biological agriculture
  - Nutrition underlies everything!

Soil Testing

- Soil Testing
  - C.E.C. v. Reams
  - Minimum values
  - Simple Calculations
  - **No numbers perfect unless all perfect**
- Needs for program building



Organic Program by neglect

- Plant the "organic" seed
- Weed daily or so it seems
- Dust and spray frequently with copper, sulfur and pyrethroids
- Complain that the organic premium is to low and WalMart is ruining organics
- Harvest half a crop and barely/not pay the bills
- Blame the consumer for not beating a path to you
- Blame the consumer for desiring asthetically pleasing, sweet tasting, worm free, mold free fruits that keep in the frig more than 12 hours.
- Drive a Trabant with a Mercedes hood ornament

Organic for Nutrient Density

- Get calcium in line
- Base minerals
- Organic materials and inoculants
- BYO Seamless Growing Program
  - Minimal brix
  - Nutrient density
  - ORAC: **Oxygen Radical Absorbance Capacity**
    The assay measures the oxidative degradation of fluorescein after being mixed with peroxyl radical. The reaction alone is compared to the reaction in the presence of a standard antioxidant (trolox, a vitamin E analogue) and the antioxidant sample being tested. The fluorescent intensity of the fluorescein decreases as it gets oxidized, and measurements of this intensity are taken every minute for 35 minutes after the addition of the oxidant. The oxidative decay of fluorescein is less rapid in the presence of antioxidants.

Bio-Dynamic Approach

- This method uses materials from biological/sustainable and organic systems.
- BD Preparations: Special preparations that when properly made by the Rudolph Steiner method will dramatically change the soil's life, structure, and nutrient levels when used in amounts as small as one gram/acre. There are nine preparations with some being soil applied and some foliar applied.
- 500 - Cow horn with manure buried in the fall uncovered the spring, soil applied. Calcium - Earth Force.
- 501 - Cow horn with quartz buried in the summer uncovered in the winter. Silica - Cosmic Force.
- 502 - Yarrow with manure. Potassium and Selenium - Light.
- 503 - Chamomile. Calcium regulated breakdown of proteins; prevents protein to NH_4.
- 504 - Stinging Nettle. Iron, Magnesium, Sulphur and other minerals.
- 505 - White Oak Bark - Calcium.
- 506 - Dandelion - Silica.
- 507 - Valerian - Warmth-Phosphorous-Light
- 508 - Horsetail - Silica.
- Bio-Dynamics on top of good nutrition achieves the goals of high brix, high nutrient density, high ORAC

Fertilizer Mixing

- Mixing fertilizers, either liquids or drys, can in some cases make the difference between success or failure in the field. In other cases it spells the difference between successful application or having a mess in the fertilizer tank or truck and hours of labor to clean it out.

- Mixing Liquids:
- There are two reasons for ordering liquid materials in a specified sequence. A. for protection of biological or sensitive materials and B. to create a structured energetic micel in the solution. "A" is the most common encounter because "B" requires the formulation of unique biological materials with no "purified" inorganics involved.

Fertilizer Mix Order

- The mix order guidelines for "A" are as follows:
  - 1. Water, Nitrogen, Phosphate, chemical N-P-K's, chemical Micronutrients
  - 2. Carbohydrates, Seaweed, Fish
  - 3. Biologicals, Vitamins, Delicate Materials

Fertilizer Mixing Reasoning

- This sequence will ensure that the potentially harsh chemical fertilizers are maximally diluted by the time the organics are added, and finally the delicate materials. It is also recommended that dry materials like sugar be pre-mixed in water to prevent their plugging the mix tank. One way to maximize the energy value of the tank mix is to leave a portion of the water until last and then add the remaining water with a conductivity meter probe in the solution stopping the addition of water as soon as the conductivity meter reading peaks. Some farmers have noticed that spinning the solution in a particular direction seems to alter the field response of the mix.

Fertilizer Mixing Reasoning

- The mix order for situation "B" must be determined by trial and error, dowsing or radionics.
- When mixing materials recognize that calcium and phosphate or caustics simply do not mix very well. You will have a solid material in the bottom of your tank if you attempt to mix these things. Example: liquid calcium and 10-34-0. It is quite an experience to behold. There is one product on the market manufactured by International Ag Labs, Fairmont Minnesota, called "Amaze" that is a true solution of calcium and phosphate. This is an excellent material for fruit trees, alfalfa, vegetables, grains, etc to fill fruit, increase crop density and shelf life.
- Mixing dry materials is a little less delicate than liquid materials but there are still some problems that can occur if the mix is left unspread in the truck for any length of time. Again, calcium and phosphate are tricky so if you mix them, spread the mix A.S.A.P.

Fertilizer Movement in the Soil

- Carbon wants to move up as CO2
- Nitrogen wants to move all around
  - Soluble salts and gaseous N2
- Phosphorous will stay put only if it is in a non-soluble form. Otherwise it will leach or volatize into the air as a phosphine gas
- Calcium wants to move down
- Always combine Ca, P, N with carbon

Basic Program Principles

- 1. **Get off the undesirable fertilizers**:
  - Muriate of Potash (KCl) - no compromise - use potassium sulfate (K_2SO_4), liquid or dry soluble blends, potassium nitrate (KNO_3), organic and compost. Get calcium into the program in order to release "fixed" potassium but be gentle with this. You can flush too much at once and have a disaster. No chloride fertilizers, period.
  - Anhydrous Ammonia (NH_3) - can tolerate a partial compromise, which is to carry saddle tanks filled with at least water and a carbohydrate T'ed into the ammonia line just above the knife. You can also add other materials to this solution like 10-34-0 or liquid fish. The more water you add the better the result.
  - Stop doing what is causing the problems!

Programming Principles cont.

- 2. **Soil test** (Reams Test) at least once during the growing season and preferably every week with high value crops. This will give you the trends of nutrient availability to the crop as well as the stability of the microbial system. Take soil and air temperatures at the same time.
- 3. **Cut nitrogen** by 10 - 40% simply by adding a carbohydrate with it, reducing the dolomite/magnesium and split applying the nitrogen mix.
- 4. Apply **dolomite in fertilizer quantities** only for supplying needed magnesium, not as a primary liming material.

Programming continues…

- 5. Get **calcium** into the system either by liquid calcium (NO CHLORIDE) at 1 - 4 gal/ac – 10 to 40 l/ha or by finely ground or pelleted high calcium lime at 25 - 500 lbs/ac – kg/ha. You could apply both the liquid and the dry calcium materials. Get the material out early in the season and combine it with a carbohydrate or organic (humate, compost). If gypsum is needed put 50 - 500 pounds or kilograms of this in addition.
- 6. Apply your phosphate and potash fertilizer starters or sidedress materials **with a carbon** - sugar, molasses, humic acid, humate, fish, seaweed, compost. Remember, liquid phosphates must be accompanied by a sugar for most efficient utilization.
- 7. **Foliar spray** where appropriate according to the refractometer test. Forget the guessing, select according to refractometer increases.

Programming continued…

8. **Scout for insects and diseases** and spray only when the technician suggests. Use predators where available. If it is too much bother to be so attentive then find another profession. As soon as one farmer says he cannot do such and such, several other farmers do it and more.

- 9. Apply **biological inoculants** with seeding/transplanting, fertilization and ideally foliars. If available, apply fresh compost teas with verified lab analyses.
- 10. Keep good **records** and always leave a test strip that gets actual checking.

Field Data Log

- Name______________________ Date___________ Time__________ Field________ Survey Person_______________
- Crop_________Tillage type: Previous crop
- Variety_______ Size______ Irr/Dryland_ Bird life: Erosion:______ Odors:____
- Fertilizer Used & Quantity:
- Calcium lime_____ Gypsum_____
- Pre-plant N-P-K________ Side-dress Fertigation Residue Mgmt______
- Zn___ Cu___ Fe___ Mn___ Other______
- Inoculant________ Bio Mix______
- Humic/Fulvic________ Sugar/Molasses______
- Other______
- Nitrogen________
- Herbicide_______ Fungicide_______ Insecticide__
- Plant Observations:
- Current Growth Stage:
- Germination: slow/fast/normal uneven/uniform
- Stem shape: round/oval Filling/stem: solid/hollow
- Plant population_____ Color: yellow/lt green/green/blue green
- Brix:leaf: stem fruit Cloud/some cloud/rain/sun
- Sap pH: Sap EC:
- Ave Root Depth: Root mass: poor/average/extensive
- 2ndary root growth: poor/average/extensive
- Soil attachment to roots: easily removed/average/difficult
- Root diversion: none/evident depth:
- Pest & disease incidence: none/low/high
- Vitality: low/medium/high
- Weed pressure: low/medium/high
- Photo's: yes/no Direction: across row/down row
- Soil Monitoring:
- Soil pH in root zone Soil EC Respiration CO2
- Penetrometer Soil Temp Chlorophyll
- Soil moisture: dry/moist/wet
- Infiltration rate
- Soil color red/yellow/grey Soil texture:
- Earthworms: none/few/many Dung beetles: none/few/many
- Other information: Yield & quality

It Starts With The Seed!

- Always keep in mind for what you are fertilizing.
  - The seed must be considered and nurtured
    - Seed treatment
      - Nutrition
      - Microbes

Start with the seed!

- Any time the opportunity presents, inoculate the seed with the appropriate biology and nutrition
  - Mycorrhizae for most commercial crops
  - Compost tea, packaged product
  - Kelp, minerals, extracts, humic/fulvic acid

Fertilizer Programs

- Dry Mineral Plan to start:
- 500 lbs.-kg carbon pell-lime per Ac-Ha
- 4-500 lbs.-kg carbon pell-phos
- 200 lbs-kg potassium sulfate
- 200 lbs-kg sul-po-mag
- 2-20 ton compost (lab or sprout tested)
- Fish, Kelp, Rock Dust, Gypsum

Fert Plan Cont.

- Are you desiring fruit/seed or foliage?
  - Ca, K, Cl, NO_3 are growth "energies"
  - All others, P, Mg, Fe, Zn, Cu, NH_4... are fruiting "energies"
- Annuals need growth early, fruit later
- Perennials need growth/fruiting early, grow fruit later

Fert Plan Cont.

- Always add carbohydrate to N, P, Ca
- Poor water management kills program
- Apply nutrients in divided doses
- Add water
- Follow common sense agronomics
- Soil test: Albrecht and Reams
- Nutrient test the harvest and adjust fertility/fertilization accordingly

Fert Plan goes awry

- Every consultant/product company has had its share of failures
  - Environmental conditions
  - Farm management deficiencies
    - Left product in the barn
    - Tillage and execution problems
  - Product quality control
  - Ignored common sense – blinded by own product

Fertility Program Gone Awry

- Australian Wheat Program
  - Conventional

MAP	65kg/HA including S, Cu, Zn, Mo, Mn	$33
NH_4SO_4	140kg/HA	30
KCl	40kg/HA	16
	Total Cost: $79/HA	
Yield	2.8 - 3.5 ton/HA	

  - Biological

Lime	350kg	$ 4
RPR	100kg	30
MAP	25kg	13
NH_4SO_4	150kg	32
BioMixSS	3ltr	18
BioMixBG	1.5ltr Foliar	9
BioMixBG	1.5ltr Foliar	9
BioMixFB	1.5ltr Foliar	9
	Total Cost: $124	
Yield:	1.3 – 1.7 ton/HA	

- Key to failure: energy (salts), potassium and available phosphorus in sandy soils.

240 Bu./Ac. Corn Program

- Michael McNeill: Corn on Soybean program
  - Banded under the row in fall
    - 120# "Encapsulated Urea
    - 75# MAP 11-52-0
    - 75# K2SO4 potassium sulfate
    - 50# AMS ammonium sulfate
    - 10# 36% zinc sulfate
  - Apply side-dress nitrogen as needed: approx. 20 gal/Ac 32%
  - 142# nitrogen plus soybean credit = 180#/Ac.
  - Recommend in-furrow starter (4-15-13 @ 3 gal/Ac) w/micronutrients
  - Recommend foliar 1-2# CaNO3 plus Mg, Mn, B

FHR KU Mud Creek Farm 220-240 Bu/Ac.

