Detonation: The next evolution in sustainable and improved plant nutrient efficiency.

Abstract

From the beginning of agriculture, there has been a continued evolution of input technologies to increase production yield to meet the demand for food. This has included seed selection and plant breeding, enhancement of nutrients and nutrient management approaches, soil tillage practices, and pest management methods. Each of these strategies has maximized crop yield potential over time. We need to continue to explore new options, to maximize outputs while minimizing/maintaining inputs.

There have been great strides in the area of nutrient products, delivery systems, and management practices. However, these methods of efficiency can be improved to reduce off site movement, which has led to increase nutrient management regulations. In addition, nutrient products often have negative impact on soil health and microbial life, leading to a loss of biodiversity within the soil microbiome. This loss in diversity has the potential to decrease nutrient availability and delivery with reduced yields.

Healthy soil conditions are the foundation for nutrient availability and delivery. As we improve overall soil structure, nutrient management tools become more effective and improve crop yields and crop vigor.

Continued, yield increases demand effective, environmentally sound, and economical applications of crop nutrients. It is now critical to integrate natural solutions into today's conventional (often it is described as conventional vs. organic production) methods. We need to unleash the power of nature by enhancing our natural organic and biological systems to forge a new direction for microbial life and soil health. This can translate into increased crop yields, and a biological approach offers the most promise to aid agriculture production while tending and protecting our natural resources.

We need to explore new biological delivery options, which are environmentally sustainable yet cost effective. These methods should have the minimum adverse effect on the soil and water, especially as these two precious commodities are becoming increasingly limited.

Soil microbial life is the backbone for nutrient release, availability, delivery, and uptake into the plant. As we continue to study the interdependency of plants and soil microbes, we are discovering the symbiotic relationship between plant roots and microbial health. When plants excrete sugars into the soil to colonize microbes around roots, the sugars facilitate the delivery and uptake of nutrients. An efficient delivery system of these nutrients into the plant is critical to overall plant health, performance, and vigor. We have also discovered that a soil microbiome teeming with a diverse microbial population will enhance nutrient efficiencies, leading to improved crop production, and overall plant and soil health. As new biological technologies emerge, it is imperative that we consider ways to integrate and build on these nutrient management systems.

At the forefront of biological advances, Detonation (also branded as Intensify)

presents a robust package of beneficial bacteria and fungi to rebuild the delicate balance of soil health. Detonation/Intensify are a family of beneficial probiotics that can repair damaged soil systems, enhance overall nutrient efficiencies, and increase crop health and yields. Growers can expect a higher return on their input investments without significantly increasing spending or labor, while also building soil health for generations to come. Detonation/Intensify is a biological investment into yields returns for this season, and future seasons to come.

The Natural Solution

What is Detonation/Intensify?

Detonation/Intensify is a proprietary combination of pharmaceutical grade beneficial probiotics including microbial food sources to initiate growth, proliferation, and colonization. These multiple strains (or family) of probiotics promote a symbiotic reaction in the soil via dependency and interdependency that enhances their ability to integrate into the soil microbiome. This selects group of microbes cycles and deposits the enzymes, hormones, and excrements as the food source for soil colonization. When Detonation/Intensify microbes are introduced into the soil, they deliver a broad range of agronomic benefits, while establishing into the soil ecosystem.

Benefits

- Enhances nutrient solubility and availability of inorganic nutrients
- Enhanced nutrient mineralization and availability of organic nutrients
- Enhanced nutrient mineralization of nutrients locked in the soil
- Promotes plant growth and increased crop yields
- Promotes nutrient retention particularly N
- Promotes nitrogen fixation from atmospheric nitrogen
- Increased stress tolerance (temperature extremes, high salinity & traffic)
- Improves water retention and soil aggregation & structure

Nutrient Solubilization & Mineralization

Bacillus subtilis, Bacillus licheniformis, Bacillus megaterium, Bacillus coagulans, Bacillus amyloliquefaciens

Most soils contain an abundance of inorganic and organic nutrients that are locked into the soil colloid, organic matter, or the original parent materials by their electronic charge or by soil pH. These insoluble forms of nutrients are not in a plant available form. In a healthy soil profile, soil microbes produce organic acids that strip and mine these nutrients from the soil. Over years of conventional practices including tillage, fertilization, and pest control products, this microbial delivery system has become damaged. As the microbial system declines, the efficiency and effectiveness of fertilizers and other applied inputs decreases,

while straining the balance of the soils ecosystem. This can result in a reduction of the microbial life, which in turn can reduce crop yields and increase plant stress issues, adding to input costs, and loss in overall production.

