Research, Validation and Commercialization of Technologies

Part D-2: Plausible Scientific Evidence of Supreme(AG)™ with Nutri-Mastic™ as a Mulch, Soil Amendment, Natural Fertilizer, and More

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IFUS Table of Contents:

As a brief reminder, the IFUS Scientific Team is challenged with finding plausible explanations as to the reported efficacy of SupremeAG™ with Nutri-Mastic™ as this IFUS Product Line was discovered and NOT invented. Hence the science is intended to support the application, such that efficacy of SupremeAG™ with Nutri-Mastic™ creates desired performance outcomes. As we say, Input / Output.

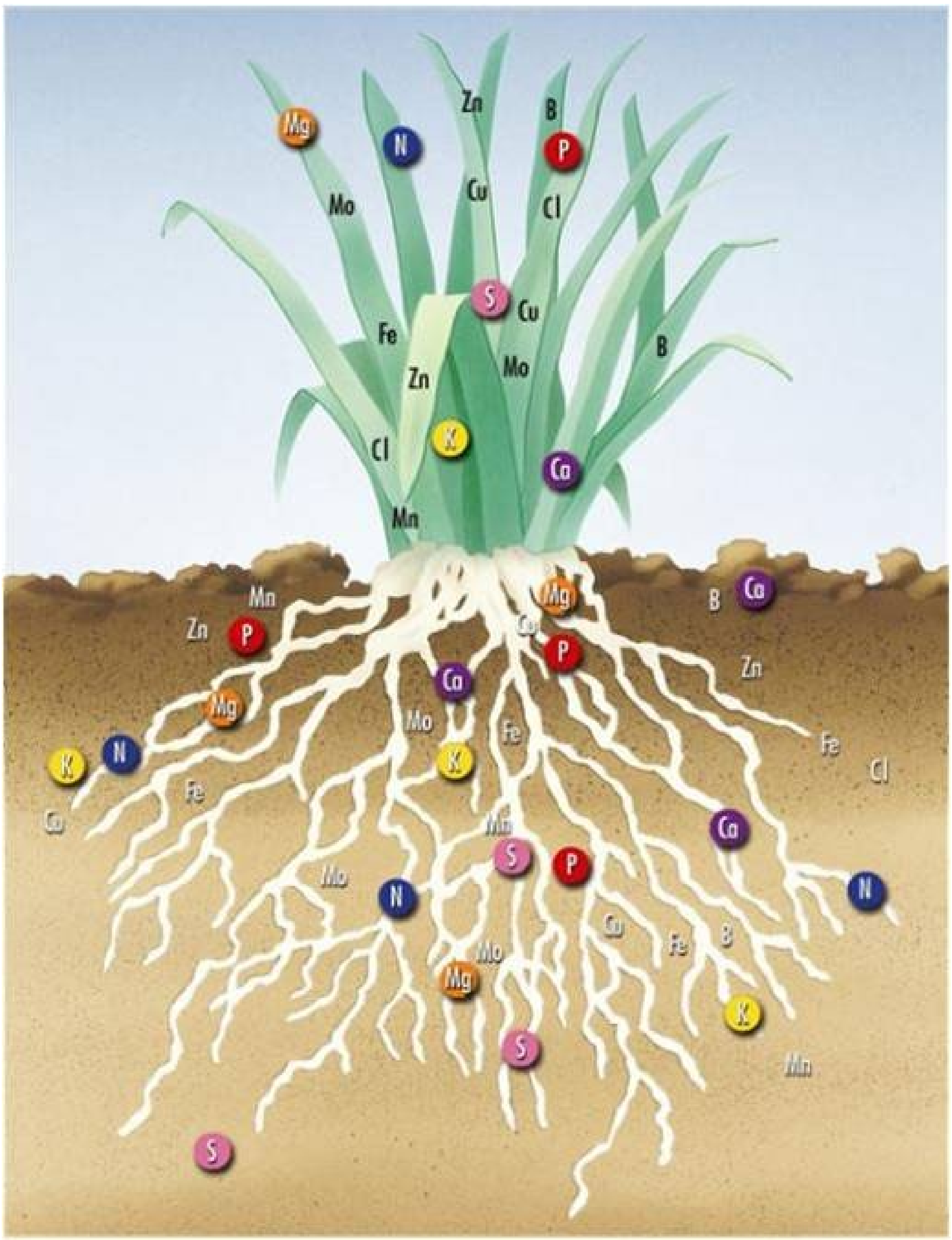
Once more, we begin with the notion of "Soil: The Foundation of Nutrition" per the illustration below. This simplified, yet complex diagram attempts to illustrate the actions, interactions, and relationships (both inter- and intra-) that create a maze of inter-dependencies, that allow for the health and unfortunately more so the illness of what is believed to be over 2-Billion of the roughly 8.25-Billion humans from "micronutrient deficiencies." This affects more than 25% of the present global population…the socio-economic consequences of which are staggering.

Source: https://talborne.co.za/wp-content/uploads/2023/02/a-bc275e_page-0001-1024x724.jpg

Of note in the diagram above (and on the far-left hand bottom corner) is the presence of "Soil macronutrients" and "Soil micronutrients". Furthermore, in the diagram, we see assigned to the plant the expression of plant performance from these "macro- and micro-nutrients". Lastly, we see in the diagram the progression of the "macro- and micro-nutrients" to human function and well-being.

In this Part D-2 White Paper, we explore the actions, interactions, and relationships of these "macro- and micro-nutrients" from an individual and collective exploration into the science.

<u>IONIC MINERALS IN SOIL:</u> What does the science tell us about ionic minerals in the soil?



Source: Minerals Nutrition In Plants at Harold Hernandez blog:
https://biology4isc.weebly.com/uploads/9/0/8/0/9080078/____4507246_orig.jpg

In a Special Issue of "Plants" (ISSN 2223-7747) 2024-2025 in the section "Plant Nutrition" and titled "Molecular Mechanism of Plant Mineral Nutrient," three Guest Editors (Dr. Cankui Zhang, Dr. Jing Huang, and Dr. Chao Xia) write:

"Dear Colleagues,

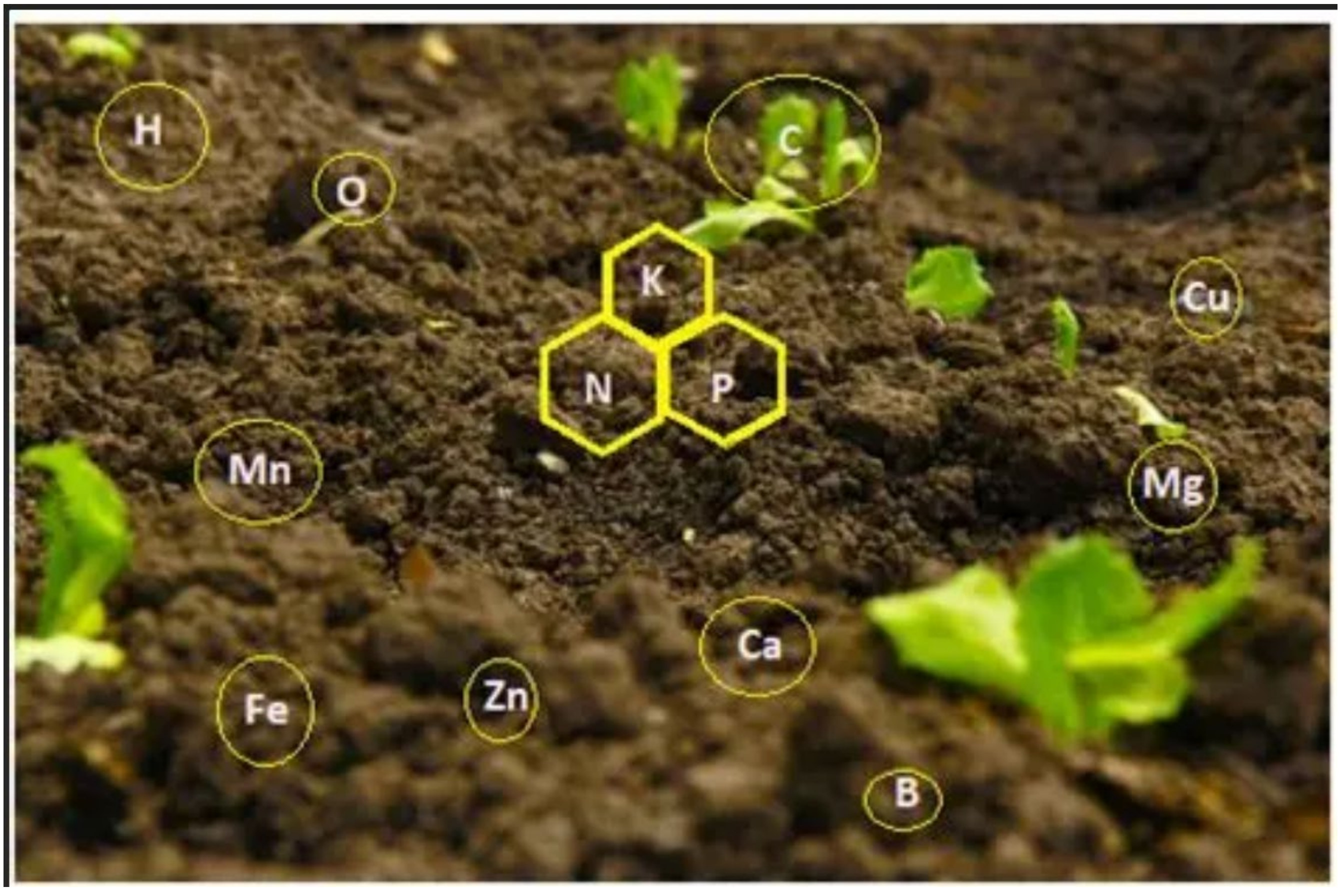
Plant mineral nutrition plays an important role in the health of plants and humans. Over the past few decades, the study of plant mineral nutrition has transformed from a predominantly applied field to a fundamental dissection of molecular mechanisms. This Special Issue will delve into the cutting-edge research and revelations that unveil the intricate molecular mechanisms of nutrient sensing, uptake, transport, and homeostasis in plants. It unravels the complex system of ion transporters and the regulatory networks orchestrating nutrient-responsive gene expression, spanning local and systemic signaling levels. Our collection of articles offers a comprehensive overview of this crucial aspect of plant biology. These insights have significant implications for sustainable agriculture, global food security, and our comprehension of how plants adapt to diverse environments. The knowledge generated can pave the way for strategies to develop crops with improved mineral use efficiency, thus mitigating fertilizer pollution of underground water systems through runoff. Join us in exploring the frontier of plant mineral nutrition for a greener, more nourished world."

Source: https://www.mdpi.com/si/190954

This exceptional strategic initiative holds great promise to assist IFUS in better understanding the efficacy of its Nutri-Mastic™ formulation as well as the application of said formulation both as an ingredient and technology in other IFUS Product Lines (to include Intact Digest™, Intact Endurance™, Equine Intact™, SGP+™, SGP+2.0™, SupremeAG™, and AIT™).

For purposes of this White Paper, SupremeAG™ remains the focus. However, at times an overlay of science discovered from research performed on other IFUS Product Lines offers valuable overlayed information.

Hence, we begin with an exploration of minerals in the soil as well as the actions, interactions, and relationship to Humic Substances and the native microbial "biome."



Source: [Mineral Riches in Soil: Formation, Minerals, Composition - Embibe](https://www.embibe.com/exams/mineral-riches-in-soil/): https://www.embibe.com/exams/mineral-riches-in-soil/