- U-Trough Spring with planter
  - 20 gal 32% N
  - 5 gal CaNO3
  - 5 gal Pursonova water
  - 150# 17-9-7 on opposite side
  - Furrow: 26 oz Micro-Pack
  - 5 gal 8-16-3 (phosphyte)
  - 5 gal Pursanova water
  - 7 oz. SafeStrike

Mud Creek continued

- Foliars
  - 1^{st}:
    - 1 gal 8-19-3
    - 8 oz Defender G4
    - 4 gal Pursonova water
  - 2^{nd} @ 3 ft:
    - 2 gal 21-1-0
    - 4-8 oz Defender G4
    - 20 gal water
  - 3^{rd}:
    - 2 oz Procidic
    - 3 gal 21-1-0
    - 2 qt. CaNo3
    - 2 oz WakeUp
    - 18.5 gal water

Mud Creek continued

- 4^{th} Foliar: Brown Silk – Airplane 4 gal/Ac total
  - 2 gal 21-1-0
  - 2 qt. CaNO3
  - 2 oz. WakeUp
  - 2 oz. Procidic
  - 2 qt. Seed Set
- 5^{th} and 6^{th} foliars same w/o Seed Set

Mud Creek continued

- Fall:
  - Strip-Till
    - 250# soft rock phosphate
    - 40# MAP
    - 30# SOP
    - 20# K-Mag
    - 10# 0-0-60
  - Broadcast
    - 2 qt. Residue Digester
    - 7 gal. 32%
    - 3 gal. water

Some current concerns regarding glyphosate and glyphosate-resistant crops (reported in various refereed and popular publications)

1. Glyphosate accumulates in plant tissues including root, shoot, reproductive organs
2. Some applied glyphosate exudes from roots into soil
3. Glyphosate can be desorbed from soil by applied phosphorus
4. Glyphosate complexes with nutrients; reduces availability for plant growth
5. Residual glyphosate in soil can damage desirable plants by root uptake
6. Stimulates soilborne pathogens and other soil microorganisms reducing nutrient availability
7. Reduces photosynthesis
8. Reduces nitrogen fixation
9. Increases drought stress
10. Reduces mineral contents of seeds
11. Increases mycotoxins in vegetative and reproductive tissues
12. Generally results in 'yield drag' in glyphosate-resistant varieties compared with isogenic parent plants
13. Glyphosate is non-selective for weed control; also non-selective within plant in immobilizing plant nutrients
14. Transgenic plant DNA (*cp4* EPSPS gene) released by GR plant into soil

Adapted from Huber (2010) and Gulden & Swanton (2007)

Regardless of the merits of current concerns of glyphosate and glyphosate-resistant (GR) crops, this attention has increased awareness of the importance of a total management system including:

- ***Complete plant nutrient program*** for healthy crop growth
- ***Holistic assessment of GR cropping systems***:
  - Consider above-ground growth AND *soil-root complex*
  - Understand plant – root – soil – microorganism environment
  - Understand plant – herbicide – soil – microorganism interactions
  - Understand how ***management*** affects the soil-root environment and the complex interactions involved

Chemical properties of glyphosate have implications on plant nutrition and microbial function and interactions (– nutrient cycling and plant-growth promotion by microbes)

Nutrients are essential to physiological and biochemical functions, many of which common to *both* plants and microorganisms

Nutrient elements	Biochemical/Physiological functions
C, O, H, N, S	Major constituents of organic substances (carbohydrates, proteins, lipids, enzymes)
P, Ca, B	Linkage of major polymers in cell walls and membranes (phospholipids, nucleotides; cellulose); energy transfer
K, Mg,	Cellular ion, pH balance; enzyme activation; photosynthetic activity
Mn, Fe, Cu, Zn, Mo, Ni	Activate/mediate numerous important ***enzymatic reactions*** in various metabolic pathways

Note: *Deficiency or immobilization* of an essential nutrient may affect one or more metabolic pathways, yet have consequences on *overall functioning* of plant or microorganism

Adapted from Datnoff et al. 2007. *Mineral nutrition and plant disease*. APS Press.

Some considerations regarding glyphosate interactions with soil/plant nutrients

Immobilized by sorption to soil colloids; chelate with nutrient cations (immobilized and not available for plant uptake or for microbial utilization (Sprankle et al. 1975)

Similar to complex formation with soluble salts in tank mix (Thelen et al. 1995)

Soils receiving phosphorus via fertilizers or organic sources (livestock manures), P may occupy adsorption sites generally considered available for glyphosate sorption, resulting in weak absorption or "free glyphosate" in soil (de Jonge et al. 2001, Simonsen et al. 2008)

P application can cause roots to proliferate near P fertilizer granules, near sites of glyphosate sorption - can glyphosate be released in exchange for P and taken up by roots??

59% of initially applied glyphosate remained in clay soil for 2 yr, confined to upper 12 inches as glyphosate and AMPA residues, resisted biodegradation (Bergström et al. 2010)

Fate of glyphosate within the plant --

Free glyphosate within plant may immobilize cationic nutrients and not translocated to metabolic sites for critical plant growth processes (Cakmak et al. 2009)

– difficult to detect such complexes within plant to differentiate unavailable forms from free or available nutrients on basis of plant tissue analysis (see Bott et al. 2008)

*Some indication that glyphosate absorbed in **crop residues** (GR crops) may increase glyphosate persistence in soil 2 - 6X relative to direct contact with soil (one study - Doublet et al. 2009)*

General summary of soil test results for Missouri soils where glyphosate-resistant soybean trials conducted, 1997-2010

Highly variable soil nutrient content likely contributes to nontarget effects of glyphosate

Nutrient	Soil test values (range in ppm)	Sufficiency range (ppm)
P	3.0 - 150	30 - 100
K	35 - 295	150 - 350
Ca	900 - 2000	400 - 2000
Mg	120 - 340	100 - 300
Fe	35 - 132	5 - 50
Mn	8.5 - 72	8 - 50
B	0 - 2.1	0.5 - 10
Cu	0.15 - 2.8	1.0 - 12
Zn	0.04 - 18	3.0 - 20
Mo	0 - 1.78	0.2 - 0.5
Ni	0 - 0.4	*0.1 - 0.5 (est.)*

KEY GROUP: Rhizosphere Pseudomonads

Important multi-functional bacterial group in rhizosphere community (Schroth et al. Prokaryotes 6:714, 2006)

Many fluorescent pseudomonads associated with antagonism of fungal pathogens (Schroth & Hancock. Science 216:1376, 1982) and Mn transformations (Rengel, 1997)

Characteristics of Some Rhizosphere Bacteria Cultured from Soybean, 2006-2007

Bacterium	Source	Fluor	EPS	Mn	Fusarium Suppression	Protease
Pseudomonas	W82+HW	+	-	Red	+	+
Pseudomonas	W82+HW	+	-	Red	+	-
Pseudomonas	RR+TM	+	+	Red	+	++
Pseudomonas	W82+TM	+	-	Red	++	++
Pseudomonas	RR+RU	+	++	Ox	-	-
Pseudomonas	RR+RU	-	-	Red	±	-
Pseudomonas	RR+HW	+	-	Red	+	-
Chryseobacterium	RR+HW	-	-	Red	++	±
Agrobacterium	RR+RU	-	++	Ox	[illegible]	[illegible]
Agrobacterium	RR+RU	-	+	Ox	-	-
Agrobacterium	RR+RU	-	+	Ox	-	-
Agrobacterium	RR+RU	-	+	Ox	-	-
Agrobacterium	RR+RU	-	++	Red	-	±
Agrobacterium	W82+HW	-	+	Red	+	-

Fluor=Fluorescence;
EPS=Exopolysaccharide

IMPACT OF RESEARCH – "In a word" – MANAGEMENT

Complete nutrient management program; monitor base saturation – % of available Ca is critical.

Monitor micronutrient levels – soil & tissue analyses

Foliar treatments for single nutrient often insufficient if others are deficient

Foliar amendments with biologicals may limit expected yield losses in short term (single season) – influence rhizo activity

Seed treatments with biologicals for control of potential fungal pathogens, restoring plant-growth promoting microbes

Plant-growth regulators, amino acids, available Ca may limit perceived adverse effects of glyphosate, pathogens
(Nafziger et al. [1983] reported reversal of glyphosate effects on plants with supplemental amino acids)

Seek sources of complete fertilizer nutrients for amending soil:

Ex: Poultry litter contains considerable amount of:

P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, B, Mo, Ni (Brady & Weil 2008, Daigh et al. 2010)

Glyphosate and Plant-Microbe Interactions. R.J. Kremer. December 14, 2010

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End Day Two

- Male/Female Fertilization
- Basic Nutrient Functions
- Micronutrients
- Sap Testing – HortiNova
- Beginning Programs

Day 2 Review

- Male fertilizers are calcium, potassium, nitrate nitrogen and sodium
- Female fertilizers are all others especially ammonium nitrogen, sulfur and phosphorous, all major trace metals
- Calcium is our foundation, major base against which we generate energy for growth, second messenger for cell function, key to successful foliar feeding

Day 2 Review Continued

- Sap Testing with HortiNova in Holland
- Basic programs must consider calcium and major minerals, microbial supplementation, organic acids, carbon
- Keep it simple

Haifa Foliar

- The following is from Haifa Plant Nutrients in Israel. They sell dry soluble foliar fertilizers. It seems to be the best instructional presentation on foliar feeding of plants.

Foliar Feeding

- General information
- Basics of foliar nutrition
- Haifa foliar products
- Haifa foliar trials

Foliar Feeding

- **Complementary fertilization** with high added value
- **Corrective nutrition** when deficiencies are noticed
- **Growth boosters** during critical stages of plant development

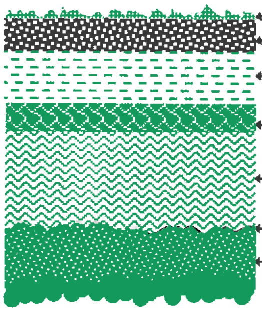
A small amount, at the right time, goes a long way in boosting yield

Basics of foliar nutrition

3 systems composing leaves:

1. **Epidermal cells**
2. **Mesophyl**
3. **Transportation vessels**

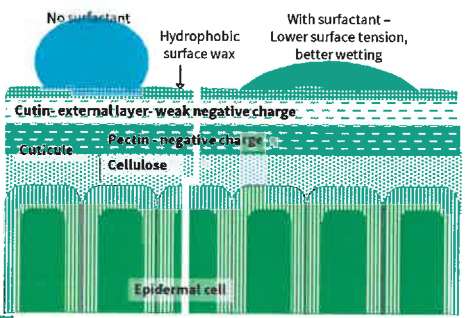
Scheme of the outer wall of a leaf epidermal cell



Steps of nutrient uptake by leaves

1. Penetration through cuticle and epidermal cell wall by passive diffusion, influenced by temperature and gradient of concentration
2. Absorption of ions by the membrane surface of the cytoplasm
3. Active penetration into protoplast, requires energy. Energy is supplied by metabolic respiration or photosynthesis.

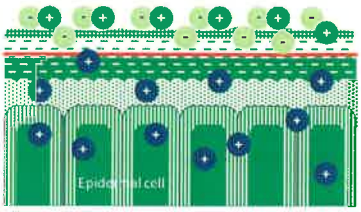
Penetration through cuticle and epidermal cell wall



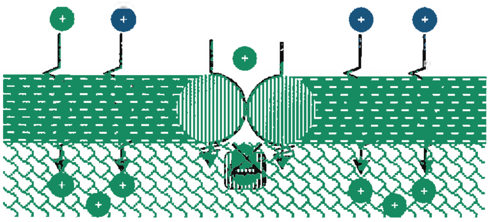
Penetration through cuticle and epidermal cell wall

Cations:
Preferred uptake due to electrical attraction to the negatively charged cell membranes and passive diffusion from high to low concentration.