Detonation/Intensify is a microbial "First Aid" for soil health. By restoring microbial life to the soil system, nutrient solubilization and nutrient mineralization becomes more efficient. The microbial package found in Detonation/Intensify produces copious amounts of organic acids. These acids (secondary metabolites) convert insoluble inorganic nutrients into plant-available nutrients. The microbial package also produces copious amounts of extracellular enzymes. These enzymes (secondary metabolites) convert insoluble organic nutrients into plant available nutrients. The solubilization and mineralization processes results in increased availability of phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, and zinc to the plant. Detonation is effective in all soil types, and all pH and organic levels.

Phosphorus Solubilization

Trichoderma harzianum, Bacillus subtilis Bacillus licheniformis Bacillus megaterium

In the soil, the electric charge of calcium binds it to phosphate to create insoluble calcium phosphate. Calcium has a positive charge (cation) whereas phosphate has a negative charge (anion). It is very common to find excessive levels of both calcium and phosphorus that are unavailable to the plant. This is a direct result of the overuse of conventional management practices, which holds necessary nutrients in non-plant available forms. Conventional growing systems have limited microbial soil populations, due to cultivation practices, which limits the ability to metabolize these nutrients into a plant excessable form and limits the release of these two nutrients.

The soil microbe organisms in Detonation/Intensify can release calcium and phosphorus from their bound state in the soil. Within Detonation, there are specific microbes that will produce organic acids. These acids solubilize the bound calcium phosphate to split nutrients back into soluble calcium and soluble phosphorus. The solubilization process will also act upon inorganic insoluble synthetic compounds affecting nutrients such as potassium, iron, magnesium, zinc, manganese, and copper and make them plant available.

Plant Growth Promoting Rhizo-Bacteria (PGPR)

Bacillus subtilis, Bacillus licheniformis, Azospirillum lipoferum, Bacillus megaterium, Bacillus amyloliquefaciens

Aside from facilitating better growth through the solubilization and mineralization of nutrients, the beneficial organisms in Detonation produce phytohormones. Organisms capable of producing phytohormones, which enhance plant growth and yield are commonly

referred to as Plant Growth Promoting Rhizo-Bacteria or PGPR. These growth hormones impact a wide variety of the plant growth characteristics. PGPRs improve vegetative, reproductive and root growth.

Plant Growth Hormones (phytohormones) are secondary metabolites produced by beneficial soil bacteria. The plant growth hormones produced include auxins, cytokinins, and gibberellins. Auxins stimulate flowering, root architecture, issue differentiation, lateral root initiation, polar root hair positioning, and root gravitropism. Auxins play a large role in plant establishment and continued vigor.

Cytokinins stimulate flowering, control cell division in roots and shoots, increased resistance to drought, and enhanced chlorophyll synthesis. Gibberillins control cell elongation, cell division, cell differentiation, and stress reduction. Phytohormones produced by beneficial bacteria activity increase yields independent of supplemental fertilizer applications.

Free Living Nitrogen Fixing Bacteria

Paenibacillus polymyxa,* *Azospirillum lipoferum

The earth's atmosphere contains 78% di-nitrogen or N_2, which is not a plant-available form of nitrogen. With help from healthy soil teeming with beneficial microbial life, these nitrogen fixing bacteria convert atmospheric di-nitrogen (N_2) to a plant-available form of ammonia nitrogen (NH_3). Ammonia nitrogen is then further converted into ammonium (NH_4) by binding to organic matter with the addition of water. Ammonium is a more stable form of nitrogen in the soil and is less prone to leaching due to its positive charge. Ammonium's positive charge is attracted to negatively charged soil particles and therefore resists leaching. Due to the reliance of conventional management practices, the nitrogen fixing bacteria organically present in soil have decreased in population due to conventional farming practices. This has disrupted the natural atmospheric nitrogen fixing process, and thus total microbial populations within the soil.

Detonation/Intensify can reverse this trend of declining populations of atmospheric nitrogen fixing microbials. The key bacteria in Detonation/Intensify help to fix atmospheric nitrogen into the soil. These free-living bacteria colonize near the plant root system. The bacteria and root develop a symbiotic relationship. The root excretes a food source for the bacteria, comprised of glycoprotein and polysaccharides. This supports the colonization around the root. In turn, the bacteria produce a nitrogenase enzyme. Nitrogenase is a complex bacterial enzyme that catalyzes the ATP-dependent reduction of di-nitrogen (N_2) to ammonia (NH_3). This reaction functions in aerobic or anaerobic environments, and during periods of drought and/or high salts.

