Specifically Formulated - Balanced Ratios of the Ionic and Nitrogen bound Micro-Nutrients Zinc (Zn) and Copper (Cu) together with Sulfate

BIO-AVAILABLE MINERAL FORMULA-X (BAM-FX™)

by Dr. John L. Freeman

The White Paper describes the new (BAM-FX™) technology that utilizes balanced ratios of ionic micronutrients, together with micro-molar amounts of nitrogen-bound micronutrients and sulfate in order to achieve enhanced Growth Rates, Greater Yields and Better Crop Quality. This paper is based on the U.S. Patent No. 9,266,785 by John Wayne Kennedy.

The Science and Philosophy behind BAM-FX™

The Importance of Zinc and Copper to Crop Plants (The S*cience behind BAM-FX field trial observations*)

High levels of Zinc are found inside seeds located in the plant embryo's root tips because germinating seedlings require Zinc for the machinery inside dividing root cells and for the activation of gene transcription events, which occur during germination, growth and plant development. Zinc finger transcription factors [1] (Zinc containing proteins that bind DNA, which initiates gene transcription events, often associated with plant growth[2] and stress responses [3]) which do the following:

1. Activate genes controlling plant developmental regulation hormones [2]; Auxin (which includes hormones up-regulating root and shoot growth) Gibberelins (responsible for flowering and continued growth), Ethylene (which control fruit ripening processes) [4].

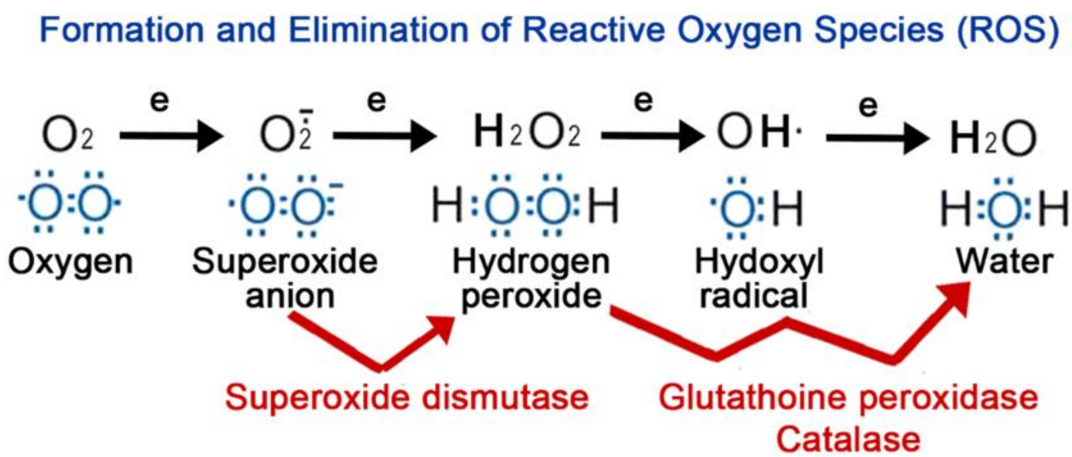
2. Activate plant stress responses [4, 5] and secondary metabolism [6] ; Increase antioxidant function; Induce secondary defense compounds (N and S containing primary and secondary metabolites).

This often allows crop plants to cope with environmental plant stresses, which produce reactive oxygen species (ROS) that are caused by drought, salt, heat, intense light, frost, pathogens (insects and microbes), excess nutrients and metals. ROS generated by these environmental stresses are most often responsible for killing crop plants. **Excess ROS > Plant Death**

KEY ENZYMATIC MECHANISMS OF CROP PLANT ROS DEFENSE AND PHOTOSYNTHETICALLY DRIVEN GROWTH

Copper and zinc containing enzyme Superoxide Dismutase (SOD) is a preferentially targeted large molecular weight protein complex [7] [8] that contains zinc and copper at the active site where ROS is reduced or scavenged/destroyed.