Anions:
Only small quantity penetrates, because of rejection by negatively charged cell membrane



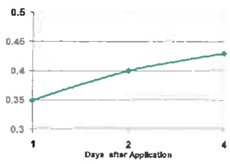
Penetration through cuticle: temperature-dependence



Most solutes do not penetrate through open stomata

Uptake of ions is higher at night, when stomata are closed.

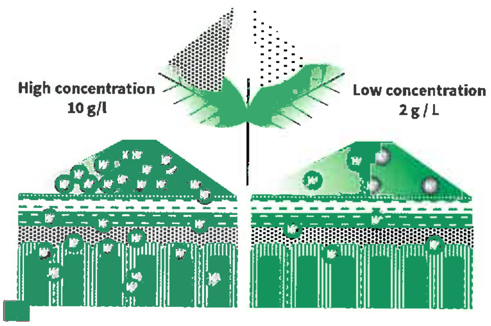
Dynamics of Foliar- Applied N^{15}-Nitrate Absorption in a Tomato Leaf*



* $NaN^{15}O_3$ solution was applied at pH=6.0 to the upper leaf surface

Source: Tan, Ikeda & Oda, 1999.

Passive diffusion:
uptake is proportional to spray concentration

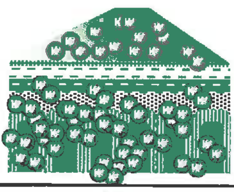


Passive diffusion:
uptake is proportional to spray concentration

Passive diffusion is responsible for most of the penetration.
The rate of diffusion across a membrane is proportional to the concentration gradient.

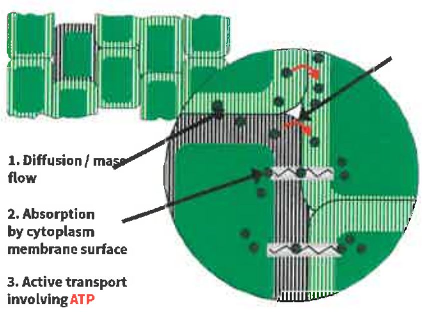
Efficiency of uptake by passive diffusion improves

- As concentration of solute which can be applied to leaf surface without causing damage is higher
- As the time it remains active state on the leaf surface is longer



Ion absorption by the cytoplasm membrane surface

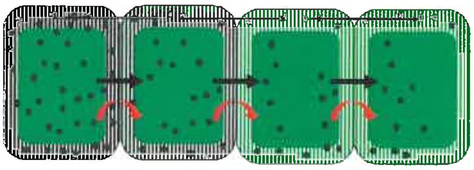
Scheme of cell-to-cell transport of ions



Ion absorption by the cytoplasm membrane surface

Scheme of cell-to-cell transport of ions

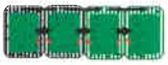
1. Diffusion / mass flow
2. Absorption by cytoplasm membrane surface
3. Active transport involving ATP



Steps in absorption of foliar-applied nutrients

1. Uptake by epidermal cells

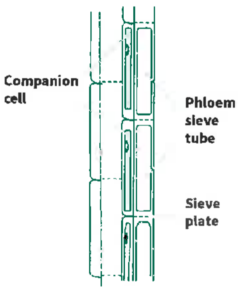
2. Cell-to cell transport in the mesophyl



3. Convection to remote parts of the plant through transportation vessels

Transportation vessels

Phloem

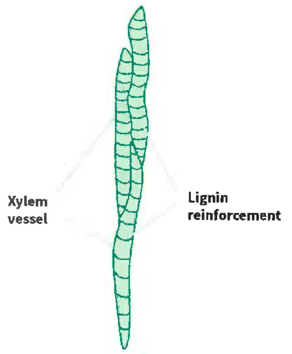


Transportation vessels

Phloem transport is extremely important for distribution from mature leaves to growing regions in the roots and shoots.

Transportation vessels

Xylem



Transportation vessels

Flux through the xylem is regulated by root output and driven by water potential differences between soil, leaf, and atmosphere.

Little importance to the transport of foliar applied plant nutrients from sprayed leaves to growing organs with low transpiration rates
(buds, flowers, fruits).

Transportation vessels: Phloem mobility

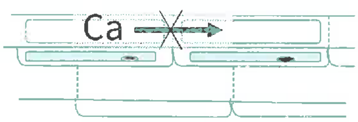
1. Nutrients enter the phloem at the "source".
2. Nutrients move within the phloem.
3. Nutrients move out of the phloem at the "sink".

Transportation vessels: Phloem mobility

Change of nutrients in leaf concentration during maturation. Young leaves (green) vs. mature (old) (%)

	N	P	K	Ca	Mg
Avocado	-48.7	-54.9	-24.9	-1.7	-7.4
Apple	-52.4	-27.4	-36.0	+18.4	NA

Transportation vessels: Phloem mobility



Calcium is not transported through the phloem system

Mobility of plant nutrients in the phloem

Mobile	K	P	S	Cl	Na
Partially mobile	Zn	Cu	Mn	Fe	Mo
Immobile	Ca	Mg			

Source: Bukovac & Wittwer (1957), Kunnan (1980)

Haifa Products for Foliar Feeding

- 100% soluble fertilizer compound
- Easily absorbed by leaf
- No leaf scorching
- Superior adhesion
- Proven safety
- Used in multiple crops in over 50 countries

Foliar Feeding – General Instructions

- Spray during the cooler and more humid parts of the day.
- Never spray plants under stress.
- Test for possible side-effects or phytotoxicity by a small trial spraying, a week prior to the intended commercial treatments.

Kiwifruit Trial

- CEC testing v. Reams Testing
  - By the book
    - Test results still didn't change at year end
  - By the crop
    - Did poorly
    - Needed energy, K, Ca, trace balance

Potato Plans

- **Norkotah 3**
- Seed Cut: Spray 3 oz of **SP-1** and dust 1-2 oz of **BSG** per 100 lbs of seed
- Band: 60-140-25-40S-1.5Zn plus a 7-8 gallon biological blend (we call **P-1**; that includes **SP-1**)
- Sidedress: 30-50-20-10
- Inject: 50 N plus **SP-1** at 1-2 gallons per week

Look at the obvious...

- Avocado plantation
  - CEC 40% Ca, 30% H
  - Reams 5ppm P
- Brix 17 – 19, low pH and EC of sap
  - 15 leaves to get sap
- Foliars only were used, fruit dropping
- Correction: Base minerals in soil: lime, biophos and biological drench
- Within couple weeks new growth, fruit hold
  - Brix 13 from only 5 leaves, pH and EC normal

Products: USA

- International Ag Labs: Amaze, PGR, RL-37, Z-Hume, Crescendo/Arouse, soil/feed testing
- AgriEnergy Resources: SP-1, Bio-Cal, BSG, Residuce, Fulvic Acid, soil/feed/organic materials testing
- Humates, humic/fulvic acids, fish, seaweed/kelp, trace mineral chelates (Albion Labs)
- Table sugar, molasses, dextrose

Products

- Compost Tea: numerous farm suppliers
- Compost Extract: numerous farm suppliers
- Packaged biologicals; numerous
- Arcadian and MaxiCrop: seaweed/kelp
- SeaMineral concentrate
- Compost: many suppliers – do sprout test

Products

- There are no magic bullets
- The best companies do full programs
- Customer service and reliability are key
- Outcome on the farm is the judge
  - Brix
  - Nutrient value
  - ORAC
  - Marketable/economic/sustainable yield

Basic Program

- Physical Assessment
  - Soil test both reserve and functional nutrients
- Calcium with carbon – 12 to 20 kg/ton powder humates – lignite per ton of lime
  - ½ to 2 ton per acre or hectare of $CaCO_3$
    - F/U with liquid cal or AnSulf and carb
  - 50 to 200 lb-kg BioPlex calcium
- Rock Phos and Potassium Sulfate as needed with carbon plus traces
- Inoculants plus humic acid/humates and molasses/sugar, fish

Basic Program cont.

- Be careful not to rely totally on CEC or Albrecht testing to determine nutrient need
  - As the calcium comes into line the magnesium will come up with a few exceptions
- Microbial inoculants are important
- Follow with foliars, side dressings, etc. as appropriate for the crop
- I personally prefer fish on the soil and seaweed on the foliage; humic acid on the soil and fulvic on the foliage
- Track sap brix, it must be coming up over time

Basic Program cont. futher

- If irrigating, keep in mind that as soil carbon comes up, the water applied must be cut back or you will drown the program and go backwards

Programs

- Trees:
  - 3 ton/acre (7 ton/ha) Compost, Spring and Autumn, banded or 8 to 10 ton broadcast
  - 1 ton/ac hi-cal lime (2.5 ton/ha) , 500 lbs-kg soft rock, 400 lbs-kg course humate, 200 lbs-kg potassium sulfate, 200 lbs-kg gypsum
    - Appropriate quantities of micronized minerals if available
  - Soil drench band or irrigation – 2 to 12 per year
    - 5 gal fish (50 lt), ½ to 1 pint kelp (1/2-2 lt), 1 pint fulvic acid (1.5 lt), 1 to 2 quart humic acid (2.5-5 lt), 1 quart to 5 gallons biological (2.5-50 lt), 1 to 2 quarts sea minerals (2.5-5 lt), 5 to 10 lbs ammonium sulfate (5-10 kg), 1 to 2 quarts molasses (2.5-5 lt)
  - Weekly fertigation of 4 to 5 lbs-kg of liquid lime or calcium nitrate or Amaze with 1 pint of fulvic acid (1.25 lt), 1 quart of molasses (2.5 lt) or 2 lbs-kg sugar, 1 to 4 quart fish (2.5-10 lt)
  - Foliar weekly with tea/1 – 10 lbs.-kg. N-P-K/traces – 1 to 4 quart vinegar (2.5-10 lt) early to set fruit; Amaze last 4 weeks of season

Programs continued…

- Can we get by with compost tea/extract only? Sure, you can get by, however, if you want to move faster, and have products of premium brix and nutrient density, then we add both mineral and biology.
  - Many failures after 1 or 2 years when mineralization neglected
  - 80% of organics (poorest product on market) get by…
  - We must produce high brix, high nutrient density food
- Soil test whenever you have a critical time and things are questionable
  - Bloom, tillering, bud break, fruit set, fruit fill, tuber set, tuber fill
  - Vinegar, $MgSO_4$, phos/fish, Mn, NH_4 to set fruit or excess NO_3

Corn

- Fall Tillage
  - Broadcast 400 lb/ac-kg/ha of 4-21-20(4-10-20)
- Starter
  - 2.5 gallons/ac 8-19-3 (25 ltr/ha 8-9-3
  - 2.5 gallons/ac water (25 ltr/ha)
  - 26 ozs/ac Bio-Pac (1.82 kg/ha)
  - 6 ozs/ac Mn Chelate (420 grams/ha)
- Nitrogen Pre-Plant Injection
  - 25 gallons/ac 32%N (250 ltr/ha)
  - 5 gallons/ac 12% Amm.Thio-Sul (50 ltr/ha)
  - 2 lbs/ac carbon (2 kg/ha)
- Sidedress
  - 20 gallons/ac 28% or 32% UAN (200 ltr/ha)
  - 5 gallons/ac 10-34-0 (50 ltr/ha 10-17-0)
  - 5 gallons/ac water (50 ltr/ha)
- Foliar
  - 1st: 1 qt/ac Seed Set 5-11-0 w/15 gal water (2.5 ltr/ha Seed Set 5-5.5-0 w/150 ltr water
  - 2nd: 2 qt/ac (5 ltr/ha)
  - 3rd: 1 qt/ac (2.5 ltr/ha)

Soil Test for previous rec on corn

- **Nit** 25
- Amm 10
- P 56
- **K** 92
- Ca 2711
- Mg 184
- Na 4
- EC 222
- pH 7.2
- Cu 1.1 (.8-2.5
- Fe 62.6 (10 – 25)
- Zn 2.4 (1-6
- **Mn** 9.4 (8-30
- CEC showed
- Ca 4802 (85.9% Sat)
- Mg 423 (12.6% Sat)
- P Bray 1 28 ppm (56 lb/ac-kg/ha)
- K 155 ppm (310 lb/ac-kg/ha)

2008 Corn after Potatoes

- April 24, 2008 pre-plant
- Humus 9
- NO3 2
- NH4 4
- P 59
- Bray1 66
- Olsen 30.5
- K 218
- CEC K 93 at 5.1%
- Ca 307
- CEC Ca 400 at 42.4%
- Mg 359
- CEC Mg 117 at 20.8%
- Na 0
- EC 86
- ORP 27
- pH 6.9
- Cu 0.3 (.8-2.5)
- Fe 19.9 (10-25)
- Zn 3.4 (1-6)
- Mn 5.3 (8-30)

- Humus is reasonable initially for sand. N very low. Need to watch P as low on Morgan but CEC reasonable so availability issue; need microbes. K very high compared to P so nutrient assimilation and transport will be poor. Calcium very low and must be addressed via CaNO3, micro lime and carbon/inoculants in the Autumn. EC is very low, partially expected in cool Spring soils. Copper to be looked at for mid- to late-June applications.