This same group of bacteria is critical to the nitrification process. This microbial digestive process converts chemical nitrogen fertilizer into plant-available nitrogen. This biological process is essentially responsible for the delivery of all nitrogen fertilizer to the plant. Without this progression, the efficiencies and effectiveness of these fertilizer inputs can be reduced, which will negatively affect overall crop health and yield.

Reduction in Nitrogen Loss / Leaching

Bacillus subtilis, Bacillus licheniformis, Bacillus amyloliquefaciens, Bacillus coagulans, Bacillus megaterium

Nitrogen (particularly nitrate) is very mobile in the soil profile, and it often leaches past the root system before the plant has a chance to sequester this nutrient. With a weakened microbial system, nitrogen is lost into the soil profile and moves out of reach for plant uptake. This has led to an increase in nutrient input costs, due to these nutrient losses. In addition, the resulting nitrogen run off has fostered more nutrient regulations in a growing number of states as fertilizer moves into rivers and streams.

Detonation can significantly reduce the incidence of nitrogen leaching. There are multiple strains of microbials in Detonation that temporarily incorporate free nitrogen into their bodies, utilizing it to meet their metabolic functions. This storehouse of nitrogen is then given back to the plant through a process known as nutrient mineralization. Nutrient mineralization occurs when protozoa (another soil dwelling organism) consume soil bacteria to meet their own carbon and nitrogen requirements. With soil bacteria containing more nitrogen than the protozoa require, the protozoa keep the carbon and release this excess nitrogen back into the soil. It is then absorbed by the plant roots and utilized by the plant. Much of this nitrogen would have leached past the roots and been lost if it had not been temporarily stored and re-deposited in the root zone.

Drought Tolerance

Bacillus subtilis, Bacillus licheniformis, Bacillus coagulans, Bacillus megaterium, Bacillus amyloliquefaciens

Many of the Plant Growth Promoting Rhizobacteria (PGPRB) in Detonation promote the formation of short- and long-chain polysaccharides. These compounds improve the water holding capacity in the rhizosphere (root-soil interface). The water retention capacity of polysaccharides exceeds their mass weight by several times. Therefore, even a small amount of a polysaccharide can help to maintain a hydrated soil rhizosphere. These polysaccharides enhance water retention at the root and soil interface, which has a direct positive effect on drought tolerance. In addition, polysaccharides are a glue-like substance that helps to promote soil aggregation. This enhances soil structure and aids in overall water retention.

There are multiple species in Detonation that aid to manage ethylene soil levels. Low ethylene levels promote root growth, root hair formation and seed germination. When ethylene levels get too high, they inhibit root growth. This can put the plant at a serious disadvantage during periods of stress. In response to high ethylene levels, select Plant Growth Promoting Rhizobacteria release an enzyme. This enzyme, which is a precursor to ethylene output, can reduce ethylene production impacting soil levels. By limiting ethylene soil levels, this reduces their negative impact on plant roots. This aids in reducing plant stress and improving crop drought tolerance.

Mitigating Ethylene Stress

Bacillus subtilis, Bacillus licheniformis, Bacillus megaterium, Bacillus amyloliquefaciens

There are multiple species in Detonation that aid in the management of ethylene levels within the plant. Low ethylene levels are advantageous as they promote root growth, root hair formation and seed germination. When plants are exposed to stress, they begin to produce excessive amounts of ethylene! When ethylene levels get too high, they significantly inhibit root growth. This can put the plant at a serious disadvantage especially during periods of stress. In response to high ethylene levels, select Plant Growth Promoting Rhizobacteria release an enzyme. This enzyme, which is a precursor to ethylene output, reduces ethylene production and its negative impact on plant roots.

Mineral Sequestration

Bacillus subtilis, Bacillus licheniformis, Bacillus coagulans, Bacillus megaterium, Bacillus amyloliquefaciens

The Plant Growth Promoting Rhizobacteria (PGPRB) in Detonation promote the formation of short- and long-chain polysaccharides. These are all natural chelation compounds. As nutrients are unlocked from the soil colloid, these polysaccharides help chelate and deliver these nutrients to the plant. This plant-derived polysaccharides protect this nutrient and supply energy for growth to the plant.

As these chelated nutrients are assimilated into the root system, the resulting energy can be utilized by the plant to move nutrients around within the plant. This helps to optimize nutrient availability within the plant during all growth stages. Tissue tests have been used to validate these optimal nutrients levels within the plant. This process supports the growth of plants by increasing the nutrient availability to the plants.