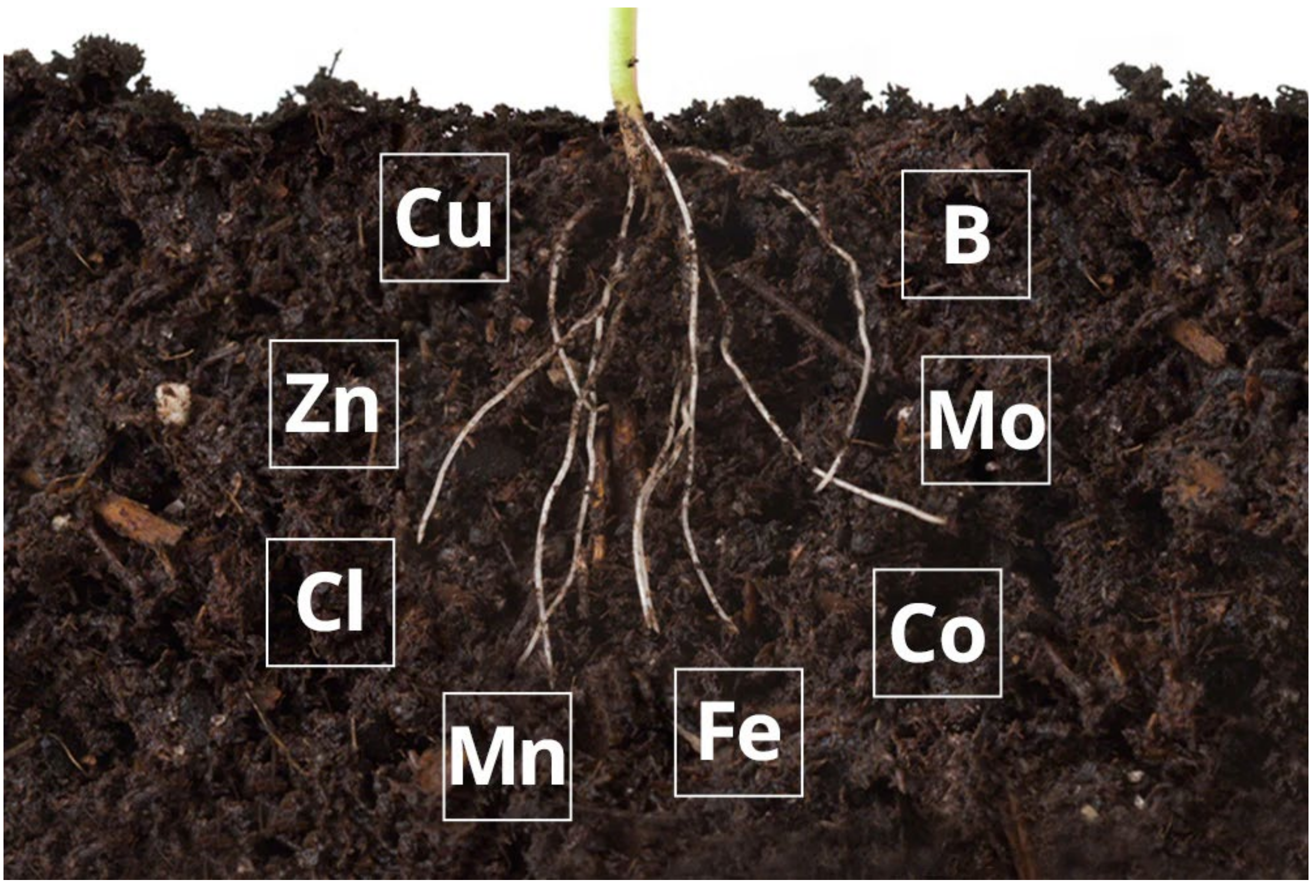
"ECOFARMING DAILY" discusses "Soil Testing", in which it is stated: **"We know there are over 20 minerals needed to grow plants. We know there is a certain level of minerals needed in the soil (a sufficiency level), and that there is a balance or a ratio between them. We also know soil with "perfect" soil testing results does not always grow perfect crops."**

Soil testing is not looking for perfection in numbers. It is a tool to identify limiting factors: nutrients that are deficient or in excess. **It hopefully doesn't matter which soil testing lab you use; they all use extraction methods that give clues as to mineral levels** and what type of soil it is based on CEC, pH and organic matter. It's simple to add the nutrients that are short and not to add more of what you already have enough of."

Souce: https://ecofarmingdaily.com/build-soil/soil-inputs/minerals-nutrients/for-healthy-soil-high-quality-top-yields/

Where the IFUS Scientific Team acknowledges the invaluable information provided to it (as demonstrated by "ECORFARMING DAILY"), the team believes that if a renewed approach to more eco-friendly, cost-effective, and sustainable agriculture is to be realized, the simple addition of any given nutrient may well be reflective of thinking that no longer aligns with where science is evolving.

Hence, it considers that at the basis for plant health, is healthy root development. We beg the question as to what ionic minerals are required for healthy root development of plants, trees, and shrubs.



Source: https://geolifeshop.com/cdn/shop/articles/Taurus-Inbound-Blog-Mar2018-AgriculturalNutrientProfile-Micronutrients-Part2-02a.jpg?v=1653152516

"Abstract: The soil contributes to the main pool of essential mineral nutrients for plants. These mineral nutrients are critical elements for the building blocks of plant biomolecules, play fundamental roles in cell processes, and act in various enzymatic reactions. The roots are the main entry point for mineral nutrients used within the plant to grow, develop, and produce seeds. In this regard, a suite of plant nutrient transport systems, sensors, and signaling proteins function in acquiring mineral nutrients through the roots. Mineral nutrients from chemical fertilizers, composed mainly of nitrogen, phosphorus, and potassium (NPK), are added to agricultural land to maximize crop yields, worldwide. However, improving nutrient uptake and use within crops is critical for economically and environmentally sustainable agriculture. Therefore, we review the molecular basis for N, P, and K nutrient uptake into the roots. Remarkably, plants are responsive to heterogeneous nutrient distribution and align root growth and nutrient uptake with nutrient-rich patches. We highlight the relationship between nutrient distribution in the growth environment and root system architecture. We discuss the exchange of information between the root and shoot systems through the xylem and phloem, which coordinates nutrient uptake with photosynthesis. The size and structure of the root system, along with the abundance and activity of nutrient transporters, largely determine the nutrient acquisition rate. Lastly, we discuss connections between N, P, and K uptake and signaling."

Ref. 1: Wendy J Lyzenga, Zhigang Liu, Toluwase Olukayode, Yang Zhao, Leon V Kochian, Byung-Kook Ham, Getting to the roots of N, P, and K uptake, Journal of Experimental Botany, Volume 74, Issue 6, 28 March 2023, Pages 1784–1805, https://doi.org/10.1093/jxb/erad035

Ref. 2: Bhardwaj, E., Shukla, R., Das, S. (2020). Plant Roots and Mineral Nutrition: An Overview of Molecular Basis of Uptake and Regulation, and Strategies to Improve Nutrient Use Efficiency (NUE). In: Giri, B., Sharma, M.P. (eds) Plant Stress Biology. Springer, Singapore. https://doi.org/10.1007/978-981-15-9380-2_5

Where again the aforementioned studies provide invaluable insight into the function of Mineral Nutrition to healthy root development of plants, we remind ourselves of the contention of Dr. Pettit: “Man became distracted from the importance of organic compound cycling when it was discovered that soluble acidic based N P K 'fertilizers' could stimulate plant growth. Large industrial concerns took advantage of the N P K discovery to market industrially processed 'fertilizers' from mineral deposit. Continued use of these acidic fertilizers in the absence of adequate humic substances (in the soil) has caused many serious sociological and ecological problems. Man needs to reconsider his approach to fertilization techniques by giving higher priority to soil humus.”

Hence, where we acknowledge the importance of proper N, P, K balance in soil, we also suggest that present science seeks to balance these ONLY in relationship to "soluble acidic based N P K "fertilizers"', while neglecting the actions, interactions, and relationships to "soil humus". We further contend that this present-day focus fails to include the role of both "macro- and micro-nutrients" contained within the soil (specifically the soil humus) in such a manner that the natural microbial "biome" is not only sustained and supported, but optimized.

As an aside, Dr. Sam Westreich asks in an article titled, "How Does a 1,200 Pound Cow Get Enough Protein?" Per Dr. Westreich and simply put, the microbes on the grass.

As a PhD in genetics, bioinformatician, and scientist, **Dr. Westreich contends: " Microbiome is the secret of biology we've overlooked…"**

Dr. Westreich's "content on the microbiome is a blend of scientific exploration and personal insights. His articles often delve into complex biological questions, such as the role of the gut microbiome in health and disease, and the implications of microbiome disruption."

Hence, prior to the application of acidic NPK fertilizers, anhydrous ammonia, pesticides, and herbicides, a natural microbial biome existed both in the soil and on/in the plant. With the advent of WWI and more so WWII, the industrialization of countries like America saw migrations of people into urban population centers. Where these people once grew their own food, the need to feed them (along with the building of large military forces) demanded a shift in the rate of speed and yield of crops.

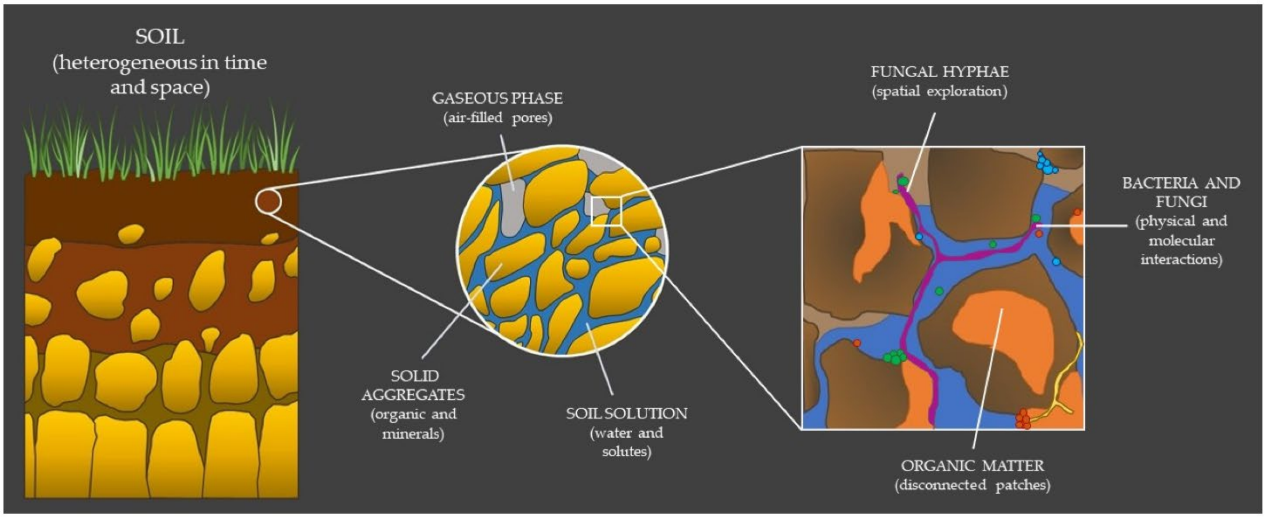
Feedlots for cattle, the shift from free-range grazing, decreased renewal of the soil from the cycling of manure and urine, the application of NPK Fertilizers and other synthetically derived substances, shifting weather dynamics, economic pressures for land utilization and more are but one example of humankinds intervention and disruption of natural processes…to include naturally renewing and occurring humic substances, minerals, microbes, and phytochemicals.

In a perfect storm, this need coupled with the discovery, refinement, and application of petroleum and petrochemical products resulted in dramatic shifts in agricultural practices. Not until recently have we begun to question the nutritive quality of crops and produce from these life-cycle shortening agricultural practices. Where the plant, tree, and/or shrub might find a short-term acceleration in growth and production, it tends to experience shorter life expectancy (a decrease in life-cycle optimization), as well as produce of poorer quality and lower nutritive value. Hence, we must eat more to get the same amount of nutrition we once experienced from crops and produce.

Soil complexity took a necessary back seat to the need to feed a rapidly shifting population base. However, the short-term impacts of agricultural practices that to some extent ignored soil complexity, became more exaggerated over time and have now reached a point where many are calling for significant changes in these agricultural practices

As an example of the complexity of microenvironments, we consider a study (Mandolini, E.; Probst, M.; Peintner, U. Methods for Studying Bacterial–Fungal Interactions in the Microenvironments of Soil. Appl. Sci. 2021, 11, 9182. https://doi.org/10.3390/app11199182).

Per "Figure 1. The complexity of soil depends on the scale of analysis and is ultimately a mosaic of dynamic microenvironments defined at a specific point in time and space. Fungi and bacteria, together with other soil residents, live, grow and interact in this reality to the best of their fitness, perpetually looking for their realized niche."



"Abstract: Mineralization by soil micro-organisms plays an important role in the environment as it releases trapped mineral nutrients (phosphorus, potassium, magnesium, calcium, and iron) required for plant growth. Ectomycorrhizosphere hosts diverse microorganisms (bacteria and fungi) that can stimulate each other forming specific interface between soil and trees. Fungi are known to cause geochemical changes and have a major role in the plant-root region, soil and in rock and mineral habitats. Therefore they have different roles in nutrient cycling that keeps the soil in good condition for plant growth. Majority of ectomycorrhizal root tips occur in mineral horizons exploiting the nutrient-rich substrates and helps to assimilate and translocate the nutrients. The extramatrical mycelia of ectomycorrhizal fungi acquire carbon from the soil through the enzymatic breakdown of organic matter and from tree photosynthates. This contributes to the association between weathering of minerals in the soil and photosynthetically-assimilated carbon acquired from trees. The microorganisms residing at mycorrhizosphere are capable of solubilizing the organic phosphate and other organic nutrients and can also mobilize iron. The structure and functions of the bacterial community involved in the mineral weathering are also determined by ectomycorrhizosphere. Plants, in turn, alter the soil structure through their root exudates favoring the activity of microbial communities. This chapter addresses the significance of mineral weathering by microbial interactions and the contribution of plant-microbial communities on soil formation through nutrient cycling which further improves the soil functionality."