Corn after potatoes program

- PPI (pre-plant)
  - NH4SO4 200 lbs/ac-kg/ha
- Planter Starter: (in furrow)
  - 3 gal/ac 8-19-3 (30 ltr/ha 8-9.5-3)
  - 2.5 gal/ac RO water (25 ltr/ha)
  - 26 oz/ac Bio-Pack (1.82 kg/ha)
- Beside the row:
  - 15 gal/ac 28%N (150 ltr/ha)
  - 1.5 gal/ac old starter (15 ltr)
  - 1 pt/ac ZAP (1.2 ltr)
- 2-3 leaf stage: 24 oz/ac Overture in 20 gal RO water/ac
  - (1.68 kg/ha in 200 ltr/ha RO water)
- Sidedress
  - 20 gal/ac 28% (200 ltr/ha)
  - 5 gal/ac CaNO3 (50 ltr/ha)
  - 8 ox/ac Z-Hume (625 ml/ha)
- Foliar: Prior to tassel
  - 3-4 qt/ac Seed Set 5-11-0 (7.5-10 ltr/ha)
  - 20 gal/ac RO Water (200 ltr/ha)
  - 6-10 oz/ac Fungicide Stratego/Bayer (420-700 ml/ha
- Green Silk
  - 2-3 qt/ac Seed Set 5-11-0 (5-7.5 ltr/ha)
  - 20 gal/ac RO water (200 ltr/ha)
  - 6-10 oz/ac Fungicide Stratego/Bayer (420-700 ml/ha)
- Every chance apply calcium through the sprayer using micro lime 400 mesh w/sugar (ZAP). With chemicals always use 1 pt/ac (1.2 ltr/ha) ZAP Pre-Plant or Post Application
- Additional Recs: add ½ pt/ac (0.6 ltr/ha) copper at early and late June chemical or foliar application; ½ pt/ac (0.6 ltr/ha) Mn w/RL-37 w/each chemical appl.
- Autumn: 1000-1500 lbs/ac-kg/ha ag lime with humates

Tree Fruit
Organic Apples Yr. 1
Initial soil applied mix

- Lime 1500 lb/ac-kg/ha
- Gypsum 300 lb/ac-kg/ha
- Soft Rock Phos 2000 lb/ac-kg/ha
- Compost 500 lb/ac-kg/ha
- Rock dust 500 lb/ac-kg/ha
- Aragonite 500 lb/ac-kg/ha
- Bio-Mix 5 gallon/ac-50 ltr/ha
- Boron 20% 20 lb/ac-kg/ha
- Bio traces 300 lb/ac-kg/ha
- Potassium per soil test as potassium sulfate; also get potassium via irrigation and foliar

Tree Fruit
follow up foliars over season

- Foliar weekly after petal fall to one month before harvest or to week before harvest depending upon spray mix
- Example:
- 100 gallon water (400 ltr)
- 1 lb (.45 kg) iron sulfate liquid (30%)
- 1 lb manganese sulfate liquid (32%)
- 1 qt (ltr) phosphoric acid
- 1 qt household ammonia
- 1 pt (1/5 ltr) Stimulate (bio inoculant)
- 1 pt RL-37
- 20 gallon (80 ltr) mixes with 80 gallon (320 ltr) water and applied at 100 gallons/ac (1000 ltr/ha)

Apples 1st year planting: Example 2

- Dry program was 2000 lb/ac-kg/ha each of SRP and Hi-cal lime – previously was PSU program, no liming and little traces
- Spray Program:
- 200 gallons water
- 4 qt. Vigor Cal (4 ltr) (organic liquid calcium)
- 2 qt. Stimulate (2 ltr) (humic acid)
- 2 lb or 2 gallon $ZnSO_4$ (36%)
- 2 lb or 2 gallon $MNSO_4$ (32%)
- 5 gallons Fish (20 ltr)
- 5 lb. Dextrose (2.3kg)
- 300 cc B12
- 6 lb K_2SO_4 (2.8 kg)
- 1 lb $MgSO_4$ (0.44 kg)
- 2 qt RL-37
- 2 qt. Organic 10 (inoculant plus CHO)
- Apply mix at 20 gpa (200 ltr/ha) with 15 gal fish (150 ltr/ha)

Cherries

- 300 gallons R/O water (1200 ltr)
- Seawater 50 gallons (200 ltr)
- Ammonia 15 gallons (60 ltr)
- MPK 45 lb (20.5 kg)
- MnSO4 15 lb (6.8 kg)
- Dextrose 15 lb (6.8 kg)
- Phos Acid 5 gallon (20 ltr)
- Stimulate 5 gallon
- RL-37 5 gallon
- Vigor Cal 5 gallon
- CaNO3 10 gallon (40 ltr)
- MgSO4 5 lb (2.3 kg)
- B12 300mg
- Crescendo 10 lb (4.6 kg)
- Applied at 40 gallons (400 ltr/ha) per acre into 60 gallons (600 ltr) water for total of 100 gallons per acre (1000 ltr/ha) application spray

- 4.66 ton/ac (11.65 ton/ha) yield 2007; 5.55 ton/ac (13.875 ton/ha) 2008 with brix 18 and 21 respectively

Potato

- 4 gallon Fish (4 ltr)
- 4 lb Dextrose (1.8 kg)
- 1 qt Phos Acid (1 ltr)
- 1 pt. Stimulate (1/2 ltr)
- 2 qt Vigor Cal (2 ltr)
- 50 mg B12
- 10 gallons water (40 ltr)
- Take 4 gallons of this mix added to 26 gallons water for total of 30 gpa (300 ltr/ha) after tuber set

Base Mineral following grain harvest

- Lime 2000 lb/ac-kg/ha
- Soft Rock 2000 lb/ac-kg/ha
- Sul-Po_Mag 200 lb/ac-kg/ha
- Bio-Mix 5 gallons/ac-50 ltr/ha
- Bio-Traces 100 lb/ac-kg/ha
- Sodium salt 50 lb/ac-kg/ha
- Zinc 20 lb/ac-kg/ha
- Boron 50 lb/ac-kg/ha
- MnSO4 10 lb/ac-kg/ha
- Cost in Pennsylvania 2008 is $500/ac

Onions

- MPM 2.5 gallons/ac-25 ltr/ha per week in drip (Omega Grow Fish, bio-mix, compost extract, seaweed & molasses) & Dagger 2 qt/ac (5 ltr/ha) every 3 weeks (cottonseed oil, neem, lecithin, fish and activators)
- Foliar starting 5/23/08
  - Mn 1 lb (.45kg)
  - Fe 1 lb
  - Phos Acid 1 qt. (ltr0
  - Cu 1 lb.
  - Zn 1 lb.
  - Dextrose 2 lb (0.9 kg)
  - Stimulate 1 qt.
  - B12 150 cc
  - K2SO4 2 lb.
  - Vigor Cal 2 qt. (2 ltr)
  - Water 60 gallons (240 ltr)
  - Apply 4 gallon/ac (40 ltr/ha) foliar
  - 1 pt./ac (1.2 ltr/ha) per week via drip irigation
- Starting 6/20/08
  - Vigor Cal 1 qt./ac (2.5 ltr/ha) per week via drip
  - With 0-0-52 at 3 lb./ac-kg/ha

Zucchini and Cucumber

- 300 gallons water (1200 ltr)
- 3 lb MnSO4 (1.4 kg)
- 3 lb ZnSO4 (1.4 kg)
- 6 lb K2SO4 (2.8 kg)
- 6 lb Dextrose (2.8 kg)
- 3 qt. Phos Acid (3 ktr)
- 1.5 lb. MgSO4 (0.7 kg)
- 3 qt. Stimulate (3 ltr)
- 300 mg B12
- 3 qt. apple cider vinegar (3 ltr)
- 4 qt. RL-37 94 ltr)
- Apply at 20 gpa (200 ltr/ha)

Zucchini: not fruiting well

- 100 gallons (400 ltr) for 5 acres (2 ha)
- 1 qt (1 ltr) phos acid
- 1 pt (1/2 ltr) household ammonia
- 1 lb (0.45 kg) CuSO4
- 1 lb MnSO4
- 1 qt (1 ltr) RL-37
- 200 mg B12
- 1 qt (ltr) vinegar
- Under Plastic in Drip line
- 1 qt Z-Hume
- 1 qt RL-3

Sod/Turf

- 200 gallon (800 ltr) mix (R/O water) (approximately 55 gallons water (220 ltr)
- Sea water 120 gallons (480 ltr)
- CaNO3 6 gallons (24 ltr)
- 0-52-34 (0-26-34) 10 lbs. (4 kg)
- Vigor Cal 1 gallon (4 ltr)
- Fe 4 gallon (16 ltr)
- Cu 4 gallon
- Zn 4 gallon
- NaCl 4 gallon
- Stimulate 1.5 gallon
- Dextrose 10 lb. (4 kg)
- Crescendo 6 lb. (microbial inoculant)
- RL-37 1 gallon
- B12 300 ml (300 mg)
- Apply at 20 gpa (200 ltr/ha)

Peaches

- Approximately 30 days before harvest
  - 100 gallons water (400 ltr)
  - 3 qt. (3 ltr) household ammonia
  - 7 lb. (3.2kg) 0-52-35 MPK (0-26-35)
  - 3 lb. (1.4 kg) Zn
  - 1 qt. (ltr) RL-37
  - 120 cc B12 (120 mg)
- Mix 20 gallons (80 ltr) of this mix with 80 gallons (320 ltr) of water and apply mix at 100 gpa (1000 ltr/ha)
- Alternate mix might be due to tissue testing differences:
- 100 gallons water
- 1 qt. ammonia
- 5 lb MPK
- 1 lb Fe
- 1 lb Mn
- 1 qt. RL-37
- 120 cc B12
- Mix 20 gallons with 80 gallon water and apply mix at 100 gpa

Problems Encountered

- Soil test values are not moving or actually moving in the wrong direction
  - See the whole picture and repeat the fundamentals/basics like any professional
- Soil test values seem excellent or better yet the crop is not performing
  - Treat the patient, not the lab test
  - Feed the plant with that for which it is asking

Pasture/Turf

- Reams Test: 2000ppm Ca, 2:1 P:K
  - Mycorrhizae one time should suffice
  - Calcium QS
  - Gypsum if needed QS
  - Rock or soft rock phosphate QS
  - Compost if available QS
  - Soil drench as with trees
- Per cutting: 200-500 lbs-kg $CaCO_3$; 50-100 lbs-kg phos rock; 25-50 lbs-kg MAP; 25-50 lbs-kg NH_4SO_4