1. Cu/Zn SOD is an enzyme that actively reduces superoxide and to form hydrogen peroxide in plants before being further reduced to water using, enzymes, vitamin C and Glutathione**.



THE IMPORTANCE OF COPPER IN PHOTOSYNTHESIS AND THE ENERGY REQUIRED FOR CROP PLANT GROWTH

PLASTOCYANIN COPPER CONTAINING ELECTRON CARRIER IN CROP PLANT PHOTOSYNTHETIC SYSTEMS

Copper's primary target in plants is the plastocyanin family of copper-binding proteins. These proteins are in the chloroplast (site of photosynthesis) and are key molecules for efficient photosynthesis. They are responsible for physically delivering or shunting electrons from photosystem II [9] specifically into photosystem I.

Having a higher efficiency in photosynthesis will enhance the overall crop yield and help enhance the quality of crops. It can also help reduce the occurrence of ROS, because if the plant has just the right amount of copper, it is most highly efficient at producing photosynthate - ATP or sugar (degrees Brix^{o}).

THE IMPORTANCE OF CROP PLANT ANTIOXIDANT - GLUTATHIONE AND THE EFFECT OF INDUCED SULFATE ASSIMILATION

Sulfate ($SO4^{2-}$) is the best form of sulfur to have in a precision mineral nutrient product for crop plants. Sulfur is one of the most important minerals in plants ranked equally to Nitrogen.[10]

1. Sulfate is efficiently taken up by roots and enters the sulfur assimilation pathway, being reduced and incorporated into cysteine and methionine, important for protein structure and function, cysteine often being found at the active site of enzymes.
2. Another, and likely most important target site for sulfate in plants, is glutathione, which is a potent antioxidant. Glutathione (GSH) is reduced in the above listed enzyme glutathione peroxidase path, which, along with ascorbate (vitamin C) reductase, removes harmful reactive oxygen species (i.e.,hydrogen peroxide) to produce water (H_2O).
3. Another target site for sulfate is into secondary defense compounds that protect plants from pathogens (insects and microbes). These compounds are very important for plant resistance to infestations and infections that result in undesirable taste. Incidently, these same compounds have been shown to have anti-carcinogenic properties in humans and may help resist the development of cancer. http://www.cancer.gov/about-cancer/causes-prevention/risk/diet/cruciferous-vegetables-fact-sheet