> Source: Koshila Ravi, R., Anusuya, S., Balachandar, M., Muthukumar, T. (2019). Microbial Interactions in Soil Formation and Nutrient Cycling. In: Varma, A., Choudhary, D. (eds) Mycorrhizosphere and Pedogenesis. Springer, Singapore. https://doi.org/10.1007/978-981-13-6480-8_21

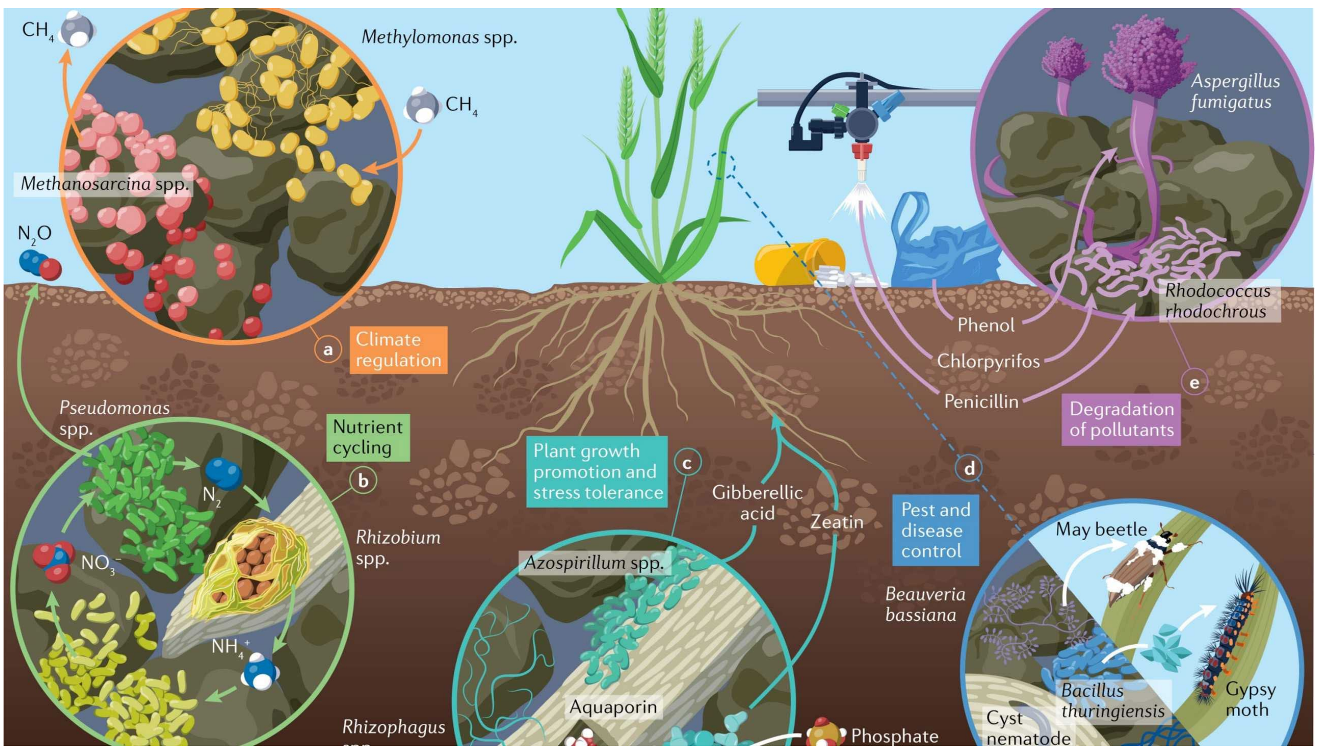
Yet, as the science continues to evolve, we continue to discover more evidence of the complex actions, interactions, and relationships of Humic Substances, Minerals, and the Microbial Biome. This new information demands that we rethink soil and plant management, especially in consideration of the contentions of individuals like Drs. Petitt and Westreich (both of whom seem to provide new thought leadership for our consideration).

ETH Zurich, offers a perspective into "Soil microbiomes – a nature-based solution for sustainable agriculture," which states, " Soils are complex systems that harbor diverse, microscopic lifeforms called the microbiome. Interdependent constituents of the soil microbiome regulate key functions in agroecosystems that determine soil fertility, crop productivity and stress tolerance."

> Source: https://usys.ethz.ch/en/news-events/news/archive/2022/11/soil-microbiomes.html

"Abstract: Soil microbiomes regulate critical ecosystem functions, yet their relationship with agronomic practices and farmer beliefs remains unclear. Through surveying 85 organic farms, we identified five practices that reshaped soil microbiomes and linked these changes to plant defense functions. Compost and organic pesticide use were associated with decreased levels of two plant defense compounds, jasmonic and salicylic acid, while targeted irrigation, grass cover crops, and no tillage were linked to increased jasmonic acid, through changes in three microbial taxa (Fusarium chlamydosporum; Paenibacillus senegalensis; Microtrichales spp.) and two beta diversity metrics. Structural equation modeling suggested no tillage, pesticide, and compost use were influenced by farmers' beliefs in the microbiome, while adoption of targeted irrigation and grass cover crops was shaped by abiotic and economic factors. Our work indicates that soil microbiomes and their ecosystem services can be managed through farming practices and highlights sustainable pest management strategies to prioritize for outreach programs."

We see the information rom the aforementioned Abstract in the diagram provided below:



Source: Bloom, E.H., Atallah, S.S. & Casteel, C.L. Sustainable soil management practices are associated with increases in crop defense through soil microbiome changes. npj Sustain. Agric. 3, 67 (2025). https://doi.org/10.1038/s44264-025-00109-6

Importance of Ionic Minerals in the Soil

It is well-established that "Ionic minerals play a crucial role in the soil's structure and fertility, influencing plant growth and overall ecosystem health. They are essential for nutrient availability, microbial activity, and soil fertility. The availability, mobility, and balance of these ions affect not only plant growth but also the physical and chemical characteristics of the soil.

- Nutrient Availability: Ionic minerals are vital for feeding plants, with each nutrient ion playing specific roles in protein synthesis, chlorophyll production, and overall vegetative growth.
- Soil Structure: The mineral content of soil is categorized into primary and secondary minerals, with primary minerals providing a long-term reservoir of nutrients and secondary minerals playing a significant role in nutrient cycling and soil fertility.
- Soil Fertility: Minerals like calcium, magnesium, and potassium enhance the soil's cation exchange capacity (CEC), facilitating the availability of essential nutrients to plants.
- Soil Health: The presence of ionic minerals in the soil is crucial for maintaining soil health and supporting plant growth.
- Understanding the impact of soil minerals is essential for optimizing soil management practices and contributing to healthier ecosystems."

Source: https://livetoplant.com/how-ionic-nutrients-affect-soil-health/

As an example, "How Ionic Nutrients Affect Soil Health" from "Plant & Gardening Guides" (https://livetoplant.com/how-ionic-nutrients-affect-soil-health/) offers this guidance:

"Soil is the foundation of terrestrial ecosystems and agriculture, supporting plant growth by providing essential nutrients and a medium for root development. Among the many factors influencing soil health, ionic nutrients play a critical role. These nutrients, existing as charged ions in the soil solution, are vital for plant nutrition, microbial activity, and overall soil fertility. Understanding how ionic nutrients affect soil health is essential for sustainable agriculture, environmental conservation, and effective land management.

What Are Ionic Nutrients?

Ionic nutrients refer to mineral elements in the soil that are dissolved in water and exist as charged particles—either cations (positively charged) or anions (negatively charged). These include macronutrients such as:

- **Cations:** Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Potassium (K^+), Ammonium (NH_4^+), Sodium (Na^+)
- **Anions:** Nitrate (NO_3^-), Phosphate ($H_2PO_4^-$/HPO_4^{2-}), Sulfate (SO_4^{2-}), Chloride (Cl^-)

Micronutrients such as Iron (Fe^{2+}/Fe^{3+}), Manganese (Mn^{2+}), Zinc (Zn^{2+}), Copper (Cu^{2+}), and others also occur in ionic forms.

Plants take up these nutrients primarily through their roots in ionic form. The availability, mobility, and balance of these ions affect not only plant growth but also the physical and chemical characteristics of the soil.

The Role of Ionic Nutrients in Soil Health

1. Nutrient Availability and Plant Growth

The primary function of ionic nutrients is to feed plants. Each nutrient ion plays specific roles:

- **Nitrogen (NO_3^- and NH_4^+):** Vital for protein synthesis, chlorophyll production, and overall vegetative growth.
- **Phosphorus ($H_2PO_4^-$/HPO_4^{2-}):** Key to energy transfer via ATP, root development, and flowering.
- **Potassium (K^+):** Regulates osmotic balance, enzyme activation, and drought tolerance.
- **Calcium (Ca^{2+}):** Important for cell wall structure and signaling.
- **Magnesium (Mg^{2+}):** Central atom in chlorophyll molecules.

An adequate supply of these ions ensures robust plant growth, which in turn contributes to organic matter input into the soil through roots and residues, enhancing soil structure and microbial habitats.

2. Soil pH Regulation

Ionic nutrients influence soil pH through various processes:

- **Cation Exchange:** Soils possess negatively charged sites that hold cations such as Ca^{2+}, Mg^{2+}, K^+, and Na^+. The ratio of these ions affects soil acidity or alkalinity.
- **Nitrate vs Ammonium:** Nitrate uptake by plants tends to increase rhizosphere pH because it involves uptake of negatively charged ions; ammonium uptake tends to decrease pH due to release of H^+ ions.
- **Fertilizer Effects:** Application of ammonium-based fertilizers can acidify soils over time; liming adds Ca^{2+} to replace acidic hydrogen ions.

Maintaining balanced ionic nutrients helps prevent extreme pH levels that can limit nutrient availability or harm beneficial microorganisms.

3. Cation Exchange Capacity (CEC) and Nutrient Retention

CEC is a measure of how well soil can retain positively charged ions for plant use. Soils with high CEC can hold more cationic nutrients such as K^+, Ca^{2+}, Mg^{2+}, preventing them from leaching away with water movement.

Clay minerals and organic matter contribute negatively charged sites responsible for CEC. The presence of adequate ionic nutrients ensures that these exchange sites are saturated with plant-available cations rather than harmful ions like aluminum (Al^{3+}) or heavy metals.

Good nutrient retention promotes long-term fertility and reduces the need for frequent fertilization.

4. Soil Structure and Aggregation

Calcium ions play a fundamental role in stabilizing soil aggregates by bridging negatively charged clay particles and organic matter. This aggregation improves porosity, aeration, water infiltration, and root penetration.

Magnesium also influences aggregation but can sometimes cause dispersion if present excessively relative to calcium.

The balance between calcium and magnesium ions is crucial to maintain favorable soil structure. Poorly structured soils lead to compaction or erosion risks that degrade soil health.

5. Microbial Activity and Biogeochemical Cycles

Soil microbes require ionic nutrients for metabolism. For example:

- Nitrogen-fixing bacteria convert atmospheric nitrogen into ammonium ions.
- Phosphorus solubilizing bacteria release phosphate ions bound in insoluble forms.
- Sulfur-cycling microbes transform sulfur into sulfate ions used by plants.

A proper ionic balance supports diverse microbial communities that drive nutrient cycling processes essential for maintaining soil fertility over time.

Excessive or deficient ionic nutrients can disrupt microbial populations—leading to imbalances such as pathogen outbreaks or reduction in beneficial symbionts like mycorrhizae.

Factors Influencing Ionic Nutrient Availability

Soil Texture and Mineralogy

Sandy soils have low CEC and poor nutrient retention because they lack sufficient charged sites for ion exchange; thus ionic nutrients leach quickly from these soils.

Clayey soils have higher CEC but can fix some anions like phosphate strongly on mineral surfaces reducing their availability despite presence in total amounts.

Soil mineralogy governs how different ions adsorb or desorb influencing nutrient dynamics.

Soil Moisture and Temperature

Water is the solvent medium allowing ionic nutrients to move towards plant roots via mass flow or diffusion. Dry soils reduce ion mobility restricting nutrient uptake; waterlogged conditions may cause anaerobic environments altering nutrient forms—for example nitrate reduction to nitrogen gases causing losses.

Temperature affects microbial activity underpinning nutrient transformations influencing ion availability indirectly.

Fertilization Practices

Chemical fertilizers add ionic nutrients directly but improper application may cause imbalances leading to toxicity or deficiencies.

Organic amendments such as compost release ionic nutrients slowly improving retention while enhancing CEC through added organic matter.

Crop rotations including legumes help replenish nitrogen in ionic form naturally supporting overall ionic balance.

Soil pH

Nutrient ion solubility is highly pH-dependent:

- Phosphorus becomes less available at very acidic (<5) or alkaline (>7.5) conditions.
- Micronutrient cations become more soluble under acidic conditions increasing potential toxicity.

Adjusting pH through lime or sulfur applications can optimize ionic nutrient availability promoting healthier soils.

Negative Impacts of Imbalanced Ionic Nutrients on Soil Health

While ionic nutrients are essential, their excessive accumulation or deficiency poses threats:

- **Salinization:** High sodium ion concentrations degrade soil structure causing dispersion of clay particles leading to poor aeration and drainage.
- **Nutrient Toxicity:** Excessive micronutrients like iron or manganese can harm roots and microbes.
- **Leaching Losses:** Overapplication of nitrate leads to groundwater contamination causing environmental hazards beyond soil issues.
- **Acidification:** Overuse of ammonium fertilizers lowers pH harming beneficial organisms while mobilizing toxic metals like aluminum.

Maintaining balanced ionic nutrient levels is critical for long-term sustainability of soil health.

Strategies to Manage Ionic Nutrients for Healthy Soils

1. **Soil Testing:** Regular analysis to monitor ion concentrations guides precise fertilization avoiding deficiencies or excesses.
2. **Balanced Fertilization:** Applying macronutrients in appropriate ratios along with micronutrients based on crop needs prevents disproportionate accumulation.
3. **Use of Organic Matter:** Compost addition increases CEC improving ion retention while buffering against rapid changes in nutrient availability.
4. **Crop Rotation & Cover Crops:** Incorporating legumes enhances biological nitrogen fixation maintaining ammonium/nitrate balance; cover crops reduce leaching losses by uptaking residual ions.
5. **pH Management:** Liming acidic soils releases calcium ions improving structure while optimizing available phosphorus; sulfur amendments lower pH where needed enhancing micronutrient availability.
6. **Irrigation Management:** Avoid excessive watering reducing leaching especially in sandy soils preserving ionic nutrient pools within root zones.