Pasture/Turf continued…

- If adequate mineral is present:
  - 20 gallons (200 lt) compost tea/extract or 2-10 gal. (20-100 lt) SP-1 or 1-10 gal. (10-100 lt) "sleeping tea" or 1-2 lbs-kg packaged biological inoculant; 1-5 gallons fish (10-50 lt); 1-2 qt. (2.5-5 lt) humic/fulvic acid; 1-2 qt. (2.5-5 lt) SeaMinerals; specific traces as needed
  - Seaweed/kelp is excellent, but can also be applied via livestock given as a free choice supplement
  - In grazing operation, always include free-choice supplementation to livestock for their health and benefit to the pasture via the manure

Pasture for producing milk for people

- *Journal of the Science of Food and Agriculture J Sci Food Agric* 88:1431–1441 (2008)
- **Fatty acid and fat-soluble antioxidant**
- **concentrations in milk from high- and**
- **low-input conventional and organic systems:**
- **seasonal variation**
- Gillian Butler,1∗ Jacob H Nielsen,2 Tina Slots,2 Chris Seal,1 Mick D Eyre,1
- Roy Sanderson3 and Carlo Leifert1
- 1*School of Agriculture, Food and Rural Development, Newcastle University, Nafferton Farm, Stocksfield, Northumberland, NE43 7XD, UK*
- 2*Department of Food Science, Danish Institute for Agricultural Science (DIAS), PO Box 50 DK-8830 Tjele, Denmark*
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- *Tyne NE1 7RU, UK*
- **Abstract**
- **CONCLUSIONS: Milk composition is affected by production systems by mechanisms likely to be linked to the**
- **stage and length of the grazing period, and diet composition, which will influence subsequent processing, and**
- **sensory and potential nutritional qualities of the milk.**
- **□ 2008 Society of Chemical Industry**

Veggie Crop

- Soil test: 1000ppm Ca; 100ppm ea. P/K
  - Must maintain throughout season – Reams Test
  - 500-1000 lbs-kg $CaCO_3$; 200-500 phos rock
    - Include carbon – humates, kelp, etc.
  - Mg, S, K rock as needed
  - 5-20 ton compost – then hill up with above minerals
  - Alternate mix: dry humates, kelp, fish, biology, carbs
    - 100 to 200 lbs-kg
  - Seed/seedling dip/inoculation – biology/stimulant
  - Biological with starter at seeding – dry or liquid
  - Soil drench/stimulant at first irrigation
  - Foliar weekly – nutrition and biology
    - If fruiting, keep it "female"
    - If leafy, keep it "male"

Grain Crop

- Soil Test: 1000ppm Ca; 100ppm P/K
  - Add calcium and phos w/carbon per budget
  - Potassium sulfate, sul-po-mag as needed
  - Seed inoculant
  - Starter with biological and foods
  - Foliar at tillering time and boot stage and grain fill
    - "male" mix early
    - "female" mix later
      - Phos, Mn, Mg, other traces, SeaMinerals, fish, SW, fulvic/humic acids, carbs
    - Can use compost tea/extract or packaged biological alone if soil mineral is sufficient and you feed the biological
    - One can get by with just the biological, better results can be had when additional mineralization is added to the program

Programs:

- Crop: Soybeans – foliar approx. 30 days before harvest; S. Minnesota, August 2006; 4 gal via air
- Area average normally 42 bu/Ac
- IAL area average 72 – 80 bu/Ac
- Foliar cost $3.00/Ac; 6-8 bu/Ac increase yield
- 1 gallon mix in water; spun CCW after blending
- 0.6 lb. MKP
- 1 pint 3% aqua ammonia
- 0.3 lb. dextrose
- [0.15 lb. MnChelate/1.2 oz. RL-37(w/CaOH)]

Programs:

- Crop: Corn – NC Iowa, mid-August 2006; 30 reps
- Foliar alone + 15 bu/Ac; Headliner fungicide alone +16 bu/Ac; Foliar/Headliner +72 bu/Ac
- Control was 200 bu/Ac; 215;216; 272
- Water qs 1 gallon
- Phos Acid 85% 23 oz.
- 3% aqua ammonia 28 oz.
- Vinegar 1/3 oz.
- Dextrose 1 lb.
- RL-37 2 oz.
- PGR (IAL) 2 oz.
- At field, add in water to 10 gal/Ac total; spun CCW in final cone bottom mix tank prior to application with Nitro ground applicator

240 Bu./Ac. Corn Program

- Michael McNeill: Corn on Soybean program
  - Banded under the row in fall
    - 120# "Encapsulated Urea
    - 75# MAP 11-52-0
    - 75# K2SO4 potassium sulfate
    - 50# AMS ammonium sulfate
    - 10# 36% zinc sulfate
  - Apply side-dress nitrogen as needed: approx. 20 gal/Ac 32%
  - 142# nitrogen plus soybean credit = 180#/Ac.
  - Recommend in-furrow starter (4-15-13 @ 3 gal/Ac) w/micronutrients
  - Recommend foliar 1-2# CaNO3 plus Mg, Mn, B

FHR KU Mud Creek Farm 220-240 Bu/Ac.

- U-Trough Spring with planter
  - 20 gal 32% N
  - 5 gal CaNO3
  - 5 gal Pursonova water
  - 150# 17-9-7 on opposite side
  - Furrow: 26 oz Micro-Pack
  - 5 gal 8-16-3 (phosphyte)
  - 5 gal Pursanova water
  - 7 oz. SafeStrike

Mud Creek continued

- Foliars
  - 1st:
    - 1 gal 8-19-3
    - 8 oz Defender G4
    - 4 gal Pursonova water
  - 2nd @ 3 ft:
    - 2 gal 21-1-0
    - 4-8 oz Defender G4
    - 20 gal water
  - 3rd:
    - 2 oz Procidic
    - 3 gal 21-1-0
    - 2 qt. CaNo3
    - 2 oz WakeUp
    - 18.5 gal water

Mud Creek continued

- 4th Foliar: Brown Silk – Airplane 4 gal/Ac total
  - 2 gal 21-1-0
  - 2 qt. CaNO3
  - 2 oz. WakeUp
  - 2 oz. Procidic
  - 2 qt. Seed Set
- 5th and 6th foliars same w/o Seed Set

Mud Creek continued

- Fall:
  - Strip-Till
    - 250# soft rock phosphate
    - 40# MAP
    - 30# SOP
    - 20# K-Mag
    - 10# 0-0-60
  - Broadcast
    - 2 qt. Residue Digester
    - 7 gal. 32%
    - 3 gal. water

Fertigation Mix

- Twice weekly, keep EC at 300 uS or better especially in poor soil; may need 5 – 6 apps before stabilizes (numbers are lb/ac-kg/ha
- 2 lb-kg micronized calcium carbonate
- 3 lb-kg sugar
- 4 oz-280gm Crescendo (microbial)
- 4 oz-280ml RL-37
- 10ml-25ml vitamin B12

Sap Testing: NovaCropControl

- Goal:
  - Ca > 1000ppm
  - P > 1000ppm
  - K 2 – 3000ppm
  - N 3 – 4000ppm

Root Zone Soil Testing: Morgan

- Test before and after foliar spray (0, 24, 48…)
  - Some sprays lower soil conductivity values
    - Inappropriate spray
  - Some sprays raise test values
    - Continue foliar spray until EC values stay up
      - May need every few days, weekly or bi-weekly
  - If brix comes up but still insects, etc.
    - It is a trace element deficiency needed to convert simple sugars to complex carbohydrates: reducing sugars to non-reducing sugars

Foliar Nutrition...

- Foliar Feeding
  - "Ask the crop" – very good on cereals/grasses
    - Check brix of test area
    - Spray test areas with possible foliar mixes
    - Recheck brix in 30 to 45 minutes
    - Broadcast product mix with greatest brix elevation
    - Spray early morning (1) or late at night (2)
    - Consider electrostatics or charge the water
    - Products off the shelf or made from scratch
- Pest/Disease Management
- Natural Predators
- Review Guidelines
- Refer to: *Science In Agriculture*
- Water quality – use RO water, Pursanova

Foliar Feeding

- Potentially most efficient/effective feeding
- Directly proportional to calcium foundation
- Factors
  - water quality
  - product quality
  - crop growth stage
  - timing, mixing, mode of application
  - goal desired: growth v. fruit v. fruit size/quality

Key times to Foliar

- Early season annuals to increase growth
- Early season to increase seed count
- Pre-bloom to increase fruit set
- Post-fruit set to hold set
- Late fruit to grow fruit and improve quality
  - especially fruit storability
  - difficult to get calcium late season
    - best with phosphate, difficult to mix

Foliar Mixes

- Fruit Setting Mix: alter as desired
  - 180 litres water (20 gallons) for ½-2 ha (1-5 ac)
  - 1/2 - 2 litres household ammonia (3%)
  - 1/2 - 2 litres phosphoric acid
  - 1/2 - 2 litres apple cider vinegar
  - 1 - 4 litres fish
  - 1/2 litre seaweed
  - 1/2 - 1 kg sugar
  - If excess NO3, add 300 gms MgSO4 (Epsom Salts)
  - Can add manganese and other traces as needed
  - Should add 1-2 litres SeaMinerals (1-2 qt)
  - Always "jar mix" and spray with hand sprayer to check leaf burning and mix sedimentation. Always err on the low side of product quantity.

Coca-Cola does have a purpose...

- Foliar Fertilizer Mix – set fruit
  - 1 – 2 litres Coca Cola – the real thing
    - Equivalent to 10 liters/ha (1 gal/ac)
  - 1/20 – 1/10 litres apple cider vinegar
  - 1/20 – 1/10 litres household (cloudy) ammonia
    - 3% N product
  - 50 to 200 gms seaweed (kelp)
  - 1 – 2 gms Royal Jelly or 1 Tblsp RJ honey
  - 3 or 5 gallon home sprayer

Foliar Bullets:

- Foliars are potentially most efficient feed
- Use to alter or enhance crop status
  - growth v. fruiting
- Mixing, timing, water all considerations
- Use mix that raises brix
- Can enhance pesticides with fertilisers

Foliars and Pests

- Foliars can mix with pesticides
  - can use without pesticides to control
  - feed leaf surface beneficial microbes
- Apply predator insects

Foliar Program: Soil Test Comparison

Oats

	6/10/84	6/16/84
Ca	5400	14,000
P	100	150
K	100	130
NN	10	10
An	2	2
pH	7.0	6.9
Ergs	110	330 (6/14/84)

Sprayed between the tests:

- 5 oz 10-52-10 dry soluble
- ½ oz Multi-Crop Seaweed
- 5 gal water in mist blower

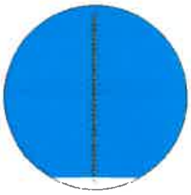
- Post season calcium levels dropped back to original level. Biology is key to keeping these numbers balanced and stable
- Another oat crop in the same area dropped from 130 – 150 bushel per acre to 37 due to release of Atrazine, though 5 – 6 years since last application. Atrazine confirmed by laboratory test of oats. We forgot the RL-37.