The Technology & Application Opportunities

Detonation has high probiotic counts.

Detonation is a family of probiotics cultivated from pure lyophilized cultures. These probiotics are processed using a proprietary method, which maximizes their counts and viability. Our processing method contains little water, which increases our total counts in the concentrates. In addition, our concentrate contains a microbial food source to aid with soil colonization at the time of application. After processing is completed, Detonation is plated and screened to ensure the counts meet label specifications.

Detonation applied to granular fertilizer products

Detonation can be sprayed onto dry, granular fertilizer products, also known as sparged. These blended fertilizer products have a shelf life of 24 to 30 months (about 2 and a half years). The rate applied to dry fertilizer is based on the product analysis and applied rate. This rate can range from 64 to 128 oz. per acre. When applied with dry fertilizer products, these fertilizer products minimize any change to standard crop fertility management practices.

Detonation mixed in combination with liquid fertilizer products

Detonation can be blended into liquid fertilizer products. These combination

products can be injected, sprayed over the top, or used as a drench. These liquid blends have a tank life of 18 months with some limitations. The fertilizer solution pH needs to range from 5 to 9 and the maximum tank field temperature cannot exceed 90 degrees. The rate of application ranges from 8 oz. per acre per month to 64 oz. per acre per 8 weeks. It is always good to test new product combinations for pH.

Detonation mixed with pest control products

Detonation can be tank mixed with most pest control products. Detonation should be added last to the tank. This tank combination needs to be applied within 8 to 12 hours of mixing. It is always good to test new product combinations for counts.

Detonation applied to fertilizer containing a nitrogen inhibitor additive

Detonation can be applied to dry fertilizer products containing a nitrogen-inhibiting additive. It can be sprayed onto nitrogen-inhibiting products when dry; and will not reduce the effectiveness of these fertilizer products. This combination with Detonation helps to retain more nitrogen, phosphorus, potassium, and minors for plant availability. These products have a shelf life of 24 to 30 months.

Detonation can be sprayed on coated nitrogen products

Detonation will not reduce the effectiveness of sulfur- or poly-coated nitrogen products. Many times, poly-coated nitrogen products are blended with other conventional NPK fertilizer products. Detonation will enhance the effectiveness of these fertilizer combinations. These products have a shelf life of 24 to 30 months.

Detonation can be combined with humic acid products

Detonation can be tank mixed or used in conjunction with liquid humic acid products. In combination, Detonation helps to mine and release nutrients in the soil, which can be retained by the benefits of humic acid products. The fertilizer solution pH needs to range from 5 to 9. This combination enhances overall nutrient efficiencies.

Application Methods

Detonation offers a wide range of flexible application rates, timing, and in-season application opportunities. This application flexibility allows ease of alignment with crop management choices, and applications regimes. From pre-plant planned applications to a wide range of in-season applications, and into a fall liming application. Detonation can be applied to fertilizer or calcium products, used as a soil drench, sprayed as a foliar application, tank mixed with pest control products, injected into the irrigation system, or placed in the furrow at planting.

Sprayed on Fertilizers

Detonation can be applied to fertilizer and calcium products. This method provides a very cost-effective approach to using Detonation. With Detonation sprayed on the fertilizer, it enhances nutrient release and delivery of nutrients into the plant is greatly improved. This offers an effective way to manage and control the placement of

Detonation. Plus, this method maximizes the effectiveness of fertility products while managing operational costs.

Soil Drench

The organisms in Detonation are rhizosphere organisms that live, thrive, and perform their functions in the soil immediately surrounding the root system of the plant. A broadcast soil drench is a highly effective method of improving overall biological activity in the soil profile. This method of application can be affected by the volume of water used at application, soil type and crop canopy. The rule of thumb would be to utilize enough water to achieve desired coverage and product placement. This volume of water can be supplemented with secondary irrigation to ensure Detonation moves into the soil profile. This application method is best used for forage crops, turf application or greenhouse bedding plants.

Foliar Applications

Research shows that beneficial microorganisms colonize on the leaf surface known as the phyllosphere. These probiotic colonies are similar to those found in the soil naturally. On both the root and leaf surface, the plant releases exudates to support the colonization of these beneficial bacteria colonies. The phyllosphere microbiome help fix atmospheric nitrogen and produce growth-promoting hormones that affect leaf function, apical growth, and fruit development. Detonation is a true foliar colonizer. Detonation can play a key beneficial role in leaf functions and creating a competitive microbial balance on the leaf surface that promotes overall plant growth.