Conclusion

Ionic nutrients are fundamental drivers of soil health influencing physical properties, chemical environment, biological activity, and ultimately plant productivity. The dynamic interactions between cations and anions within the soil matrix determine nutrient availability, retention capacity, pH stability, microbial community structure, and overall ecosystem function.

By comprehensively managing these ionic forms through informed agronomic practices—including balanced fertilization, organic amendments addition, crop diversification, moisture control, and pH adjustment—farmers and land managers can sustain fertile soils that support resilient agricultural systems while minimizing adverse environmental impacts.

Understanding the science behind ionic nutrients empowers us to protect one of our most precious resources: healthy soil capable of nourishing both current crops and future generations alike."

With this stated, IFUS contends that if one is to shift into a different form of agricultural practice, like that which applies a product and technology like SupremeAG™, then one MUST educated one's self as to what the product/technology is and isn't. **The immediate testing using present science may lead to erroneous conclusions as to the practical application of**

SupremeAG™…and application that results in failure. This is not the fault of the testing, but a misunderstanding as to the intent of the testing method and the resulting data.

Furthermore, should standard testing be performed on SupremeAG™, the testing may fail to demonstrate its true efficacy. This failure may in fact have little to do with the efficacy of SupremeAG™ or the testing method, but more so like that of the adage, that it is at the height of stupidity to throw a hammer through a glass window, then question the hammer's fitness for use.

Hence, IFUS has to date employed a basic qualitative "Input/Output" model. Select a control group and a test group. Apply SupremeAG™ as only (1) a mulch, (2) as only a soil amendment, (3) as both a soil mulch and soil amendment. Then, observe plant performance. However, before applying SupremeAG™, one must educate one's self as to whether the predilection of the plant, tree, or shrub aligns with SupemeAG™. To date, Iron- and Acid-loving plants, trees, and shrubs rich in flavonoids vs indoles seem to be the governing factor.

"How do chemistry and physics involving soil minerals play a crucial role in controlling the availability of essential plant nutrients?

In extraordinary work created by Singh, B. & Schulze, D. G. (2015) (Soil Minerals and Plant Nutrition. Nature Education Knowledge 6(1):1), we find another batch of invaluable information as to how Soil Minerals affect Plant Nutrition:

"All plants require 17 elements to complete their life cycle, and an additional four elements have been identified as essential for some plants (Havlin et al. 2005). With the exception of C, H, and O, which plants obtain from air and water, plants derive the remaining 14 elements from the soil or through fertilizers, manures, and amendments (Parikh & James 2012). The bulk of the soil solid fraction is constituted by soil minerals, which exert significant direct and indirect influences on the supply and availability of most nutrient elements. The main processes involved in the release and fixation of nutrient elements in soils include dissolution-precipitation and adsorption-desorption. We will discuss these processes and how they impact macronutrients and micronutrients.

Primary Minerals and Soil Fertility

Sedimentary rock covers 75-80% of the Earth's crust, and it forms parent materials for a large majority of soils. Soil parent material has a significant direct influence on the nutrient element contents of the soil; this influence is more pronounced in young soils and diminishes somewhat with increasing soil age and soil weathering. In order to better understand the effect of soil parent materials on the soil elemental composition, it is useful to review the mineralogical composition of common rocks that make up the soil parent material (Table 1). Primary minerals form at elevated temperatures from cooling magma during the original solidification of rock or during metamorphism, and they are usually derived from igneous and metamorphic rocks in soil (Lapidus 1987). In most soils, feldspars, micas, and quartz are the main primary mineral constituents, and pyroxenes and hornblendes are present in smaller amounts.

Mineral constituent	**Igneous rock**	**Shale**	**Sandstone**	**Nutrient element constituents**	
	%			**Major**	**Minor**
Feldspars	59.5	30.0	11.5	K, Ca, Na	Cu, Mn
Amphiboles & pyroxenes	16.8	–	sm	Mg, Fe, Ca	Ni, Co, Cu, Mn, Zn, Mo
Micas	3.8	–	sm	K, Ca, Na, Mg, Fe	Ni, Mn, Co, Zn, Cu
Titanium minerals	1.5	–	sm	Ti, Fe, Ca	Co, Ni
Apatite	0.6	–	sm	Ca, P	
Clay	–	25.0	6.6	K, Mg, Fe, Ca, Na	
Iron oxides	–	5.6	1.8	Fe	Mn, Zn, Ni, Co
Carbonates	–	5.7	11.1	Ca, Mg, Fe	

Other minerals	–	11.4	2.2	–	–

Table 1: Average mineralogical and nutrient element composition of common rocks on the Earth's land surface (Klein & Hurlbut 1999, based on data of F. W. Clarke).

Primary minerals — including K-feldspars (orthoclase, sanidine, and microcline), micas (muscovite, biotite, and phlogopite), and clay-size micas (illite) — are widely distributed in most soil types, except in highly weathered and sandy soils. These primary minerals act as an important reservoir for K, with over 90% of K in soils existing in the structure of these minerals. Significant amounts of Ca, Na, and Si and smaller amounts of Cu and Mn are also present in the feldspars. Micas and illite are the most important source of K in many soils, and they also contain Mg, Fe, Ca, Na, Si, and a number of micronutrients. Amphiboles and pyroxenes are vital reservoirs of Mg, Fe, Ca, Si, and most of the micronutrients. Carbonate minerals, including those derived from soil parent material and those formed in soil through pedogenic processes, serve as both a source and a sink for Ca and Mg in soils.

The physical, chemical, and biological weathering of primary minerals releases a number of nutrient elements into the soil solution. Weathering rates and pathways of primary minerals are highly variable and depend on several factors, including mineral properties and climatic conditions. Although the weathering rates of primary minerals for certain elements may not be fast enough to meet plant nutrient requirements on a short-term basis, particularly in managed cropping systems, mineral weathering is an important and long-term source of several geochemically derived nutrients. The nutrient supply capacity of a soil through weathering of primary minerals diminishes as the extent of soil weathering increases.

Secondary Minerals and Soil Fertility

In contrast to the primary minerals, secondary minerals in soils are usually formed by low-temperature reactions during the weathering of primary minerals in the aqueous environment at the Earth's surface. Secondary minerals primarily control nutrients through adsorption-desorption, dissolution-precipitation, and oxidation-reduction reactions.

Adsorption reactions involving minerals are often more important in controlling plant nutrient element availability than the release of nutrient elements by mineral weathering. Phyllosilicates with a permanent charge (e.g., vermiculite and smectite) offer exchange sites that hold a number of essential nutrients in their cationic form (cation exchange capacity), such as Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}; the nutrients are retained by outer-sphere complex formation (Figure 1) and may be easily taken up by plant roots. On the other hand, variable charge minerals (e.g., Fe oxides) retain some nutrients (P, Zn) by forming inner-sphere complexes (Figure 2), and such nutrients are not readily available to plants. Important reactions relevant to specific nutrient elements are discussed below.

Figure 1: Hydrated exchangeable cations within the interlayer region of the clay mineral smectite.

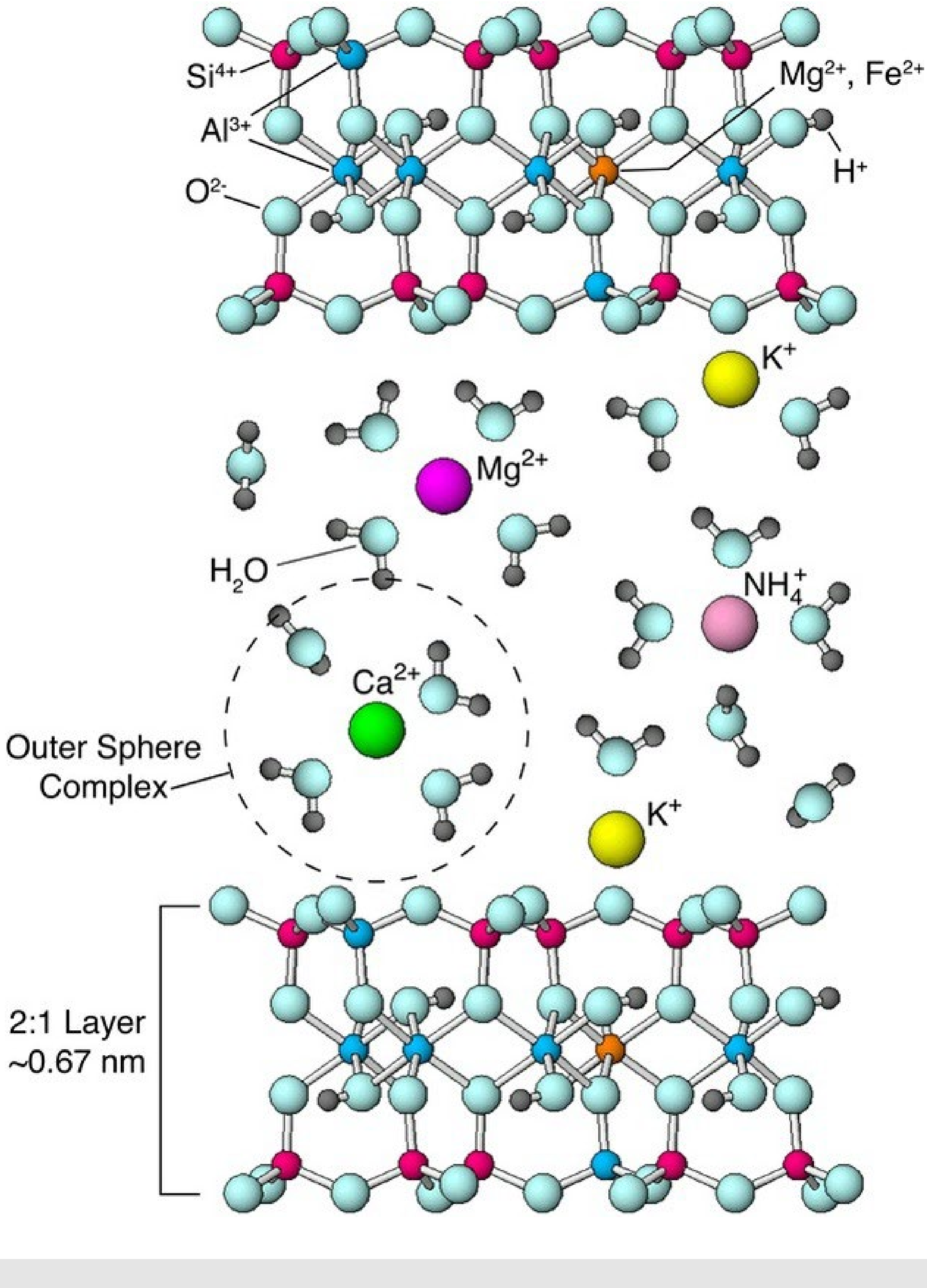
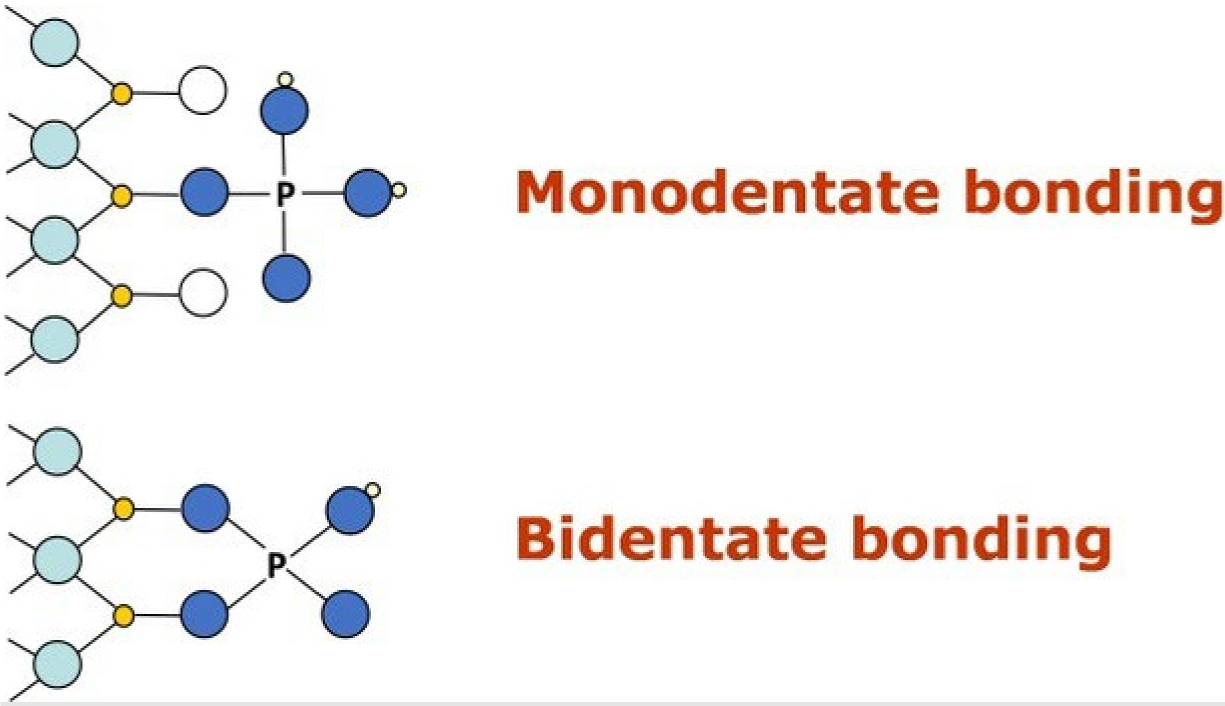


Figure 2: Schematic representation of phosphate adsorption by forming inner-sphere complexes involving monodentate and bidentate bonding on a goethite

surface.