Pesticide/Herbicide Issues

- Can enhance with fertilisers
  - humic acids/fulvic acids
  - N-P-K's
  - Bio's may not tolerate
  - Spices

Testing Tools Tutorial

- Conductivity Meter
- Refractometer
- pH, ORP, pNa Meters
- Penetrometer
- Thermometer
- IR Stress Meter
- Field Notes



Water on Lens

Refractometer Lens Simulation with plant sap: Plant likely to be attacked by insects and or disease

Field Test Bullets:

- Must collect data to make good decisions
- Conductivity precedes brix
- Collect data consistently/regularly
- The best soil test is your footprints in field

Irrigation and Water Issues

- Water is/will be most precious commodity
  - input for crop growth
  - regulated private/public asset
  - trading commodity

Irrigation Quality

- Quality varies
  - salinity: sodium hurts calcium
  - pesticides: stresses bio system
  - hardness: interferes with product mixing
- May be most toxic input
  - fertiliser program must adjust
  - may need to filter for spray application

Irrigation Practices

- 4 main applications
  - flood - hard on microbes
  - furrow - better for microbes
  - sprinkler - overall best
  - drip - conservative, limits microbial zone
- Potential fertilization carrier
  - never waste an opportunity

Water Bullets:

- Water will be most precious asset
- Quality must be addressed: Ca for Na
- Use irrigation to deliver fertilizer
- Key to disease
  - Panama Disease, Rhizoctonia, Fusarium, Verticillium,...
  - Frequently better to water qod than qd
  - Track NO2, ciliates, disease and tissue color

Water and Bio-Farming

- As the soil improves with increased bio-active carbon, the farmer will need to REDUCE irrigation or he will destroy all the progress he has made.
- Bio-active soils need less water
- Over watering causes the soil to become anaerobic, killing the beneficials, compacting the soil, reversing carbon fixing

Dairy Challenges

- Dairy farm
  - Foot rot problems
  - Mastitis problems
  - Swollen legs and lameness
  - Rough hair
  - Glassy eyes
  - Loose manure
  - Ammonia odor and fly problem to point of needing sprays weekly or more
  - Employ professional nutritionists for TMR including corn silage, high moisture shell corn
  - Vet visits weekly to evaluate cows, restock meds and deal with displaced abomasums
- Where do you start and what are 2 immediate interventions and two long term interventions to correct these problems

Dairy Solutions

- Consult Dr. Paul Detloff, Dr. Dan Skow, Jerry Brunetti or Lancaster Ag or a local/regional holistic vet
- Must correct the acidosis caused by the diet
  - Bicarb and apple cider vinegar
  - Free choice kelp and minerals
  - Aloe vera pellets and humates
- Long term
  - Possibly fire the nutritionist
  - Change the ration according to holistic vet/consultant
  - Get long stemmed hay and forage into the ration
  - Raise the brix of forages

Environmental Energetics

- Geopathic issues
  - Ley lines
  - Underground water
- Electromagnetic
  - Stray voltage
  - Power lines and transformers...
- Cell towers, burial grounds, etc.
- The American Society of Dowsers, Danville, Vermont, 802-684-3417, www.dowsers.org

Tree Challenges

- Fruit trees: write short and long term corrections
  - Young trees extensive primary branch growth without much lateral branching
  - Thrips and or aphids are an annual problem
  - Alternate year bearing
  - Mostly terminal branch fruit set
  - Tree branches break easily from fruit load
  - Fruit must be picked very green to ship
  - Fruit sizing is quite varied
  - RoundUp is used every year to control grasses and broadleaf weeds but nutgrass is resistant and a problem
  - NO2 levels in the soil is frequently higher than desirable

Grain/Pasture Problems

- Soil compaction is an issue
- No-till program requires extensive herbicide use
- Soil insecticides must frequently be used
- Emergence is often a problem due to crusting
- Smut and other fungal diseases of the grain head/ear are common
- Mycotoxins and nitrates are prevalent in the grain
- Mites and other insects must be sprayed
- Who cares, it all goes for ethanol production

Grain/Pasture Solutions

- Calcium, calcium, calcium, calcium, calcium,...
- Humic acid, biologicals and carbon for the soil
- Probiotic seed inoculants
- Foliar nutrients to raise brix
- Consider that the price of oil directly effects the price of diesel fuel, nitrogen, herbicides, insecticides and fungicides, distillers grain is fed to animals which people eat and fertilizer and chemical runoff affects everyone and laws limiting the farmer's use of these products are getting more prevalent making the status quo unsustainable by law.

Bio Principles: "The Enemy"

- Weeds, diseases, and insects are due to sick soils/crops which are due to poor soil/crop nutrition and microbial management
- If you are neglecting the microbes you are missing one oar in the water.

Weeds

- Geobiological Succession: weeds are more primitive/less sophisticated biologically than domesticated crops (Ingham)
- This is not a herbicide deficiency
- Sour grasses: functional calcium problem
- Broadleafs: P:K functional imbalance, often a lack of beneficial fungi

Insects

- Nature's garbage collectors
- Per Callahan: home in on signatures of ill-health, ignore plant signatures of health
- Nutrition solely determines RF/IF emission signatures
- NOT due to, NEVER were due to nor EVER will be due to genetic flaws in the plants necessitating GE crops

Hands On Management

- Truly managing the microbes which actually take care of the crop
- Conditions today are different than when Reams and Albrecht evolved
- ANY change in most conventional systems elicits positive change
- All biology effects chemistry, all chemistry effects biology, every cause has an effect

Biological Principles

- Numbers cannot be forced into compliance
  - Albrecht % saturation by mass fertilization
  - Microbial system won't tolerate the "big hammer"
  - Would you feed an ailing baby as a healthy adult?

Bio Principles: Examples

- Will a 20-inch down pour solve a two year drought? 20 days of 1-inch rains?
- Can a lifetime of copper deficiency in pigs be solved in one feeding? It can if death is your solution!
- Can you correct osteoporosis in one dose of calcium?
- Iron deficiency anemia by one shot of iron?

Bio Principles

- You are truly farming the microbes which in turn take care of your crop
- The chemistry, physics, tillage, cultural practices all alter the microbes
- Must employ common sense, field observation, refractometer, testing…..

Know your energy

- All things are fundamentally
  - energy.
- Crop management depends
  - upon one's ability to manage energy by way of fertilizers, water, bio-products, cultural practices, and timing.
- Maximize output per unit input.

Energy Pearl

- Manage the ***energy*** and the rest
  - will take care of itself, Soil to Food to Human Health
- Need the foundation
  - (calcium/base minerals), the framing (nutrient ratios), the finishing (humus) to manage the energy for best case outcome.

Practical Energy Management

- Tree and Fruit Crop Pruning:
  - Prune at harvest before leaf drop
    - If you wait until winter you are robbing the tree/vine of valuable energy and regardless of the nutritional program employed you will not achieve the potential of the crop
      - Mark Nakata, Fresno, California

Fundamentals

- 1. **Plants live off of the energy** released by the interaction of fertilizers and microorganisms and from the sun.
- 2. Nature will always follow the line of least resistance.
- 3. Using pumped phase conjugation phenomena, like things can be made to "attract" or increase like things, e.g. liquid calcium drawing in more calcium.
- 4. Yang energy fertilizers produce growth and Yin energy fertilizers produce fruiting. "Growth inducing" materials include calcium, potash, chlorine, and nitrate nitrogen (Reams' viewpoint) while all others are fruiting inducing.
- 5. For every cause there is an effect and vice versa.
- 6. The higher the nutrient balance and availability the faster the plant will grow in a balanced state.
- 7. Plant growth is limited only by energy availability/balance.
- 8. The greater the soil nutrient density the greater the crop yield provided there is adequate moisture.
- 9. The greater the humus content the greater the nutrient quantity required to maintain soil test levels.
- 10. All elements ideally go into the plant in the phosphate form with the exception of nitrogen which can erroneously carry other nutrients in with it.

Fundamentals

- 11. **Nitrogen is the major electrolyte** in all biological systems.
- 12. Nitrogen can carry potassium into the plant during times of nitrogen excess relative to phosphate which results in minerally imbalanced, low refractometer reading, watery plants susceptible to a multitude of pests and conditions.
- 13. **Phosphate is a catalyst** for nutrient and energy transport along with carbohydrate production and metabolism.
- 14. The higher the phosphate availability, the higher the plant's sugar and dissolved solids content, which in turn means the higher the mineral content resulting in a higher specific gravity crop and fewer pest problems.
- 15. Potash determines the caliber of the stalk and leaves, the fruit size and number of fruit sets.
- 16. The phosphate to potash ratio (on the Reams Test) should be 2 parts phosphate to one part potash for crops other than grass/alfalfa crops which should have a 4 to 1 ratio.
- 17. **Carbon is the governor of moisture.**
- 18. Ideally, about 80% of the nutrients for biological life come from the air and about 20% come from the soil or diet.
- 19. Top quality produce will dehydrate rather than rot.
- 20. Magnesium is the major governor of nitrogen.
- 21. Anytime there is less than a 7 to 1 calcium to magnesium ratio (Reams Test) there will be an increased nitrogen demand due to less efficient nitrogen utilization requiring increased nitrogen fertilizer applications.

Fundamentals

- 22. **Always add carbohydrate** with nitrogens and phosphates.
- 23. **Keep materials in the soil aerobic zone.**
- 24. As the soil system improves the inputs must get more "sophisticated" and fine tuned.
- 25. Acid/salt based fertilizers are less effective in making long chain functional amino acids than non-acid/salt fertilizers.
- 26. The condition called "gumosis" in plants is caused by excess nitrogen and is easily relieved with a laxative - $MgSO_4$.
- 27. Sun dried humates are best to use.
- 28. Think of the soil system as an animal (ruminant) digestive system and treat it accordingly. Some soils are very sick "baby calves." THINK about how a sick baby calf must be cared for and fed to nurse it back to health and apply these common sense principles to your farm management program.
- 29. **SEE WHAT YOU LOOK AT!**
- 30. Insect pests, diseases, and weeds are manifestations of nutritional imbalances NOT GMO/pesticide deficiencies.
- 31. Apply, execute, assess & reapply the fundamentals over and over.
- 32. Get a coach.

Group 1 scenario

- Potatoes
- pH 7.4 calcium 65%, magnesium 20%, potassium 4%, hydrogen 6%, sodium 3%; CEC 20
- Johnson grass, foxtail, pigweed, lambs quarter, velvet leaf
- Aphids, Colorado potato beetle, army worms, early and late blight, tuber worms, hollow heart, bruising

Group 2 scenario

- Apples
- pH 7.2 calcium 70%, magnesium 12%, potassium 3%, hydrogen 8%, sodium 2%
- Johnson grass, quack, ragweed, lambs quarter, pigweed
- Nematodes, aphids, Japanese beetles
- Alternate year production
- Apple pressure testing poor, tissue calcium at 200ppm

Group 3 scenario

- Pasture
- pH 6.7 calcium 60%, magnesium 15%, potassium 3%, hydrogen 10%; CEC 20
- Thistle, pigweed, quack and nut grass
- Aphids; cattle have breading problems, mastitis, foot rot, lice, tails cut off due to diarrhea

Group 4 scenario

- Cereal grain
- pH 7.4 calcium 64%, magnesium 24%, potassium 3.0% hydrogen 5%, sodium 2%
- Quack and Johnson grass, pigweed, velvet leaf, fungus disease in head, aphids
- CEC 15

Group 5 scenario

- Multiple vegetables, small truck farm
- Soil test:
- pH 6.5; calcium 60%, magnesium 25%, potassium 3%, hydrogen 10%, CEC 10
- Foxtail, quack grass, lambs quarter, pig weed, thistles; hard pan at 14 inches, organic matter at 2.5%, few to no earthworms; struggle with aphids and other insects; mildew and blight; used much copper and sulfur in the past
- Want organic certification, some irrigation available

Thank you for your attendance at our Course. It was a pleasure sharing with You. Thank you for your willingness And dedication to improve the quality of the food and fiber that you produce. **You hold in your hands the well-being Of your fellow human beings. God Bless you and your work.**

The Glyphosate Story

- See what you look at in the field

Plant Sap Testing

HortiNova Plant Sap Testing Interpretation
as formulated by Mr. John Kempf
https://www.advancingecoag.com/plant-sap-analysis
Presented with permission.

Plant Sap Analysis

- Plant sap analysis was developed by HortiNova in The Netherlands to evaluate and address plant nutrient levels in such a way that growers could actually improve brix levels, increase production, improve quality, specifically nutrient density, and reduce infestation from diseases and insect pests.