THE IMPORTANCE OF AMMONICAL NITROGEN BOUND TO ZINC AND COPPER AT MICROMOLAR LEVELS

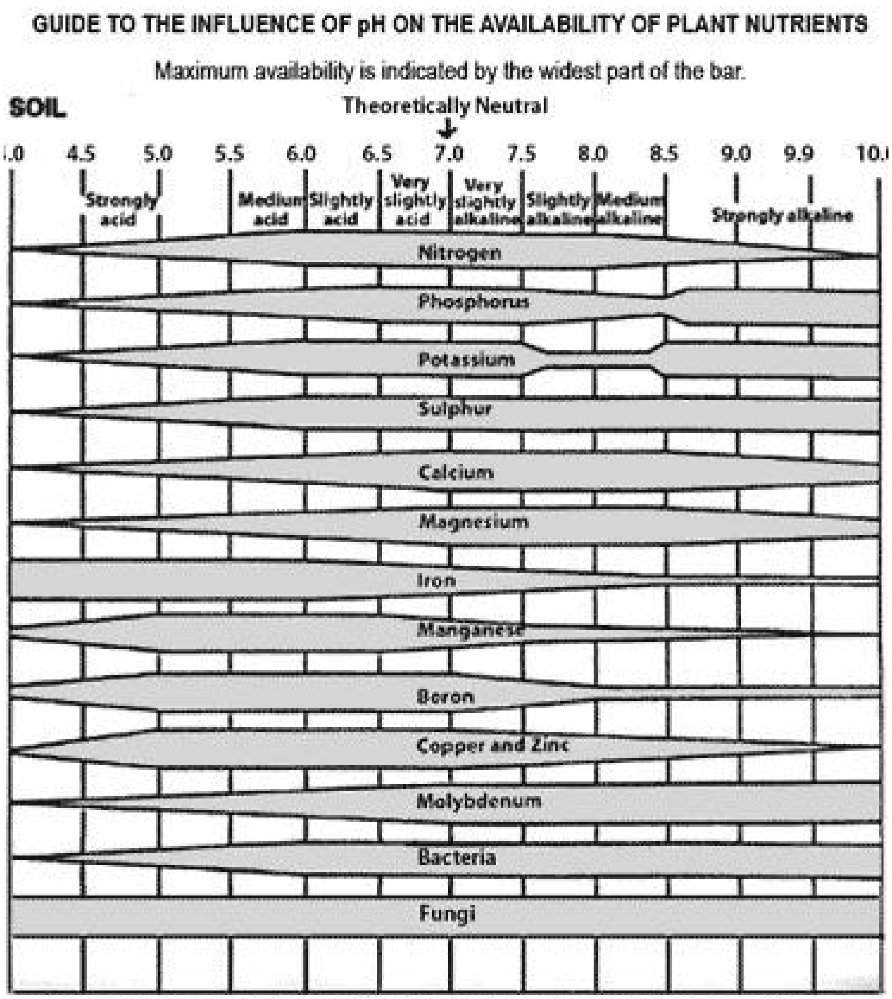
Amines or Ammonia (NH_3 are the best forms of nitrogen to provide to plants because ammonium ions are absorbed by plants via ammonia transporters.

1. Ammonia is incorporated into amino acids via the glutamine synthetase-glutamate synthase (GS-GOGAT) pathway.[11] While nearly all [12] of the ammonia in the root is ordinarily incorporated into amino acids at the root itself, plants may transport significant amounts of ammonium ions in the xylem to be fixed in the shoots.[13]
2. This may help avoid the transport costs of organic compounds down to the roots just to carry the nitrogen back as amino acids.

Additional grower based observations of BAM-FX in the field, observed by outside third parties, reported that plants recovered faster from frost induced stress and that crop plants were able to better resist drought and pathogen attacks from insects and subsequent viral infections. Further data are required; however, to substantiate these preliminary observations.

The use of BAM-FX also appears to affect the overall quality of the crops and the fruit harvested, increasing brix or sugar content in grapes and berries (strawberries and raspberries), increasing vegetative yields and protein content in feed and grains, and root growth in a variety of crops. Second and third season trials are underway to confirm these initial observations.

Finally, the use of BAM-FX in first season trials on spinach and corn appears to have yielded the best results, with a reduction in up to 25% less Nitrogen fertilizer. It is likely that the low pH (2-3) of BAM-FX may also be increasing the solubility of nutrients and together with the observed increased root growth may initially result in less nutrient requirements. Indeed, BAM-FX has been observed by many growers to cause increases in a variety of minerals derived from soil applications of often mobile at a soil pH of 5.5 - 6.5 (e.g., nitrogen, phosphorous, potassium, sulfur, calcium, magnesium, iron and olybdenum). For reference, a table of the solubility index of various minerals in soil according to pH is provided.