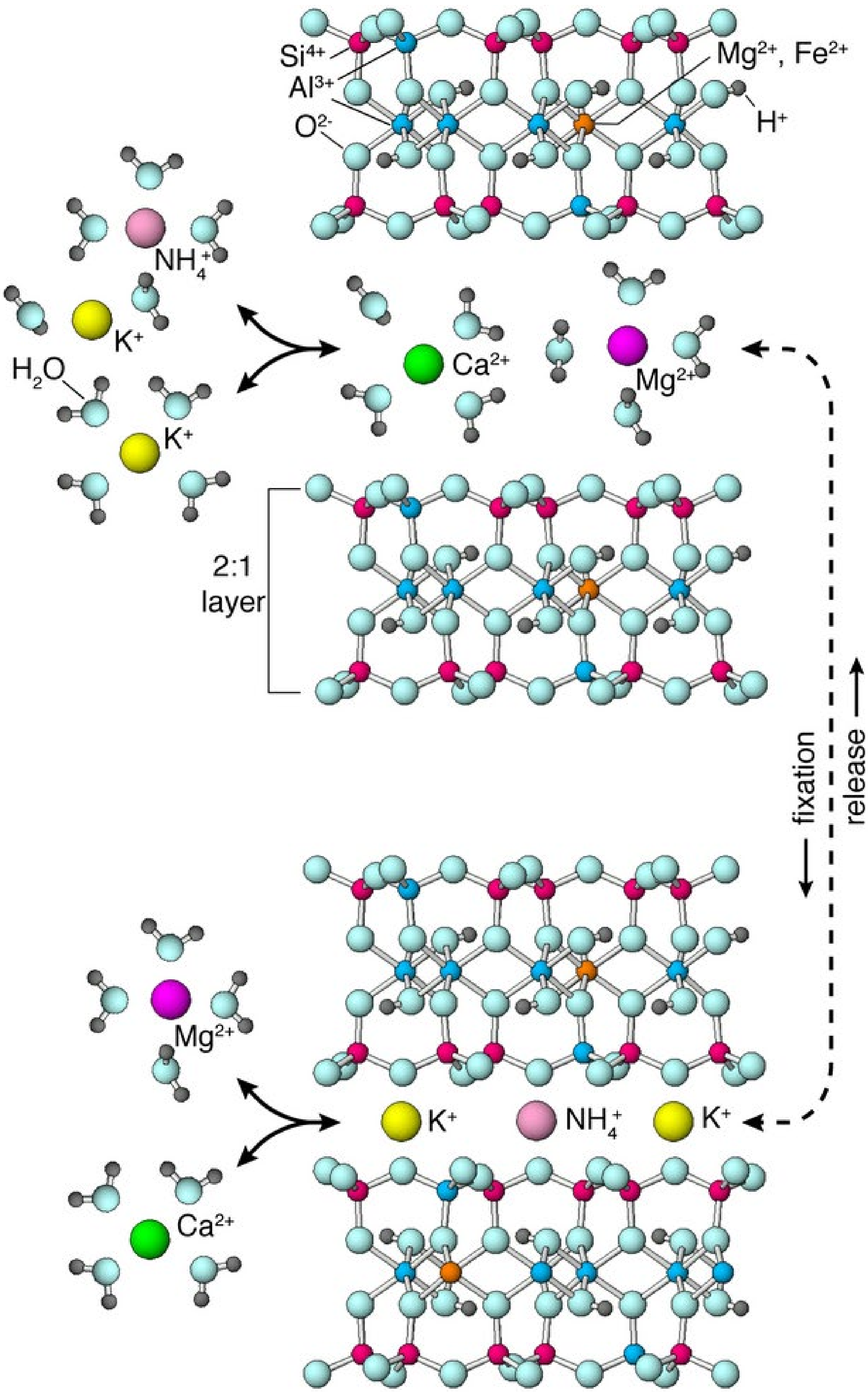


Nitrogen: Plants usually take up the nitrate (NO_3^-) and ammonium (NH_4^+) forms of soil nitrogen. In soils, N applied through fertilizers and mineralized N from organic matter mostly ends up in the NO_3^- form. Due to the limited anion exchange capacity of most soils, leaching of applied N in the form of NO_3^- ions is a common water quality problem, particularly in agricultural regions. It also represents an important economic inefficiency, because producers apply excessive amounts of fertilizer to compensate for the leaching. Highly weathered soils, such as **oxisols** and **ultisols**, are the exception. The mineralogy of oxisols and ultisols is dominated by minerals with variable surface charge, mainly kaolinite and Fe and Al oxides, which provide these soils with the capacity to retain large amounts of NO_3-N, particularly in the subsoil horizons. For example, Lehmann *et al.* (2004) observed 150-300 kg NO_3-N ha^{-1} (up to a depth of 2 m) in a Brazilian oxisol in a maize-soybean cropping system. Additionally, Rasiah & Armour (2001) estimated between 17,000-32,000 kg NO_3-N ha^{-1} to a depth of 10 m under different land uses in oxisols from northern Queensland in Australia. The anion exchange capacity of the Australian oxisols was large, with values as high as 41 $mmol_c$ kg^{-1}. The adsorbed nitrate is too deep and is likely inaccessible to most field crops, nevertheless, it does not leach into groundwater.

In contrast to highly weathered oxisols and ultisols with variable charge minerals, soils in temperate regions generally have permanent charge minerals (e.g., smectite and vermiculite) with high cation exchange capacity and the ability to retain ammonium (NH_4^+) ions. Indeed, a large proportion of the NH_4-N is retained in the interlayers of 2:1 phyllosilicates and is not readily exchangeable, causing it to be referred to as fixed NH_4. The process of NH_4-fixation is similar to that of K-fixation, which is demonstrated in Figure 3. Vermiculite, illite, and interstratified minerals with 2:1 layers are involved in the fixation of NH_4^+ ions in soils. With the exception of sandy soils, the amount of fixed NH_4^+ in the soil ranges from 350-3,800 kg NH_4-N ha^{-1} in the top 30 cm of soil; vermiculite and partially weathered illite generally have a greater capacity to fix NH_4^+ in soils than the smectite group of minerals (Nieder *et al.* 2011; Nörmik & Vahtras 1982; Stevenson & Cole 1999). The different behavior and capacity of 2:1 phyllosilicates in fixing NH_4^+ ions is related to the magnitude and origin of negative charge in these minerals. NH_4-fixation generally increases with the increasing amount of layer charge in the 2:1 phyllosilicates, and the fixation is greater in minerals with charge originating in the tetrahedral sheet than in minerals with charge originating in the octahedral sheet.

Source: Singh, B. & Schulze, D. G. (2015) Soil Minerals and Plant Nutrition. Nature Education Knowledge 6(1):1

Figure 3: Fixation of K^+ and NH_4^+ results when these monvalent cations from the soil solution (top left) displace hydrated cations (shown as Ca^{2+} and Mg^{2+}) from the interlayer of vermiculite (top right). The K^+ and/or NH_4^+ cations dehydrate and are held tightly within cavities of opposing 2:1 layers to form a structure analogous to mica (bottom right), while the displaced cations move to the soil solution (bottom left). The reverse reaction results in release of the fixed cations.


Si4+
Al3+
O2-
Mg2+, Fe2+
H+
NH4+
K+
H2O
K+
Ca2+
Mg2+
2:1
layer
fixation
release
Mg2+
Ca2+
K+
NH4+
K+

Phosphorus: P is primarily taken up by plants in the form of phosphate ions (HPO_4^{2-} and HPO_4^{-}) from the soil solution. The concentration of P in soil water is generally very low (< 0.01% of the total soil P), with the bulk of the soil P existing as organic P, insoluble compounds of P with Al, Fe, and Ca, and phosphate adsorbed to Fe and Al oxides and phyllosilicates (Stevenson & Cole 1999; Brady & Weil 2008). Phosphate ions from dissolved chemical fertilizers react rapidly in most soils, resulting in P fixation in the soil. These soil reactions involve both adsorption and precipitation processes.

(i) Adsorption Reactions

Adsorption reactions of phosphate ions on mineral surfaces predominantly involve the formation of inner-sphere complexes on the variable charge surfaces of Fe and Al oxides and kaolinite. An example is provided in Figure 2, where phosphate ions are adsorbed on goethite surfaces by forming monodentate and bidentate bonds. Phosphate ions adsorbed by such processes are only slowly available to plants. Phosphate is also known to be sorbed by calcite in calcareous soils, with the **sorption** occurring via the replacement of CO_3^{2-} on the calcite surfaces.

(ii) Precipitation Reactions

In strongly acidic soils, the precipitation reactions involving soluble phosphate from fertilizer results in the formation of insoluble Al, Fe, or Mn phosphates. In contrast, in calcareous soils, insoluble Ca phosphates are formed, which are gradually converted to insoluble carbonated hydroxyapatite. General chemical reactions of phosphate in acidic and calcareous soils are shown below:

Precipitation of phosphate in acid and calcareous soils

Acid soils:

$$Al^{3+} + H_2PO_4^- + 2H_2O \rightarrow Al(OH)_2H_2PO_4 + 2H^+ \rightarrow \rightarrow \rightarrow AlPO_4.2H_2O$$

Soluble — Slightly soluble — Insoluble

Calcareous soils:

$$Ca(H_2PO_4)_2 \rightarrow Ca_2(HPO_4)_2 \rightarrow Ca_3(H_2PO_4)_2 \rightarrow \rightarrow \rightarrow 3[Ca_3(H_2PO_4)_2].CaCO_3$$

Decreasing solubility → → →

Potassium: Among the essential elements, K is usually the most abundant in soils. Total K in soils varies from 0.5-2.5% of the soil mass, and most of the K exists in mineral form (K-feldspars and micas). Potassium is released following the weathering or dissolution of K minerals in soils, as shown in the following examples:

Potassium release from mineral weathering

Weathering of mica:

$$K(Mg_2Fe^{2+})[Si_3Al]O_{10}(OH)_2 + 0.2H_4SiO_4 + 1.25Mg^{2+} + 1.1H_2O \rightarrow$$

Biotite

$$Mg_{0.35}(Mg_{2.9}Fe_{0.1}^{3+})[Si_{3.2}Al_{0.8}]O_{10}(OH)_2 + 0.9FeOOH + 0.2Al(OH)_3 + 1.5H^+ + K^+$$

Vermiculite — Goethite — Gibbsite

Weathering of K-feldspar:

$$2KAlSi_3O_8 + 9H_2O + 2H^+ \rightarrow Al_2Si_2O_5(OH)_4 + 4H_4SiO_4 + K^+$$

Microcline — Kaolinite

Of these two reactions, K release by the weathering of mica is generally more important in supplying K to plants in unfertilized soils.

Phyllosilicates retain and release K for plants from non-exchangeable or fixed (i.e., exchanged very slowly and only when the K concentration in soil water drops below a threshold value) and exchangeable forms. Potassium ions present on the exchange sites are adsorbed by outer-sphere complexation and are readily available for plant uptake (Figure 1). On the other hand, illite, vermiculite, and interstratified 2:1 clay minerals release fixed or non-exchangeable K from interlayer sites through cation exchange and diffusion processes at slower rates than the exchangeable K (Figure 3). Similar to NH_4^+ ions, K supplied through fertilizers or other amendments can be fixed in the interlayers of the 2:1 minerals (Figure 3). The non-exchangeable or fixed K can be potentially released back into soil solution if the solution K concentration falls below a certain threshold value.

Secondary Nutrients

Among the secondary nutrients, Ca and Mg are taken up by plants in their cationic forms, Ca^{2+} and Mg^{2+}. These cations are retained at negatively charged sites of phyllosilicates via electrostatic attraction (outer-sphere complexation) (Figure 1). The precipitation of secondary carbonates, such as calcite ($CaCO_3$), magnesium calcite ($Ca_{1-x}Mg_xCO_3$), and gypsum ($CaSO_4 \cdot 2H_2O$), is common in soils of arid and semi-arid environments. Secondary carbonates are considered to be important scavengers of some nutrients through incorporation in the mineral structure (e.g., Mn) or inner-sphere complexation (e.g., P and Zn) at the mineral surface.
Sulfur is taken up by plants as sulfate (SO_4^{2-}), and this is the most common inorganic S form in soils. Fe and Al oxides and kaolinite provide adsorption sites for SO_4^{2-} in most soils, even if these minerals are present in small amounts. Sulfate ions are believed to be adsorbed by these minerals by forming both inner- and outer-sphere complexes. In calcareous soils, SO_4^{2-} may be sorbed on $CaCO_3$ by forming a $CaCO_3$-$CaSO_4$ co-precipitate, which renders SO_4^{2-} unavailable to plants. Sulfide (S^-, S^{2-})

minerals form under reducing environments (e.g., freshwater and tidal marshes) where SO_4^{2-} ions are reduced to form minerals such as pyrite (FeS_2). Such reduced forms of S are oxidized following exposure to air, releasing SO_4^{2-}, H^+, and Fe^{3+} ions to the soil solution.