Pest Control Products

As pressure to increase crop yields grows, it is critical to manage pest problems and nutrient deficiencies that can impact crop yields. Hence, there are more in-season applications of pest control products to manage pest problems, and the application of supplemental nutrient products. In-season would be an ideal time to add Detonation to the tank for the nutrient delivery benefits. It can be tank mixed with most pest control and fertilizer products. Detonation should be added last to the tank. This tank combination needs to be applied within 8 to 12 hours of mixing.

Drip Irrigation

Drip irrigation is the ultimate way to target a soil drench. It is a highly effective and economical means of bringing the organisms directly into the rhizosphere and placement within the root zone of the plant. This also ensures nutrients will be metabolized into a plant available form, in an area where the plant can gain easy access. Cropping systems that use drip irrigation, it is the preferred method of treating the soil with beneficial organisms. This method maximizes the effective placement of Detonation. Detonation can be injected directly into the irrigation water or tank mixed into the nutrient injection solution.

In Furrow

Like drip irrigation, the in-furrow placement of Detonation is the “ultimate targeted row crop application method”. A 2X2 placement of the seed, fertilizer, and microbes together in the root zone maximizes the effectiveness of these 3 inputs. This application method promotes the timely delivery of nutrients, especially

phosphorus, which is critical to seed germination. The faster the seed germinates and begins growing, this translates into increased yields come the end of the season. This application method can help to reduce the impact of spring weather on nutrient availability. It not only improves results, but it also expedites results.

Rates Recommendations

Agricultural Side Dress /Top Dress-In Furrow or 2x2	1 – 2 Quarts	Acre	Utilize at time of planting seed or sprig Or 2x2 with fertilizer at planting
Agricultural Broadcast	2 – 4 Quarts	Acre	Apply 2 qtrs. for nutrient management Apply 4 qtrs. for higher stress pressures
Vegetable Production	1.5 –3.0 oz	1000 sq ft	Apply as monthly soil drench or inject monthly throughout growing season
Ornamental Installation – Transplant	1 – 2 oz	Gal Water	Soak root ball prior to back filling hole
Ornamental Maintenance	1 – 2 Quarts	Acre	Apply as soil drench spring & fall for optimum results.
Ornamental Plants	1.5 – 3.0 oz	1000 sq ft	Apply as soil drench monthly throughout growing season for optimum results.
Tropical Plants	2.0 – 3.0 oz	1000 sq ft	Apply as soil drench monthly throughout growing season for optimum results.
Outdoor Ornamental	1.5 –3.0 oz	1000 sq ft	Apply as soil drench or sprench throughout growing season monthly for optimum results.
Bulbs	1 oz in 1 gal water	16 bulbs	Soak bulbs with solution at time of planting. Utilize 8 oz solution/average sized bulb.
Compost Activator – Bins	2 oz in 1 gal water	50 gal	Spray solution onto compost and tumble Utilize 1 gal solution per 50-gal compost bin capacity
Compost Activator – Piles	2 oz in 1 gal water	10 Cubic Foot	Spray solution on to compost and turn pile Utilize 1 gal solution per 10 cubic feet of compost
Greens & Tees	½ – 1 Quarts	Acre	Apply every 2 – 4 weeks for optimum results
Fairways & Sports Turf	1 – 2 Quarts	Acre	Apply every 4 weeks for optimum results
Turf	0.75 – 2.0 oz	1000 sq ft	Apply as soil drench monthly throughout growing season for optimum results
Greenhouse Injector @	1 – 2 Quarts	10,000 sq	Apply every 4 weeks for

1: 100		ft	optimum results
Irrigation Injection/Drip	1 – 2 Quarts	Acre	Dilute liquid fertilizer 1:1 prior to tank mixing
Manure Application (Per 3,000 gal)	1 – 2 Quarts	Acre	May be tank mixed or injected directly into line

Storage & Handling

* Product should be stored in a cool, well-ventilated area out of direct sunlight.
* * Store between 40^{O} F – 90^{O} F to optimize shelf life. Do not allow product to freeze
* Keep container tightly sealed. When stored properly product has 2-year shelf life* Refer to SDS for detailed instructions

