Micronutrient Uptake Sources, Compatibility

Serious questions need answering regarding feeding the world.

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Summary: *Why is all this important to agricultural sustainability? Quality of food in feeding the world is critical to human survival. This involves vitamin, microelement and protein. Water and nutrient efficiency involve crop performance. Water, nutrient efficiency, pharmaceutical work and plastics are equally important to a growing world population.*

We'll begin with a brief look at history. We go way back to the Romans and Greeks who brought Pb, S, Hg, and Fe into the world of agriculture. By 1,000 AD, seaweeds appeared in Ireland. N, P, K (manures) appeared on the scene in the 1800s in Rothamsted, England. In late 1800's Anton de Bary, symbiosis; Carlsberg labs and yeasts in Denmark; and Burgunday/Bordeausx mixes (Cu, S, N, and Ca) in France. In 1909, Haber-Bosch. By 1934, ethylene bis-di metal dithiocarbamates--Mn, Zn. In the 1930's, green manures via Rothamsted. Moving on to 1937 we see Florida citrus/nitrates and urea (biuret) in Agriform, California. By the late 50's, we see the first evaluation of absorption T50 times of multiple nutrients and crops at Michigan State University. Urea grain protein began appearing in the plains. Bugs and extracts were part of the Trichoderma spp by the 1970's. NPK grains, potatoes, beets, and canola began to appear in the United Kingdom in the 1980's, as did soil microbes (B) and extracts, stimulants, crop protection, P solubilization, humic/fulvic acids, hormones and novel compounds.

Truism. Plants can't run away so they need to be smart enough to survive in SITU.

Genetics ahead:

- Drought tolerance
- Nutritional
  - Constitution
  - Taste
  - Quality
- Nutrient use efficiency
- Non-conventional use e.g. B/N,
- Zn/Ca, Ni/Zn, SAR, nutrient solubilization, phylloplane/sphere, rhizoplane/sphere, rhizoplane/sphere (exudates).

Nutrition:

- Malnutrition now accounts for 45 percent of all deaths of chidrenfor 45 percent of all death o fchildren under 5 worldwide:2.6 million children lost Medecins Sans frontiers
- 30% of world population deficient in iron
  - anemia, hearing loss (Penn State
  - in UK, post-operative patients given Guinness

Agronomy. Many definitions. For us, let us stay with positive economics of favorable gene expression mediated by our advice and inputs:

- Disruptive technologies and strategy for innovation: be very careful and selective
- Creating ROI at every level from to dinner plate.

Physiology is the science of the function of living systems.

- Whole crop
- Plant

- Organ
  - Leaf
  - Root
  - Fruti/Tuber
  - Seed
- Cellular
- Organelle—chloroplast, mitochondria
- Bio-molecules (execute chemical or physical functional in living system)

Figure 1 provides a stage by stage look at the Plant Hormone Cycles.

Defining Physiology. Physiology is the science of the function of living systems.

- Whole crop
- Plant
- Organ: leaf, root, fruit-tuber, seed
- Cellular
- Organelle: chloroplast, mitochondria
- Bio-molecules (execute chemical or physical function in living system)

Physiological tools. We are no longer curing deficiencies, at worst we preempt or override (transient deficiencies). The products and solutions we offer are best considered as physiological tools to assist maximal gene expression.

Genetics

Genome

Genes

Genotype

GMO vs CRISP-CAS9—NOW-CPF1

Genetic Scissors

Prometheus/Ethic

Role of CL, CA, ZN and B in Mineral Nutrition of Row Crops—A Physiological Overview