Micronutrients

Among the micronutrients, Fe, Mn, Cu, Zn, and Ni are taken up by plants in their cationic forms, and B, Mo, and Cl are taken up by plants in their anionic forms. Fe and Mn are often present in large quantities in most soils, and adsorption reactions play little role in controlling their plant availability in soils. Oxidation and precipitation reactions predominantly control the soil solution concentration of Fe and Mn. Goethite, hematite, and ferrihydrite are the most commonly occurring secondary Fe oxides in soils. Due to the microcrystalline size of Fe oxides, these minerals possess high specific surface areas and provide numerous adsorption sites for both cationic and anionic elements in all varieties of soils. The two most stable Fe oxides, goethite and hematite, are known to have substantial structural substitution of trace elements, including Mn, Ni, Zn, and Cu. Manganese minerals are not as abundant and common as Fe oxides. Often, they exist in soils as mineral coatings, as nodules, or as finely dispersed particles in the soil matrix. Both Fe and Mn oxides are common mineral constituents in many soils and are important substrates for the retention of many macronutrients and micronutrients. Plant availability of both Fe and Mn is greatly reduced in calcareous soils due to the extremely low solubility of Fe and Mn oxides and of Mn carbonates. In such situations, plants induce biochemical responses, such as release of reducing and chelating compounds and acidification of rhizosphere, which can increase the availability of Fe, Mn, and other micronutrients.

Copper, Zn, and Ni are adsorbed by Fe and Al oxides by forming inner-sphere complexes at low solution concentrations. However, at higher solution concentrations, precipitation of metal hydroxides occurs (Ginder-Vogel & Sparks 2010). Adsorption of Cu^{2+}, Zn^{2+}, and Ni^{2+} occurs by outer-sphere complex formation on negatively charged surfaces of 2:1 phyllosilicates and perhaps by inner-surface complex formation on kaolinite surfaces. In alkaline soils, adsorption of Zn on calcite and co-precipitation of Cu in calcite may also occur.
B and Mo are taken up by plants as H_3BO_3 and MoO_4^{2-}. Limited evidence suggests that B species (i.e., $B(OH)_3$ and $B(OH)_4^-$) in soils are adsorbed by forming inner-sphere complexes on the surfaces of Fe and Al oxides (Su & Suarez 1995). Similarly, MoO_4^{2-} is strongly adsorbed by metal oxides. Chlorine is taken up by plants in the chloride (Cl^-) form, and adsorption reactions involving Cl^- ions are similar to those involving NO_3^- ions. Therefore, a relatively high potential for

exchange-based adsorption of Cl^- ions occurs in highly weathered soils because their mineralogy is dominated by variable-charge minerals, such as kaolinite and Fe and Al oxides. In certain soil environments, such as those with restricted leaching or those with low-lying areas in arid climates, Cl may exist in precipitated mineral forms, such as NaCl, $CaCl_2$, and $MgCl_2$.

Conclusions

Soil minerals serve as both sources and sinks of essential plant nutrients. As primary minerals that originally formed at high temperatures and pressures in igneous and metamorphic rocks are weathered in soils, they release plant nutrients into the soil solution. New minerals form in the aqueous phase of soil environments. These secondary minerals serve as sources of nutrients themselves, or they precipitate or adsorb essential elements, keeping them from being taken up readily by plants. In many cases, secondary minerals serve as important reservoirs where nutrients are held strongly enough to prevent leaching, yet weakly enough to allow plants to draw on them to meet their nutritional needs. In some soils and in certain topsoils, the soil organic matter contains and releases plant nutrient elements."

> Source: Singh, B. & Schulze, D. G. (2015) Soil Minerals and Plant Nutrition. Nature Education Knowledge 6(1):1

The extraordinary work presented to us by Singh and Schulze serves to demonstrate the complexity of soil minerals on plant nutrition. One then begs the question as to how synthetic formulations can even begin to mirror this complex array created by Nature. It brings to mind that for many of humankind's interventions come a rash of contraindications, that where the symptom is eased, a cascading series of negative consequences follow.

Hence, this then begs the question as to how humankind might unobtrusively intervene in cooperation with Nature in order to enable it to once more become "intact", rather than attempting to fix that which Nature is more than capable of accomplishing (with just a bit of help rather than an obtrusive intervention)?

Impact Fusion believes that such a solution cannot be "invented", but can only be "discovered." Such is the case of SupremeAG™…an aged SGP+™ formulation destined for disposal…that rather than being disposed, was tested as a mulch, and then a soil amendment…only to discover it could support the production of outstanding performance on various Iron- and Acid-loving plants, trees, and shrubs.

This, we believe, has been substantiated by any number of visitors to the IFUS Test Farm as well as customer who have reported similar positive performance results.

Ionic Minerals in the Plant System

With the aforementioned information, we believe we have presented science that establishes that ionic minerals must exists in the soil so that said minerals can positively affect plant systems.

In the IFUS world, we hold to a mantra that it is what you eat and the way you eat it so that you can more effectively digest, then absorb it.

One could overlay this mantra to plants, trees, and shrubs in that where these living things do not necessary eat in the manner in which humans and animals do, there are processes that emulate the need to have proper minerals, vitamins, proteins, carbohydrates, hydration, and more available…all in proper concentrations…so that plant can perform the human/animal equivalent of effective digestion and absorption.

Hence, we further our discussion with another question:

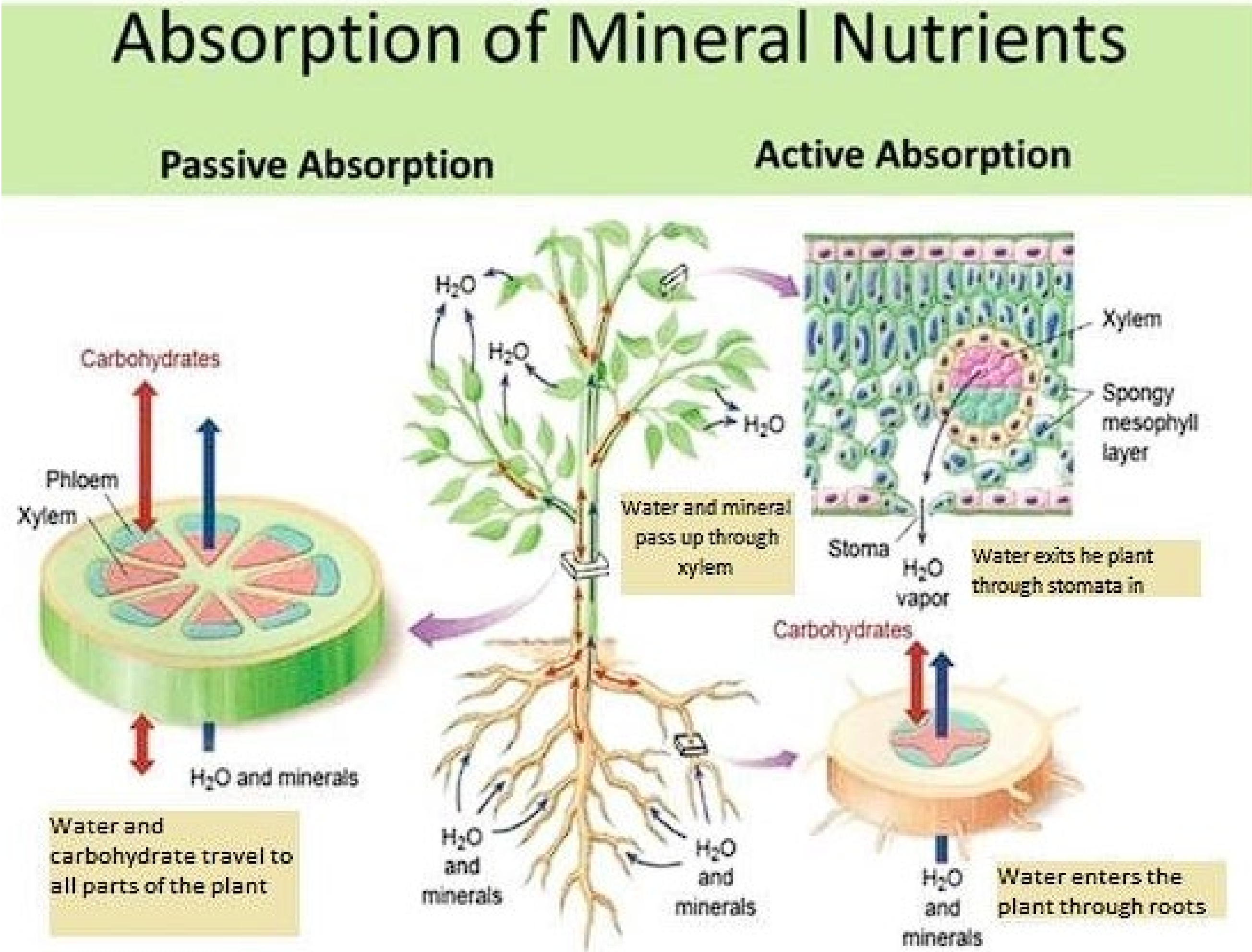
How are minerals absorbed from the soil?

The diagram that follows offers a pictorial representation of the mechanisms by which "Mineral Nutrients" are absorbed by plants, trees, and shrubs.

Note that science tells us that there are two main processes:

- Passive Absorption
- Active Absorption

Mineralized water is paramount to these two processes, and where MUCH research and science is dedicated to N,P,K (and rightfully so), these alone do NOT produce sustainable agricultural practices resulting in an optimized plant, tree, and shrub.



Source: https://www.iasexpress.net/wp-content/uploads/2023/06/image-83.png

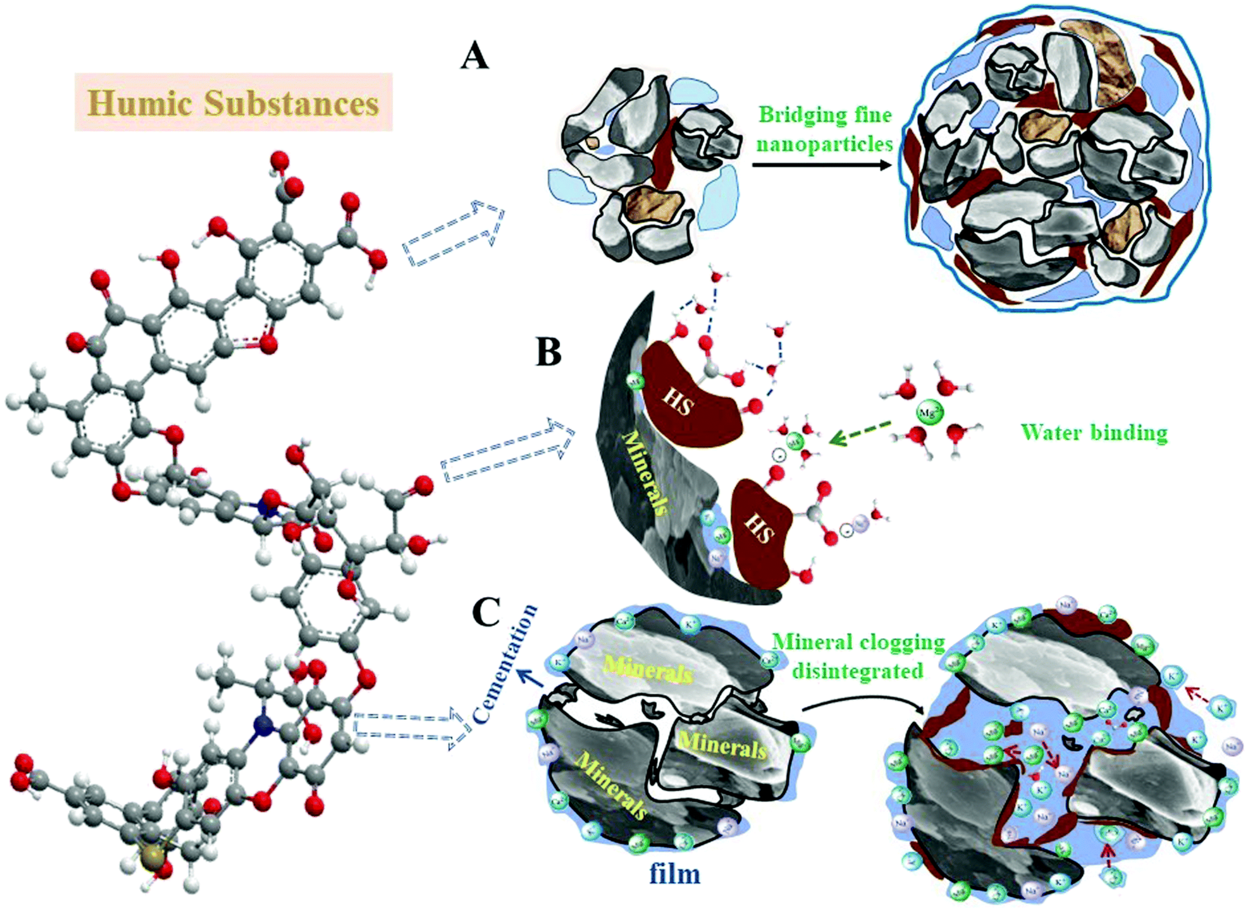
<u>MINEALIZED WATER Contained within Humic Substance and in Support of the Microbial Biome</u>

In Diagram 3 below, we find an illustration of the effect of Humic Acid, which then produces three synergistic effects if found in proper balance:

(A): The "Bridging of Fine Nanoparticles".