- Tissue analysis lags too far behind plant physiology to make significant changes in the nutrient density and immune system and particularly the brix. Most importantly, tissue analysis parameters do not correlate to insect and disease resistance.

Sap Analysis

- The refractometer is the best, on the spot, field indicator for plant health, but the question always begs as to what to do to get it to rise.

- Plant sap analysis is the answer. HortiNova principles studied various works around the world regarding plant nutrition and plant health including Don Huber and Dan Skow and myself. Subsequently, they proved to themselves in the greenhouses and fields of Germany and Holland that nutrient levels and ratios correlated to insect and disease infestation. Fast forward, John Kempf of AEA, doing 30-40,000 samples per year, coming from a holistic appreciation of plant health, developed the target range tables and the sap analysis report worksheet.

Sap Analysis 2

- Plant Sap Analysis is the next major advancement in plant production technology; beyond genetics, biology, chemicals and even robotics.

Sap Analysis Interpretation Worksheet

	1		2	3	4	5		6	7				8
	Nutrient Excesses		Photo-synthesis	Protein-synthesis	Fruit quality	Solutions for Deficiencies		Carry	Low	Med	High	Products	Recommendations
	Antidotes					Catalyst							
Potassium	Manganese					Manganese						Holo K	
Calcium	Boron					Boron, Silicon						Holo Cal, SeaShield	
Magnesium	Nitrogen											PhotoMag, SeaCrop	
Sodium	Calcium											SeaCrop, Redmond Salt	
Ammonium													
Nitrate	Mg, S, Mo												
Total Nitrogen	Magnesium											SeaShield, urea	
Chloride	Ca, P												
Sulfur	Nitrogen											SeaShield	
Phosphorus	Zinc					Zinc, Iron						HoloPhos, SeaShield	
Silicon												SeaShield	
Iron	Phosphorus											Salute/Rebound Iron	
Manganese	Phosphorus											Salute/Rebound Manganese	
Zinc	Phosphorus											Salute/Rebound Zinc	
Boron	Calcium											Salute/Rebound Boron	
Copper	Phosphorus											Salute/Rebound Copper	
Molybdenum												Salute/Rebound Molybdenum	

Advancing Eco Ag Sap Analysis Worksheet

- In all of the columns, only the highlighted cells matter

- 1) run down the list, determine if any of the highlighted nutrients are excessive on the sap analysis. If so, look at its antidote. For example, if potassium is excess, see that manganese is the antidote. Run your eye down the green column (far left) until you see manganese, and check manganese in the highlighted yellow box.

Sap Analysis cont.

- 2) Run down the list and if any of the blue highlighted cells are deficient on the sap analysis, checkmark that blue box.
- 3) Run down the list and if any of the blue highlighted cells are deficient on the sap analysis, checkmark that blue box.
- 4) Run down the list and if any of the blue highlighted cells are deficient on the sap analysis, checkmark that blue box.
- 5) If any of the highlighted cells in column 2, 3, or 4 are checked, glance over at the column labeled catalyst to see what the catalyst is. If, for example, calcium is deficient, glance over and see that boron and silicon are the catalysts. Then run your eye down the green column until you see boron and silicon, and check those minerals in the yellow highlighted cells.

Sap Analysis cont.

- 6) When you are finished, carry over all the check marked items to column 6. When you're done with colunns 2 through 5, you will have a list in column 6 of all the deficient and needed minerals.
- 7) Use the label guidelines to recommend low, medium, or high. The products column will tell you which products contain the needed mineral.
- 8) From there you are able to make your recommendations.

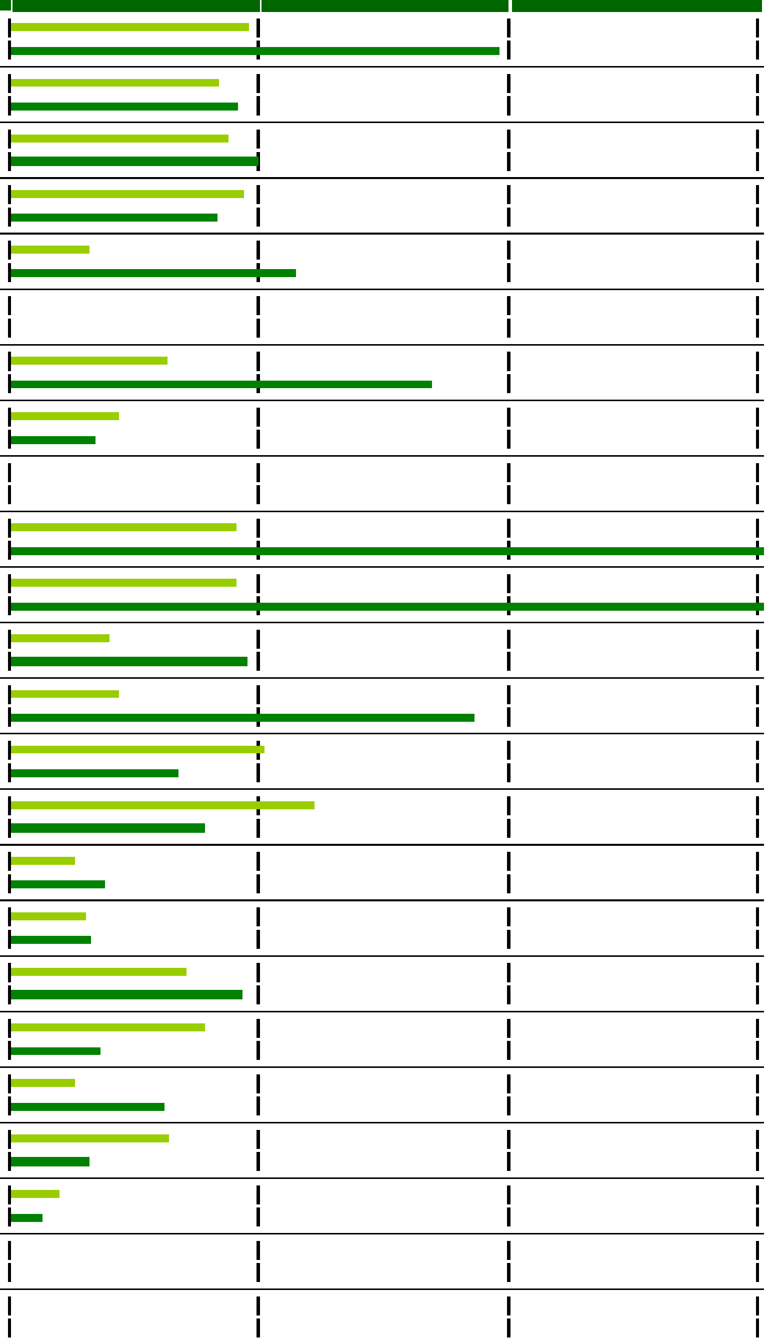
NovaCropControl
postbus 2218 - 5001 CE - Tilburg
www.novacropcontrol.nl

CROP HEALTH LABS

Plant sap-sample	[1] 201705081180 [2] 201705081181	**Sample date:**	7-5-2017
Name:	Keystone Bio-Ag, LLC	**Location/plot:**	Jacob Kauffman 554 Center Hall
Address:	430 Voganville Road 17557 New Holland, Pennsylvania USA	**Cultivation:**	Jacob Kauffman 554 Center Hall Rd, straw
		Crop:	Strawberry
		Plant part:	[1] Leaf (young) [2] Leaf (old)

Remarks

Mineral		Current level	Optimum	
Total Sugars	%	2,3	2,4 - 7,2	1
	%	7,0		2
pH		5,2	6,2 - 6,6	1
		5,7		2
EC	mS/cm	8,6	9,8 - 12,2	1
	mS/cm	9,8		2
K - Potassium	ppm	3925	4176 - 5424	1
	ppm	3453		2
Ca - Calcium	ppm	343	1065 - 1935	1
	ppm	1193		2
K / Ca		11,43		1
		2,89		2
Mg - Magnesium	ppm	353	560 - 840	1
	ppm	752		2
Na - Sodium	ppm	3	6 - 14	1
	ppm	2		2
NH4 - Ammonium	ppm	22		1
	ppm	36		2
NO3 - Nitrate	ppm	97	108 - 323	1
	ppm	726		2
N in Nitrate	ppm	22	24 - 73	1
	ppm	164		2
N - Total Nitrogen	ppm	204	510 - 690	1
	ppm	486		2
Cl - Chloride	ppm	220	503 - 998	1
	ppm	931		2
S - Sulfur	ppm	116	114 - 186	1
	ppm	78		2
P - Phosphorus	ppm	585	450 - 1050	1
	ppm	353		2
Si - Silica	ppm	2,1	8,0 - 12,0	1
	ppm	3,0		2
Fe - Iron	ppm	1,00	3,35 - 6,65	1
	ppm	1,10		2
Mn - Manganese	ppm	6,35	9,00 - 21,00	1
	ppm	8,38		2
Zn - Zinc	ppm	1,41	1,80 - 4,20	1
	ppm	0,65		2
B - Boron	ppm	0,52	2,01 - 3,99	1
	ppm	1,24		2
Cu - Copper	ppm	0,32	0,50 - 1,50	1
	ppm	0,16		2
Mo - Molybdenum	ppm	<0,05	0,15 - 0,45	1
	ppm	<0,05		2
Al - Aluminium	ppm	0,61		1
	ppm	1,17		2
Co - Cobalt	ppm	0,07		1
	ppm	0,03		2



Consult your advisor for appropriate fertilizer recommendations.

201.20170530

CROPHEALTH LABS

Sap Analysis Target Ranges

	Cucumber	Melon	Pumpkin	Zucchini
Total Sugars	.5-.6	.7-1	.8-1.2	.6-.7
pH	6.4	6.4	6.4	6.4
EC	14.0	12.0	14.0	13.0
Potassium (K)	3900-4100	3200-3400	4400-4600	4000-4300
Calcium (Ca)	1400-1600	1800-2000	1200-1400	1300-1500
Magnesium (Mg)	750-900	700-800	550-700	450-500
Sodium (Na)	15-20	20-25	5-10	2.5-3.5
Ammonium (NH4)	0.0	0.0	0.0	0.0
Nitrate (NO3)	0.0	0.0	0.0	0.0
Total Nitrogen (N)	1600-1900	1300-1500	1700-1900	1700-1900
Chloride (Cl)	400-600	500-800	425-550	450-550
Sulfur (S)	600-750	200-250	250-300	225-250
Phosphorus (P)	250-300	200-250	200-250	250-300
Silica (Si)	50-65	50-65	50-60	50-60
Iron (Fe)	3.5-5	3-4	3-4	3-4
Manganese (Mn)	3-5	3-5	3-5	3-5
Zinc (Zn)	3-5	3-5	5-7	5-7
Boron (B)	6-10	6-8	5-7	3.5-5
Copper (Cu)	1.5-2	1.5-2	2-3	1.5-2
Molybdenum (Mo)	.75-1	.3-.5	.3-.5	.2-.3
Aluminum (Al)	0.5	0.5	0.5	0.2