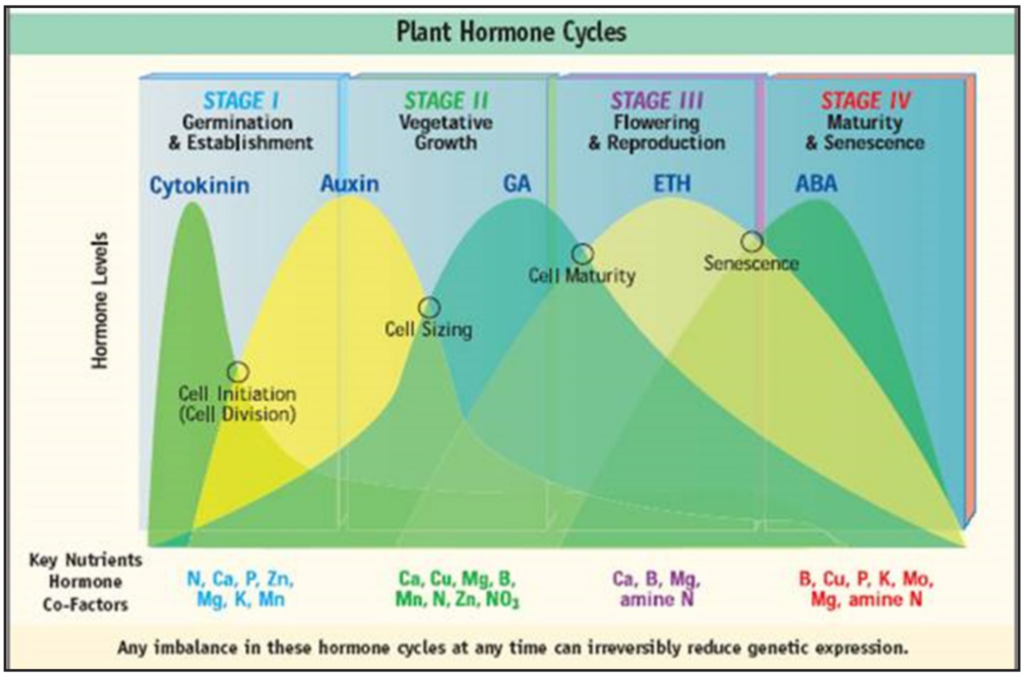


Figure 2. Leaf Shape – standard cotton vs. okra cotton

- CONSTITUTIVE (sometimes referred to as structural):
  - Cell wall membrane integrity Disease and pest resistance
  - Storage quality
  - Protein Structure (enzyme and co-enzyme)
- CHEMICAL
  - Metabolic Processes
  - Regulation
  - Messengers
  - Hormone, Protein and carbohydrate synthesis
- Functional constitutive/chemicsl cross-overs between Zn, Ca, and B
- Product Rationale

Physiological Tools

- Genetics
  - Genome
  - Genes
  - Genotype
  - Phenotype (that would be us)
- GMO vs Crispr-CAS9—NOW—CPF1
  - Genetic scissors
  - Promethesus/ethics

Physiological and Biological Targets

- Food: fruit, seed, stem, roots, leaves
- Fiber: flower/seed, stems, tubers
- Fuel: seed, stalks, leaves
- Fun: leaves and flowers

Target Manipulation:

- Seed: Abundance, germ efficiency, seed mass, oil/protein content, storage
- Leaf: Longevity, mineral content and sink available, strength, respiration photosyn- thetic area and duration
- Whole plant: Plant growth rate, architecture (height, phyllotaxis etc.) fiber and sugar content, source/ sink relationships

Figure 2: Leaf shape—standard cotton vs. okra cotton.

Figure 3: Root tip cells—generalists to specialists

Figure 4: Photosynthetic advances

Photo crystals (Figure 3) reflect blue wavelengths but absorb red and green in low light (begonias, forest floor) slowing gap between incoming and reflected light, thus improving photosynthesis. Genes protect against high light intensity damage, switch off to speed up photosynthesis after shade. Plants yield higher with fewer leaves (shade effect).

Soil Applications:

- Seed treatment/inoculation
- Starter
- Irrigation
- Drench

Limits with conventional inputs such as fungicides, insecticides.

Foliar Applications: Much maligned in "conventional" circles:

- Cure-all vs. agronomic proven supplement. Muck and mystery vs. proven solutions. Ignorance at "research" level is a hurdle

"Quality of food in feeding world is critical to human survival"

  (disparate disciplines).
- Multiple ride opportunities?
  - Clyphosateherbicide.
  - Fungicide.
  - Corrective/compensatory/ additive aspects.

Delivery Chemicals:

- Soil
  - Chelates, strong complexes
  - Soil and chemical compatibility
- Foliar
  - Weak complexes
  - Plant analogs
  - Adjuvants
  - Translaminar and translocation
  - Plant(non-phyto) and chemical copatibility

Figure 5 shows all the elements involved in Sugar Alcohols Lowe Weight Acids.