(B): The Interaction of Minerals with HS (Humic Substance) to create water binding necessary for natural hydration of the plant.

(C): "Mineral clogging" disintegration of the "cementation" effect, hence releasing key minerals required for plant nourishment.



Source: https://pubs.rsc.org/image/article/2021/cs/d0cs01363c/d0cs01363c-f4_hi-res.gif

In (A), we find nanoparticle formation. "Nanoparticle formation is indeed important in humic soil. Nanoparticles can enhance nutrient delivery, improve soil structure, and increase microbial activity, which are crucial for sustainable agriculture. They can also minimize soil contamination and aid in precision farming, making them valuable tools for soil health and crop growth. The unique physical, chemical, and biological properties of nanoparticles differentiate them from bulk materials, offering potential solutions to major soil and crop management issues."

> Source 1: Ahmed, B., Rizvi, A., Ali, K. et al. Nanoparticles in the soil–plant system: a review. Environ Chem Lett 19, 1545–1609 (2021). https://doi.org/10.1007/s10311-020-01138-y
>
> Source 2: Multifaceted impacts of nanoparticles on plant nutrient absorption

and soil microbial communities, Front. Plant Sci., 12 November 2024, Sec. Technical Advances in Plant Science, Volume 15 - 2024 https://doi.org/10.3389/fpls.2024.1497006

In (B) we find the effect of minerals in water binding, leading to proper hydration of plants, trees, and shrubs. Of note, those applying SupremeAG™ in consideration of Best Gardening Practices for the respective plant, a general reduction of about 30% in hydration requirements to sustain the plant occurs.

In (C), we find "Cementation in humic soil is primarily caused by the interaction of humic acid (HA) with soil particles, leading to the precipitation of calcium carbonate (CaCO3). This process, known as microbial induced carbonate precipitation (MICP), is facilitated by microbial urease, which catalyzes the hydrolysis of urea to produce carbon dioxide and ammonia. The ammonia then reacts with calcium ions in the soil to form CaCO3, which can stabilize the soil structure and improve its properties. The presence of humic acid is crucial for this process, as it enhances the binding capacity of the soil particles and facilitates the formation of stable aggregates." Cao J, Liu F, Song Z, Ding W, Guo Y, Li J, Liu G. Effect of Ultra-Fine Cement on the Strength and Microstructure of Humic Acid Containing Cemented Soil. Sustainability. 2023; 15(7):5923. https://doi.org/10.3390/su15075923

For phytochemical formation critical to plant nourishment (especially from the degradation and depolymerization of lignin), the biochemistry must function in a symbiotic manner such that the microbial community (biome) can perform its actions and interactions…all while maintaining is relationships. This creates homeostasis, and when required supports an energetic form of managed chaos (Enthalpy) required to produce very specific phytochemicals in very specific concentrations. This balancing act is vital to plant health and vitality.

Based on successful plant trials and the physical inspection and application of SupremeAG™ with Nutri-Mastic™ in these trials, the IFUS Scientific Team believes there exists plausible evidence as to the efficacy of SupremeAG™ (when applied with Best Gardening Practices for any respective plant, tree, or shrub). The underperformance of control plantings as compared plants mulched and/or soil amended with SupremeAG™ supports this contention.

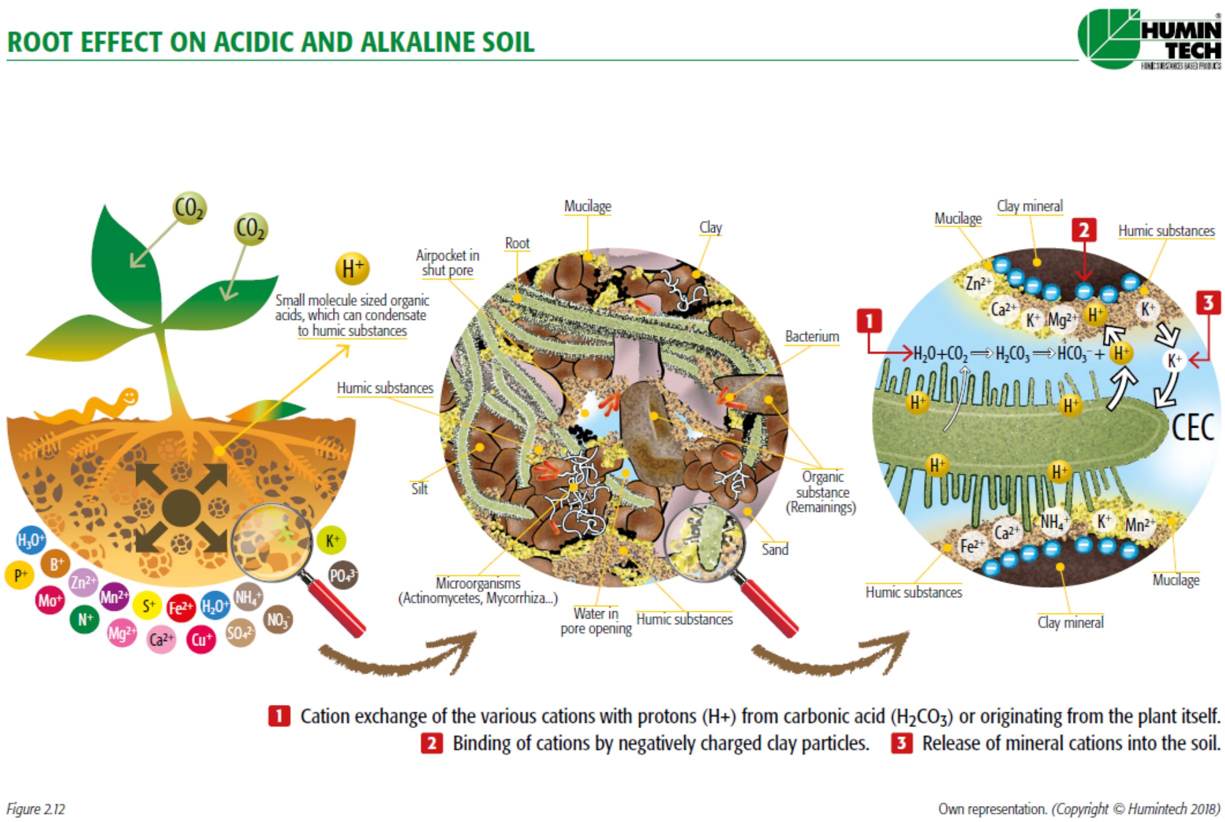
Furthermore, when considering Diagrams D, E, F, G, and H (each of which progressively illustrate the impact and involvement of minerals in root development, plant health, plant yield, and ultimately nutritive value), the IFUS Scientific Team finds reinforcing evidence for its contentions:

Diagram D: Note in Red:

1. Cation Exchange

2. Binding of Cations

3. Release of Minerals

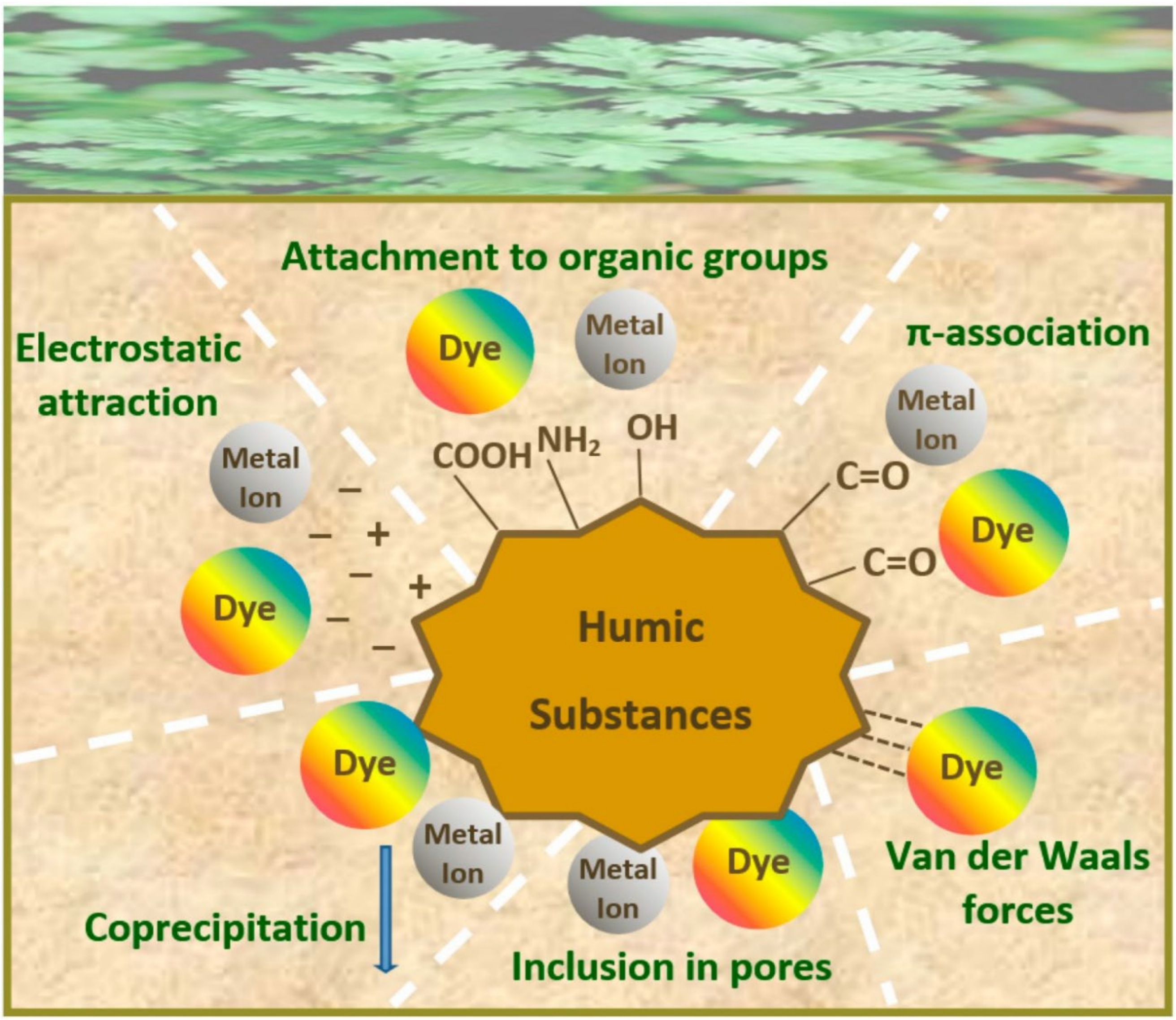


Source: Root_effect_on_acidic_and_alkaline_soil_-_Humintech.png (1130×798)
https://www.humintech.com/fileadmin/content_images/agriculture/information/what_are_humic_acids/Root_effect_on_acidic_and_alkaline_soil_-_Humintech.png

From a scientific perspective, the 72-minerals contained in Nutri-Mastic™, coupled with minerals found in the other natural ingredients in SupremeAG™, as well as the reported performance on plants being soil-amended and/or mulched with product, one could logically offer the aforementioned as plausible science in support of the efficacy of SupremeAG™.

Diagram E offers further scientific explanation of the effect and synergistic interaction between minerals ("Metal Ion"), "organic groups" (various phytochemicals), "Humic Substance", and natural physical and chemical forces that allow for healthy plant performance:

Diagram E:



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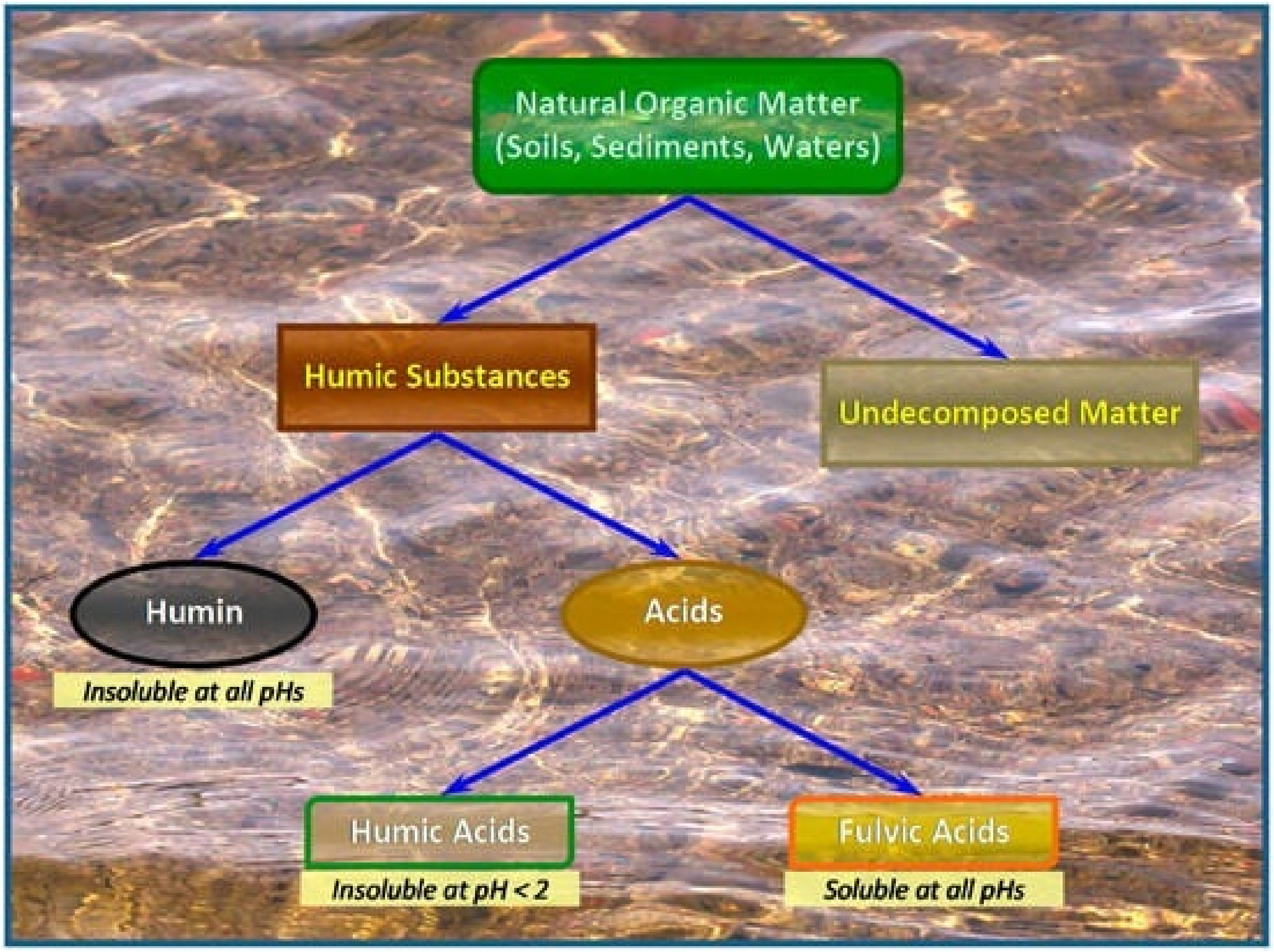
https://www.mdpi.com/agronomy/agronomy-13-02926/article_deploy/html/images/agronomy-13-02926-g002.png

Diagram F: **Based on this diagram of Humic Substance found naturally, it is plausible that SupremeAG™ could increase the concentration of beneficial "Natural Organic Matter",** so as to overcome that which (per Dr. Pettit of Texas A&M) is said to be negatively affected by the application of synthetic acid fertilizers. This is notwithstanding other negative practices or impacts like over-farming, topsoil erosion, climate change, and more.

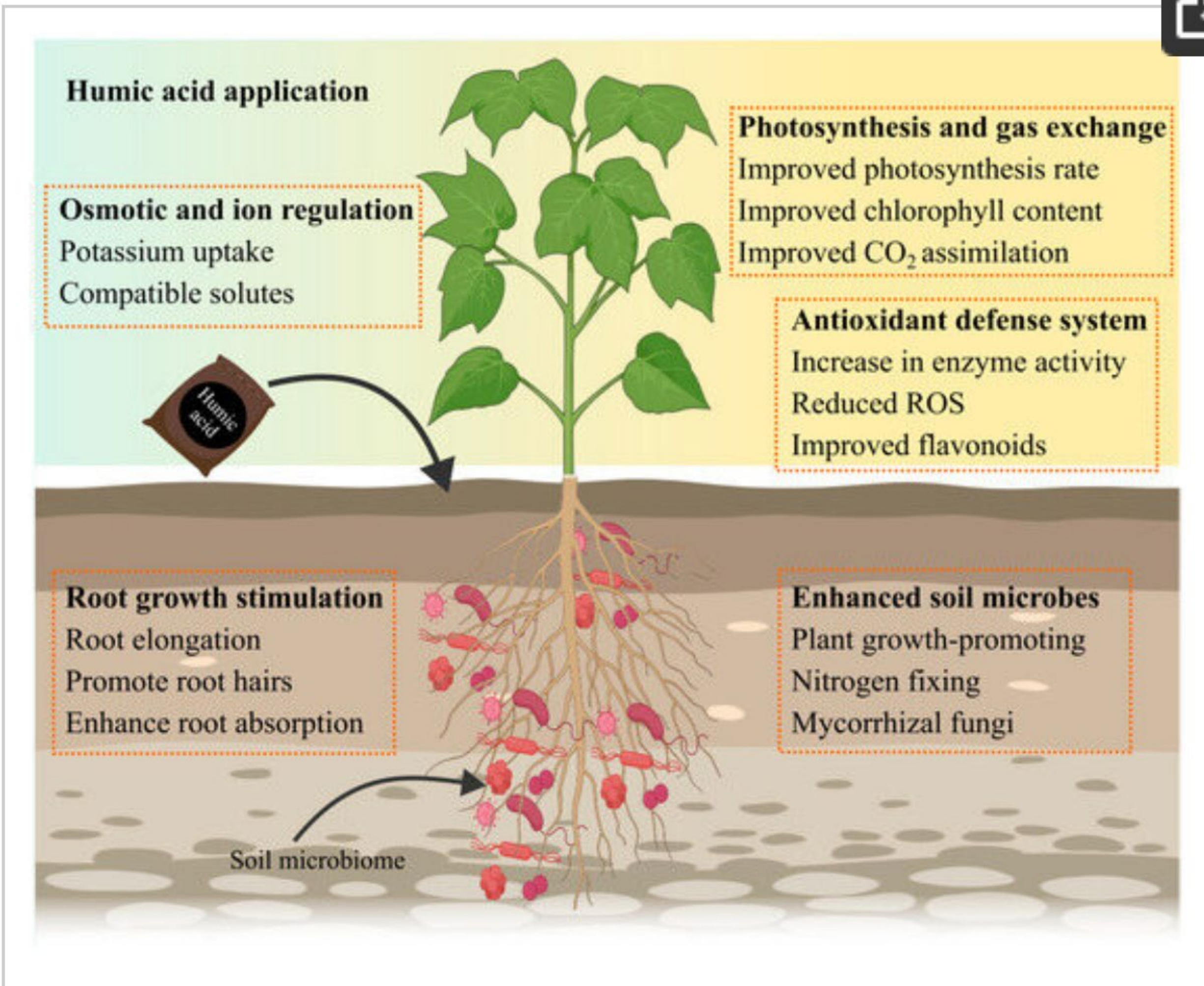


Source: [656eb90300ea2agronomy-13-02926-g001-550.jpg (550×410)]

As an added example, Nabi, F.; Sarfaraz, A.; Kama, R.; Kanwal, R.; Li, H. (Structure-Based Function of Humic Acid in Abiotic Stress Alleviation in Plants: A Review. Plants 2025, 14, 1916. https://doi.org/10.3390/plants14131916), provide added insight:

"Abstract: Humic acid (HA), a major component of soil organic matter, is a naturally occurring macromolecule formed through the decomposition of plant and microbial residues. Its molecular structure comprises functional groups such as carboxyl, phenolic, hydroxyl, and carbonyl functional groups, which enable HA to interact with soil particles, nutrients, and biological systems. These interactions significantly contribute to soil fertility and overall plant productivity. Functionally, HA enhances soil health by increasing cation exchange capacity, improving water retention, and promoting the formation and stabilization of soil aggregates. In addition to its role in soil conditioning, HA is essential in mitigating plant stress. It achieves this by modulating antioxidant enzyme activity, stabilizing cellular membranes, and alleviating the adverse effects of abiotic stressors such as salinity, drought, and heavy metal toxicity. This review highlights the structural characteristics of HA, its structure-based functions, and the mechanisms involved in plant stress alleviation. Additionally, we explore how HA can be modified through physical, chemical, and biological approaches to enhance its agronomic performance. These modifications are designed to improve HA agronomic efficiency by increasing nutrient bioavailability, reducing environmental losses through minimized leaching and volatilization, and supporting sustainable agricultural practices. Overall, this review underscores the multifaceted roles of HA in promoting plant resilience to environmental stress, highlighting its potential as a key agent in the development of sustainable and eco-friendly crop production systems."

Additionally, Dr. Nabi and team offer "Figure 3. Beneficial effects of HA on soil physiochemical characteristics (osmotic and ion regulation, cation exchange capacity, and soil microbial population), growth morphology, physiology (photosynthesis, chlorophyll content, and CO2 assimilation), and biochemistry of plants."



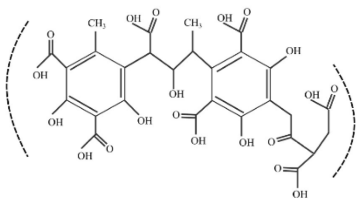
Dr. Nabi and team also offer further insight, through "Figure 1. General representation of humic substances, including their molecular structure, functional groups, and associated biological functions. The molecular models of humic acid, fulvic acid, and humin are adapted from PubChem [27]. "

> Source: (PubChem. Humic Acid. Available online: https://pubchem.ncbi.nlm.nih.gov/compound/Humic-acid (accessed on 31 May 2025).)

Humic substances

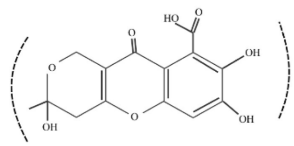
Humic acid

Molecular structure



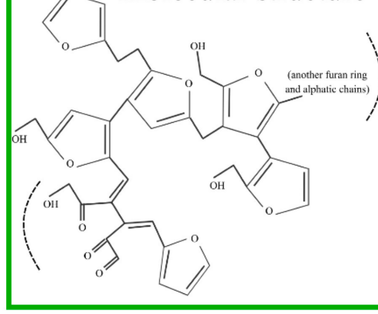
Fulvic acid

Molecular structure



Humin

Molecular structure



Humic acid

Dark brown in color

Soluble in alkaline solution

Medium molecular weight

Important component of soil

Functional groups (–COOH, –OH, Aliphatic chains)

Fulvic acid

Yellow in color

Soluble in both alkaline and acid solutions

Lower molecular weight

Biologically active part of soil

Functional groups (–COOH, –OH, C=O)

Humin

Black or dark brown in color

Highest molecular weight

Resistant to decomposition

Bind tightly to soil minerals

Functional groups (Few exposed groups, mostly aromatic)

Of note is the notion that Nutri-Mastic™ is believed to assist in the regulation of gut pH in humans and animals. The IFUS Scientific Team is wondering if a similar beneficial regulation in soil is occurring, which impacts Humic and Fulvic Acids as well as Humin.

Furthermore, depending on the aging process by which SGP+™ begins its transformation into SupremeAG™, the coloration and fibrous structure of the evolving SupremeAG™ would suggest that elements of Humic and Fulvic Acids as well as Humin are present.

The application of SupremeAG™ can be informed by the information presented as such, when reconciled to Best Gardening Practices for any respective plant, tree, or shrub.

Hence, IFUS offers that when considering the complex array of science to include the chemistry (organic, biochemical, physical, inorganic), biology, physics, mathematics, and more…in combination with phytochemicals (to include phytohormones), minerals, vitamins, proteins, carbohydrates…as well as the microbial biome…and less NOT forget the water…then one could plausibly argue that attempting to synthesize some formulation that can meet the requirements of ALL these independent and interrelated systems…as well as the actions, interactions, and relationships of individual and collective process…is at best futile.

Thus, Supreme(AG) cannot and was not invented, but discovered.

And, where one may find an improvement in one area, one also recalls the phrase "*Primum non nocere"*…these noble words of Hippocrates…and roughly translated into, "First, do no harm"

> **Hippocrates goes on to say: "I will use those dietary regimens which will benefit my patients according to my greatest ability and judgment, and I will do no harm or injustice to them."** (Excerpt translated from the original Greek by W.H.S. Jones.)

We are reminded that Mastic (Chios Mastic Gum from *Pistacia lenticus*, formulated into Nutri-Mastic™, then into SupremeAG™) has been used as a medicine since antiquity, and is still used in traditional folk medicine of the Middle East.

- In ancient Greece, it was given as a remedy for snakebite, and, in India and Persia, it was used to fill dental cavities. The first-century Greek physician Pedanius Dioscorides mentions the healing properties of mastic in his book *De Materia Medica*.
- Hippocrates wrote that the mastic is good for prevention of digestive problems and colds.
- Galenus suggested that mastic was useful for bronchitis and for improving the condition of the blood.
- In medieval times, mastic was highly valued by sultans' harems as a breath freshener and a tooth whitener.

Furthermore, "The European Medicines Agency has recognised *Pistacia lentiscus* resin as a herbal medicinal product with the following indications: (a) mild dyspeptic disorders, (b) symptomatic treatment of minor inflammations of the skin, and (c) as an aid in the healing of minor wounds [28]."

> Source: Papada E, Forbes A, Amerikanou C, Torović L, Kalogeropoulos N, Tzavara C, Triantafillidis JK, Kaliora AC. Antioxidative Efficacy of a Pistacia Lentiscus Supplement and Its Effect on the Plasma Amino Acid Profile in Inflammatory Bowel Disease: A Randomised, Double-Blind, Placebo-Controlled Trial. Nutrients. 2018 Nov 16;10(11):1779. doi: 10.3390/nu10111779. PMID: 30453494; PMCID: PMC6267573.

Impact Fusion International holds that "dietary regimens" are at the base of all of its formulations and processes, such that its products and technologies "benefit" all things living and not…in a manner both eco-friendly and cost-effective. This includes the responsible application of SupremeAG™ with Nutri-Mastic™ to plants, trees, and shrubs.