Sap Analysis Target Ranges

	Tomatoes	Potatoes	Eggplant	Peppers
Total Sugars	1.25-1.5	.8-1	1-1.2	1-1.2
pH	6.4	6.4	6.4	6.4
EC	14.0	13.0	14.0	16.0
Potassium (K)	3800-4000	4500-5000	5000-5200	6500-7500
Calcium (Ca)	3000-3500	1250-1500	500-600	80-100
Magnesium (Mg)	650-750	700-800	450-550	900-1000
Sodium (Na)	40-50	10-15	5-10	4-8
Ammonium (NH4)	0.0	0.0	0.0	0.0
Nitrate (NO3)	0.0	0.0	0.0	0.0
Total Nitrogen (N)	1300-1400	1400-1600	1400-1600	1400-1500
Chloride (Cl)	850-1000	600-800	1000-1200	450-600
Sulfur (S)	1500-1750	300-350	250-300	500-600
Phosphorus (P)	275-350	250-300	400-450	350-400
Silica (Si)	15-20	30-35	7-10	7-10
Iron (Fe)	3-4	4-5	2.5-4	5-6
Manganese (Mn)	15-20	10-12	7-10	15-20
Zinc (Zn)	3-4	3-4	3-4	10-12
Boron (B)	7-10	4-5	5-7	4-5
Copper (Cu)	3-5	1.5-2	1.5-2	3-5
Molybdenum (Mo)	.3-.5	.2-.3	.2-.3	.3-.5
Aluminum (Al)	0.3	1.0	0.5	1.0

CROPHEALTH LABS

Sap Analysis Target Ranges

	Grapes	Haskap	Hops	Kiwi
Total Sugars	4-4-05	5 - 6	1.7 -2	1.5 - 2
pH	4.5	6.4	6.4	6.4
EC	10.0	8-9	14.0	14.0
Potassium (K)	2300-2500	3000-3200	5300-5600	5200-5800
Calcium (Ca)	1500-1800	1000-1200	2200-2500	1100-1400
Magnesium (Mg)	750-900	800-900	1200-1500	1000-1100
Sodium (Na)	125-200	7-10	8-10	13-15
Ammonium (NH4)	0.0	0.0	0.0	0.0
Nitrate (NO3)	0.0	0.0	0.0	0.0
Total Nitrogen (N)	450-500	350-400	1400-1600	750-850
Chloride (Cl)	500-700	325-400	1000-1200	750-850
Sulfur (S)	400-450	150-200	350-400	950-1050
Phosphorus (P)	650-750	400-450	250-350	425-475
Silica (Si)	100-120	12-15	50-75	30-35
Iron (Fe)	25-30	5-7	4.5-5.5	5-6
Manganese (Mn)	30-40	15-20	10-15	12-15
Zinc (Zn)	15-25	3 - 3.5	10-15	5-6
Boron (B)	15-17	3 - 5	12-15	20-25
Copper (Cu)	1.5-2	1.5-2	1 - 1.2	2-3
Molybdenum (Mo)	.5-.75	.2- .3	.2- .3	1 - 1.2
Aluminum (Al)	10.0	0.5	1.0	2.0

CROPHEALTH LABS

Sap Analysis Target Ranges

	Beet	Celery	Lettuce	Onion	Spinach
Total Sugars	.8-1	1-1.5	1.4-2	2-2.5	2-2.5
pH	6.4	6.4	6.4	6.4	6.4
EC	15.0	16	11.0	8-9	17.0
Potassium (K)	5100-5300	3200-3600	2300-2500	2300-2600	4800-5200
Calcium (Ca)	25-30	2800-3000	600-700	800-1000	25-30
Magnesium (Mg)	700-1000	600-750	200-250	150-175	900-1000
Sodium (Na)	750-1000	1100-1400	80-120	25-35	650-850
Ammonium (NH4)	0.0	0.0	0.0	0.0	0.0
Nitrate (NO3)	0.0	0.0	0.0	0.0	0.0
Total Nitrogen (N)	1300-1400	1050-1200	1000-1100	750-850	1350-1500
Chloride (Cl)	400-450	700-900	1000-1100	600-800	1000-1200
Sulfur (S)	300-350	1200-1400	100-125	375-425	240-280
Phosphorus (P)	400-450	400-500	150-200	160-200	375-450
Silica (Si)	12-15	8-10	10-15	4-8	20-25
Iron (Fe)	6-8	3-4	4-5	2-2.5	6-8
Manganese (Mn)	6-8	10-15	3-5	3-5	5-7
Zinc (Zn)	4.5-6	3-3.5	2.5-3	1.2-1.5	3-3.5
Boron (B)	3-5	1.5-2	2-3	1.5-2	2-3
Copper (Cu)	1.5-2	1-1.2	.75-1	.5-.75	1-1.2
Molybdenum (Mo)	.2-.3	.3-.5	.2-.3	.2-.3	.2-.3
Aluminum (Al)	2.0	1.0	0.5	0.5	3.0

CROPHEALTH LABS

Sap Analysis Target Ranges

	Apple	Cherry	Citrus	Almonds	Peach
Total Sugars	4.5-5	2.5-3	6-6.5	2-2.5	4.5-5
pH	6.4	6.4	6.4	6.4	6.4
EC	10.0	12.0	12.0	15.5	12.0
Potassium (K)	4500-5000	6000-6500	7000-7500	7000-7500	6000-6500
Calcium (Ca)	1500-2000	1200-1400	6500-7000	3900-4300	70-100
Magnesium (Mg)	800-1000	800-900	1200-1400	2800-3000	1000-1200
Sodium (Na)	15-25	15-20	170-220	130-150	7-10
Ammonium (NH4)	0.0	0.0	0.0	0.0	0.0
Nitrate (NO3)	0.0	0.0	0.0	0.0	0.0
Total Nitrogen (N)	300-350	500-600	1100-1200	650-750	780-850
Chloride (Cl)	300-350	150-200	450-550	1000-1200	425-500
Sulfur (S)	150-200	140-160	900-1000	450-500	150-200
Phosphorus (P)	500-600	375-450	350-400	350-400	550-650
Silica (Si)	10-15	15-20	20-25	70-80	15-25
Iron (Fe)	4-5	10-15	7-10	40-50	10-15
Manganese (Mn)	25-30	20-25	15-20	35-40	15-20
Zinc (Zn)	6-8	10-12	7-10	15-20	10-15
Boron (B)	6-8	13-15	60-70	10-12	6-8
Copper (Cu)	3-4	4-5	4-5	4-5	3-4
Molybdenum (Mo)	.2-.3	1-1.2	.2-.3	1-1.2	.2-.3
Aluminum (Al)	1.0	2.0	1.0	20.0	3.0

CROPHEALTH LABS

Sap Analysis Target Ranges

	Cauliflower	Cabbage	Kale	Broccoli
Total Sugars	2-2.5	2-2.5	2-2.5	2-2.5
pH	6.4	6.4	6.4	6.4
EC	11.0	12.0	14.0	13.0
Potassium (K)	3500-3900	4000-4300	3800-4400	4300-4700
Calcium (Ca)	2500-3000	2500-2700	2500-2700	2500-3000
Magnesium (Mg)	350-450	400-500	450-500	400-500
Sodium (Na)	110-135	50-60	100-150	110-135
Ammonium (NH4)	0.0	0.0	0.0	0.0
Nitrate (NO3)	0.0	0.0	0.0	0.0
Total Nitrogen (N)	1700-1900	1800-2200	1800-2000	2000-2300
Chloride (Cl)	600-700	700-800	1000-1200	800-900
Sulfur (S)	1200-1400	1300-1500	1500-1750	1500-1750
Phosphorus (P)	350-400	350-400	350-400	350-400
Silica (Si)	5-10	5-10	5-10	5-10
Iron (Fe)	2-3	2-3	2-3	2-3
Manganese (Mn)	4-6	6-8	4-6	5-8
Zinc (Zn)	4-6	4-6	3-3.5	4-6
Boron (B)	4-6	3-5	3.5-5.5	6-8
Copper (Cu)	.5-.75	.5-.75	.75-1	.5-.75
Molybdenum (Mo)	.75-1	.75-1	.75-1	.75-1
Aluminum (Al)	0.2	0.2	0.2	0.2

Sap Analysis Target Ranges

	Alfalfa	Beans	Corn	Soybeans
Total Sugars	1.5-2	.8-1	1.25-1.5	.75-1.25
pH	6.4	6.4	6.4	6.4
EC	14.0	12.0	12.0	10-11
Potassium (K)	4500-5000	1250-1500	5000-5500	4300-4700
Calcium (Ca)	3500-4000	2200-2700	1200-1400	2000-2200
Magnesium (Mg)	600-700	600-700	425-450	750-800
Sodium (Na)	65-85	7.5-10	7-10	5.0
Ammonium (NH4)	0.0	0.0	0.0	0.0
Nitrate (NO3)	0.0	0.0	0.0	0.0
Total Nitrogen (N)	2000-2500	1250-1500	1300-1400	1600-1800
Chloride (Cl)	600-700	750-1000	400-450	100-150
Sulfur (S)	600-700	200-225	300-350	200-225
Phosphorus (P)	250-300	250-300	400-450	250-300
Silica (Si)	15-20	20-25	55-60	25-30
Iron (Fe)	3-4	3-4	3-4	3-4
Manganese (Mn)	12-14	6-9	7-10	8-10
Zinc (Zn)	3-4	3.5-5	3-4	3.5-5
Boron (B)	12-14	2.5-5	3-5	3.5-5
Copper (Cu)	1.5-2	1.5-2	1.5-2	1.5-2
Molybdenum (Mo)	.5-.75	.2-.3	.2-.3	.2-.3
Aluminum (Al)	0.3	0.5	0.3	0.5

Sap Analysis Target Ranges

	Alfalfa	Beans	Corn	Soybeans
Total Sugars	1.5-2	.8-1	1.25-1.5	.75-1.25
pH	6.4	6.4	6.4	6.4
EC	14.0	12.0	12.0	10-11
Potassium (K)	4500-5000	1250-1500	5000-5500	4300-4700
Calcium (Ca)	3500-4000	2200-2700	1200-1400	2000-2200
Magnesium (Mg)	600-700	600-700	425-450	750-800
Sodium (Na)	65-85	7.5-10	7-10	5.0
Ammonium (NH4)	0.0	0.0	0.0	0.0
Nitrate (NO3)	0.0	0.0	0.0	0.0
Total Nitrogen (N)	2000-2500	1250-1500	1300-1400	1600-1800
Chloride (Cl)	600-700	750-1000	400-450	100-150
Sulfur (S)	600-700	200-225	300-350	200-225
Phosphorus (P)	250-300	250-300	400-450	250-300
Silica (Si)	15-20	20-25	55-60	25-30
Iron (Fe)	3-4	3-4	3-4	3-4
Manganese (Mn)	12-14	6-9	7-10	8-10
Zinc (Zn)	3-4	3.5-5	3-4	3.5-5
Boron (B)	12-14	2.5-5	3-5	3.5-5
Copper (Cu)	1.5-2	1.5-2	1.5-2	1.5-2
Molybdenum (Mo)	.5-.75	.2-.3	.2-.3	.2-.3
Aluminum (Al)	0.3	0.5	0.3	0.5

AEA Comments

- We have been able to gain some unexpected insights from the use of sap analysis as a nutrition management tool. First of all, sap analysis makes farmers a lot of money.

- Secondly, sap analysis saves farmers a lot of money. Did you know that the nutrient deficiencies of your crops are likely not caused by nutrient deficiencies? Since we have starting using plant sap analysis, we have realized that many of the nutrient deficiencies that crops experience are not caused by inadequate nutrition.

- Most imbalances are created by the nutrient excesses farmers apply, which trigger the deficiencies of other elements. This is a powerful realization, because it means we can often improve plant performance and vigor by stopping unnecessary applications. This can obviously save a lot of money in wasted fertilizer applications. As the excess nutrient levels are reduced, deficiencies come into balance, and plant vigor jumps very quickly. This makes a lot of money.

- Using sap analysis gives you accurate information and data to make better assessments of what is happening, and make more effective decisions. Using sap analysis gives you the ability to detect nutritional imbalances three to four weeks earlier than tissue analysis. Using sap analysis allows you to tell immediately which products are performing in the field, and which are not. Using sap analysis allows you to accurately define the differences in nutritional requirements between different cultivars, which makes a lot of money.

- Using sap analysis allows you to make proactive decisions to manage nutrition, rather than reactive decisions after a problem has already become evident. Using sap analysis enables you to prevent problems, instead of just band-aiding them.

ADDITIONAL NOTES