Crop Protection:

Antagonism vs. "cidal"

Resistance vs Tolerance

Generally speaking, a healthy plant/crop is more resistant to:

- Fungi(balance N, green manure)
- Insects
- Weeds
- Nematodes

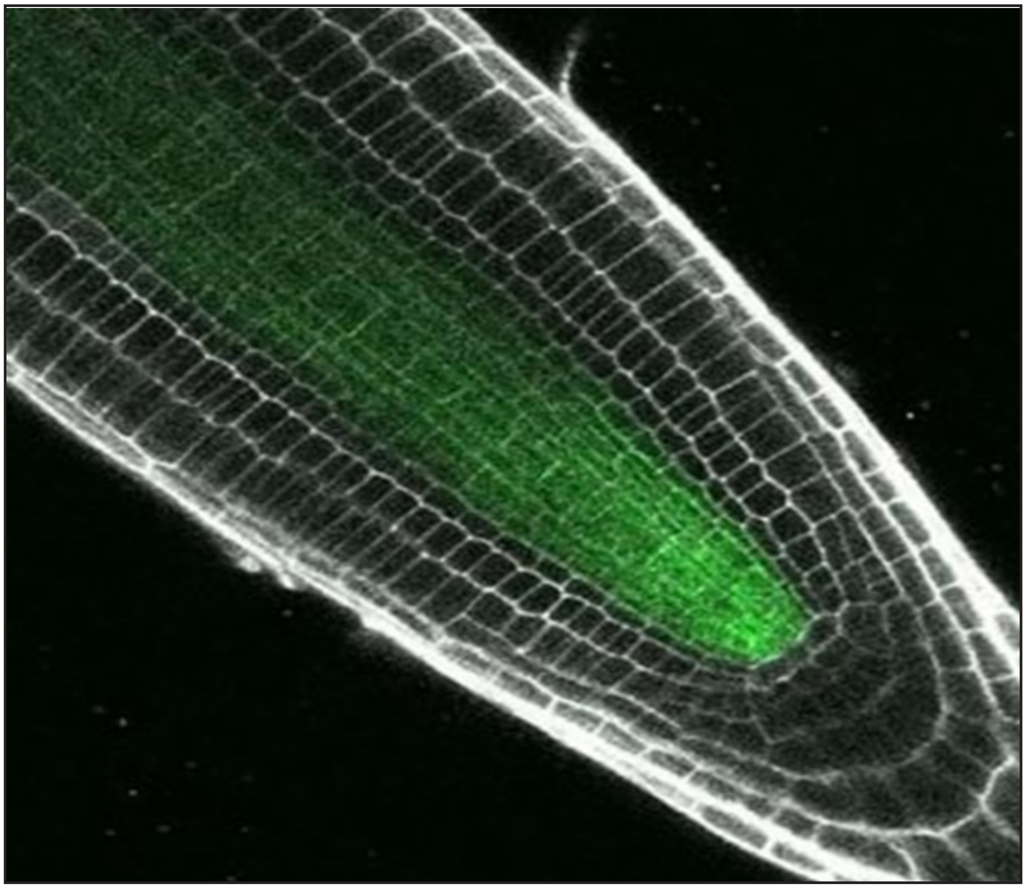


Figure 3. Leaf Shape – Root tip cells – generalists to specialists

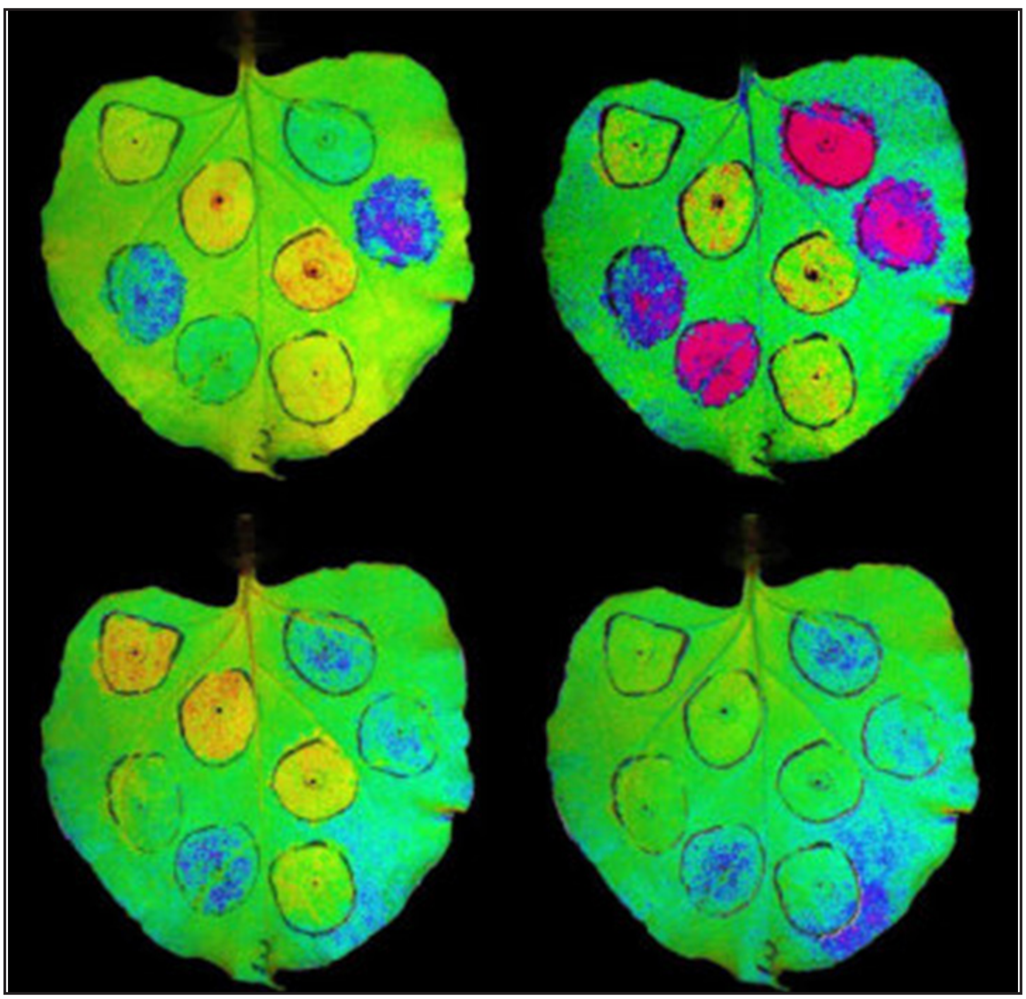
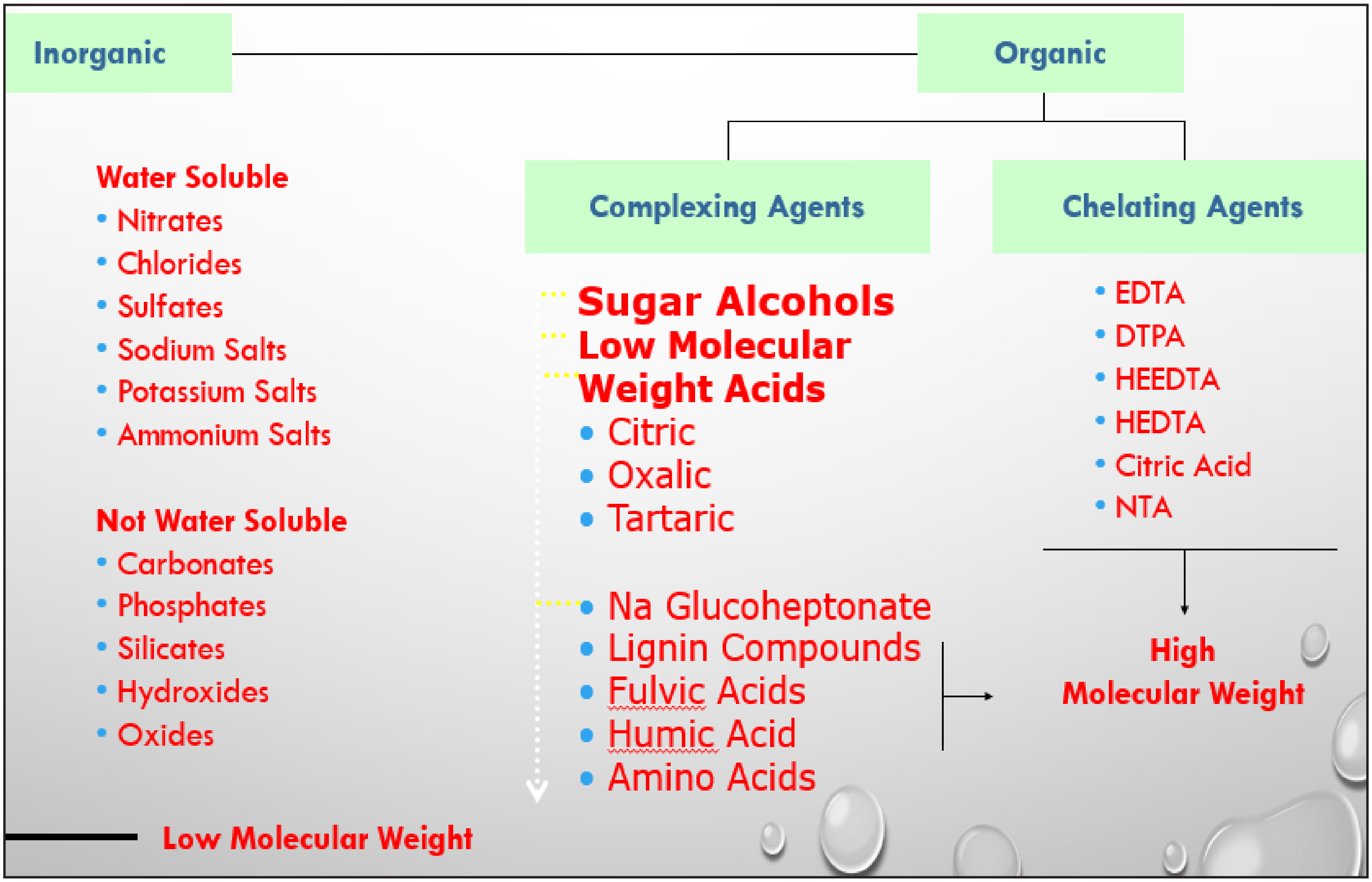