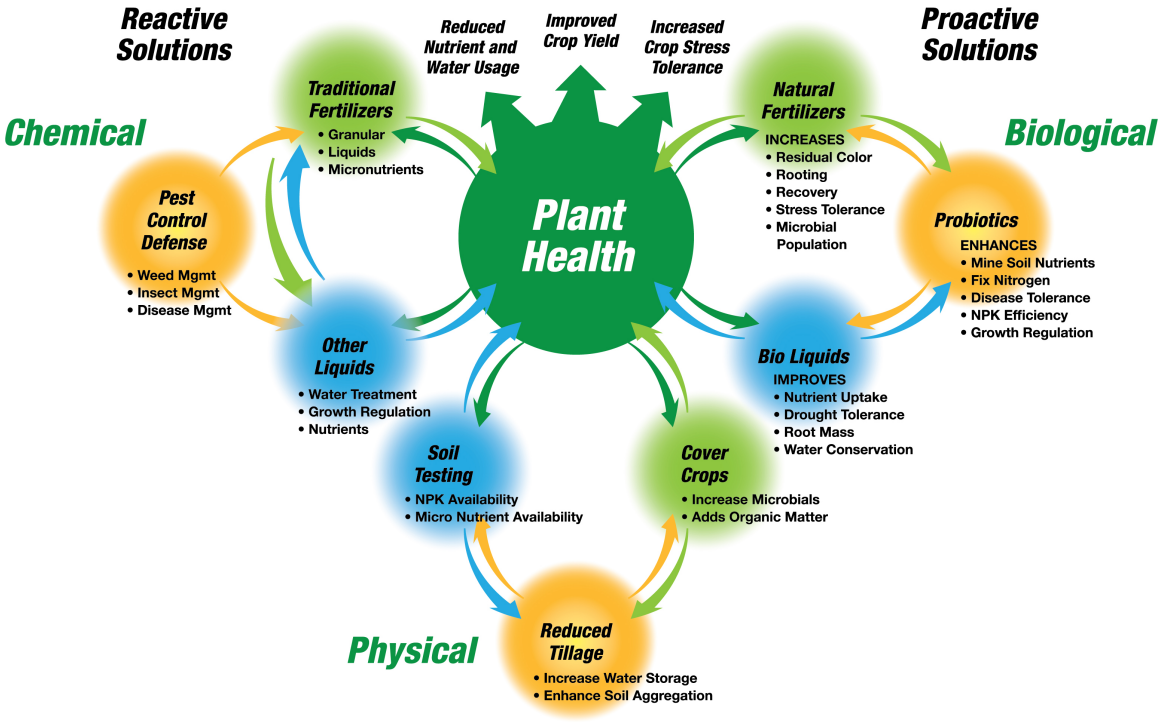
Bridging the Agronomic Gap

Conventional agricultural practices relied heavily on chemical fertilizer and pest control products to manage crop yields. Over the years, these improvements to conventional pest control and nutrient products have been the backbone to increased crop yields to meet the growing demand for food. With the exploding population growth, this demand for increased yields is placing greater pressures on conventional products and programs. These best management practices are critical to these yield increases. Yet, these same products and programs are not meeting this increased food demand; and are having a negative impact on our natural soil systems limiting product effectiveness and yield. It's time to add explore new methods that meet this food production gap.

Soil health can have an impact on both biotic and abiotic crop related stresses that can impact yields. Biological methods and products can deliver this new dimension of soil health balances that translates to improved crop yields. In recent years, there has been a movement to integrate more natural product solutions with conventional approaches.
Biological inputs can add the "Power of Nature" to crop management. Biological products can restore microbial health to damaged soil. It also can intensify the performance of conventional pest control and nutrient products that increases yields.

A simple solution is to integrate the agronomic benefits of a multiple prong program that takes advantages of the chemical, physical and biological merits of an integrated crop management program approach. This chart shows the integrated benefits of a multi-prong agronomic approach to overall crop management.

Balanced Agronomic Program



Conclusions

Detonation is a biological nutrient deliver system that can increase crop yields by building microbial populations that translates into enhanced soil health. It can used in conjunctions with conventional programs to complement and enhance product performance. Detonation is the biological product that restores microbial health to damaged soil that bridges this agronomic gap with these key benefits.

Benefits

- Enhances nutrient solubility and availability of inorganic nutrients
- Enhanced nutrient mineralization and availability of organic nutrients
- Enhanced nutrient mineralization of nutrients locked in the soil
- Promotes plant growth and increased crop yields
- Promotes nutrient retention particularly N
- Promotes nitrogen fixation from atmospheric nitrogen
- Increased abiotic stress tolerance (temperature extremes, high salinity & traffic)
- Improves water retention and soil aggregation & structure