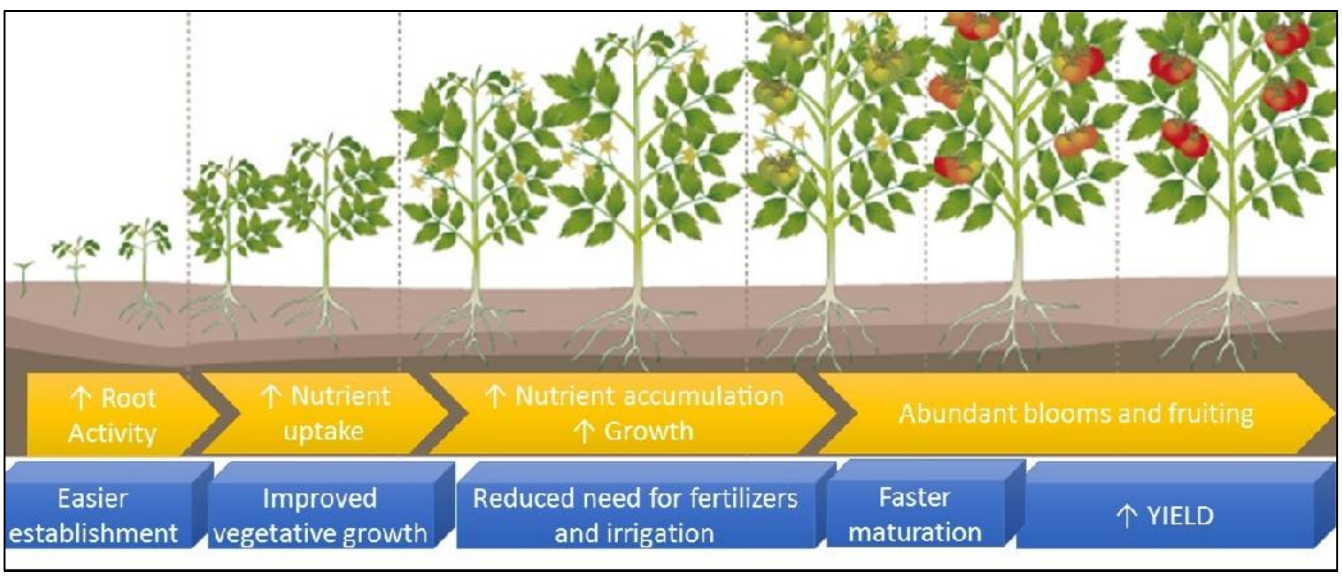
Relationships existing in mineral soils between the pH and the availability of plant nutrients and the activity of microorganisms. The wider the band, the greater the availability or activity.

BAM-FX carries a positive charge and contains zinc and copper in a ratio of 7:2. Early laboratory testing of the BAM-FX ligand chemistry showed positive effects on key aspects of plant physiology. Seed germination occurred more quickly and more reliably under conditions of stress. Root systems developed a greater degree of branching and higher abundance of nutrient and water-collecting root hairs. Maturing plants developed faster and produced more biomass, with stronger roots and stems and improved survival under conditions of stress. In the field, commercial farms conducting trials noted significantly greater plant and root growth, improved transplant establishment, coupled with high increases in crop yields.

Research to understand the full range of plant effects of BAM-FX is ongoing. One area of particular interest is in characterizing the molecular mechanisms in the plant that respond to this specific chemistry. The improved stress tolerance and recovery of plants treated with BAM-FX suggests that the positive charge carried by BAM-FX may also be acting itself as a molecular free radical scavenger to help rescue the plant from oxidative stress, and the full potential for this chemistry to positively impact crops after exposure to climatic or other stressors, and all the molecular mechanisms responsible are currently under study by many growers, CCA's, scientists and crop extension agents.

Importantly, BAM-FX also has shown the potential to reduce fertilizer usage by commercial farms in season one use. Our observations support that as a crop plant becomes more self-sufficient after proper levels of mineral micro-nutrients are provided, that it is likely much more able to also collect peripheral soil nutrients. Early laboratory testing suggested that the published "optimal," often high level requirements of many nutrients, were decreased when used together with BAM-FX.

The key to maximum production resides in the growing a more self-sufficient, robust plant. Plant growth must be improved from the time of earliest seed germination, through the growth phases of vegetative growth of roots, stems and leaves, all the way to fruiting, seed production and harvest. The plant must operate at a higher efficiency to produce all the things we consume for our food - leaves, fruits, nuts, stalks, and roots or tubers, and also become more resilient to environmental stress. The process must begin by affecting plants at the *molecular* level in early development and carry through until well after harvest (*see illustration below*).



For further information:

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