Figure 4. Photosynthetic advances



Insecticides:

- Leaf chemistry and structure
- Boron, Zn. Cu, including chemical composition
- SAR is real
- Ultra-violet and reflectance
- Physical/structural barriers
- Predation, antagonism and “cidal”

Biologicals, Bio-Stimulants, PGR??:

- Confusion of definitions, regulations, claims—this is not GMO
- Abiotic/biotic – diversity of live/dead bugs and compounds
- Nutrient efficiency, plant regulation, insect/disease suppression, genetic expression, seed enhancement, stress management (water, temp), post - harvest, light utilization, xenobiotic metabolism (herbicide st ress),
- Traits cross below ground (e.g. root architecture and leaf (e.g. life-span, LAI/PAR)—spectral phenotyping.

Tools of the Trade:

- Organisms
    - PGPR
    - Inoculants
- Metabolites
    - Fermentation products
    - Synthetic extracts
- Plant extracts
    - Oils
    - Hormones (seaweed)
    - Humics/fulvics?
- Epigenetics-DNA/RNA transcription controls.

Why is all this important? Agricultural Sustainability?

- Serious question? Feed the world, etc…
- Quality of Food and Feed
    - Vitamin, microelement, protein
- Crop performance
    - Water, nutrient efficiency
- Industrial
    - Pharmaceutical, plastic
- Fiber
- Fuel
- Quantum physics
- Real science and funding

Science to Watch:

- Plant/soil feedback
    - Roots (genes) interact with fungi and bacteria =-huge ramifications for biological inputs and NPK
- Crispr-CAS9, genetic scissors--not GMO? Know over No…(R.SAIK)
- Apartment buildings/office blocks--climate control=year-round growing
- 3-D printing cell-pods as home appliance
    - Plant cell to meal ‘cellular agriculture”
- Human agriculture dated to – 12K years ago, Fijian ants shown to sow seeds and fertilize—3 million years ago.

Dr. Julian Smith is a member of the Fluid Fertilizer Foundation Board of Directors and a managing editor on the Fluid Journal magazine’s Editorial Committee.