GREEN WAVE ENTERPRISES, LLC

Oxidized Lignite-Based New Mexico Humates and Humic Acid: A Sustainable Boost for Agriculture!

Oxidized Lignite based Humates and Humic Acid: A Sustainable Boost for Agriculture

Introduction

Agriculture today faces the dual challenge of improving crop productivity while enhancing environmental sustainability. Conventional farming heavily relies on synthetic fertilizers, which can boost yields but often degrade soil health over time and contribute to runoff pollution. Oxidized lignite-based humates and humic acid offer a promising solution to these challenges. Humic substances – particularly those derived from oxidized lignite or bituminous oxidized coal – have demonstrated significant benefits for soil health, nutrient efficiency, plant growth, and environmental quality. This white paper provides an in-depth look at the science and practical outcomes behind humates, aiming to persuade agri-business executives, fertilizer wholesalers, and blending companies of their value in future-ready farming systems.

What Are Humates and Humic Acids? (Overview and Composition)

Humic Substances: Humic substances (HS) are the natural organic compounds resulting from the decomposition of plant and animal matter in soils, peats, and certain coals(*2). They are broadly classified into humic acids (HA), fulvic acids (FA), and humin, based on solubility. Humic acids are the fraction soluble in alkali but precipitate in acid, fulvic acids remain soluble, and humin is insoluble. Humic and fulvic acids are considered the most bioactive component of HS and often form salts (humates) that are more soluble and reactive in soil(*2).

Oxidized Lignite as a Source: Refers to a specific type of humate that is extremely rich in humic substances. It is formed by the natural weathering of coal deposits and contains a high proportion of humic acids along with numerous functional groups (especially carboxylic groups) due to its higher degree of oxidation(*7). In practical terms, oxidized lignite is one of the best raw sources of humic acids, often containing humic acids in very high concentrations (sometimes exceeding 70% humic acid content by weight)(*7). This makes oxidized lignite-based humates particularly potent as soil amendments.

Chemical Composition: Humic acids are complex, heterogeneous macromolecules. Elemental analysis shows humic acids contain roughly 50–60% carbon, plus hydrogen, oxygen, nitrogen, and sulfur in various proportions. The carbon-rich structure includes aromatic rings and aliphatic chains with many reactive functional groups such as carboxyl (-COOH), phenolic -OH, quinone carbonyls, and others. These functional groups give humic acids a high cation exchange capacity and the ability to chelate (bind) metal ions and nutrients. For example, humic acid can form stable complexes with micronutrients like iron, zinc, and copper, increasing their availability to plants. The large, charged molecules also have amphiphilic properties, meaning they can interact with both water and hydrophobic substances, which helps improve soil structure and nutrient retention. Overall, humates from oxidized lignite pack a concentrated dose of aromatic carbon and functional chemistry that can rejuvenate soil ecosystems.

GREEN WAVE
ENTERPRISES, LLC

Soil Health Benefits of Humates

One of the most compelling advantages of humic substances is their positive impact on soil health. Humic and fulvic acids serve as natural soil conditioners that improve physical, chemical, and biological properties of soils(*1).

- **Improved Soil Structure and Water Retention:** Humates help aggregate soil particles, leading to better soil structure and porosity. This improved structure enhances aeration and root penetration while also increasing the soil's water holding capacity(*1). By binding light, sandy particles or loosening heavy clays, humic matter creates a crumbly, friable soil texture that retains moisture more effectively. Field studies have measured notable gains in water retention – for instance, a three-year trial in Idaho found that adding liquid humate increased soil water sequestration by about 6–11%, which helped crops better withstand dry conditions(*3). By holding more water in the root zone, humate-treated soils can reduce irrigation needs and confer greater drought resilience.
- **Enhanced Cation Exchange Capacity (CEC) and Nutrient Retention:** The carboxyl and phenolic groups on humic acids contribute to a high CEC, meaning the soil can hold onto essential cations (such as K^+, Ca^{2+}, Mg^{2+}, NH_4^+). This prevents nutrients from leaching away and makes them available for plant uptake over a longer period(*1)(*2). In practical terms, incorporating leonardite-based humates can turn the soil into a more effective "nutrient bank." Farmers often observe that fertilizers last longer in humate-enriched soil because the humic substances hold nutrients in the root zone instead of letting them wash out(*6). This nutrient retention not only improves fertilizer efficiency but also reduces environmental runoff into waterways.
- **Increased Soil Organic Carbon and Microbial Activity:** Adding humates directly adds stable organic carbon to the soil. This form of carbon is known as "aromatic" carbon – the most stable form of carbon. Soil microorganisms are the only thing that can convert carbon into this form. Aromaticity of humic substances is measured and noted in NMR "Carbon 13" analyses. In other words, soil humus "stays put". It does not wash away. Unlike fresh crop residues that decompose quickly, the carbon in humic acids is relatively resistant to rapid microbial breakdown, acting as a long-term carbon reservoir(*1). For example, a laboratory study with ^{13}C-labeled humic acid found that up to 58% of the added carbon remained sequestered in the soil after 3 months(*1). This indicates humic applications can contribute to building soil organic matter over time, which is crucial for soil health and climate change mitigation. Furthermore, humates feed and stimulate soil microbiology. Studies report that humic amendments boost beneficial microbial populations and enzymatic activity in soil(*1). Soil microbes thrive on the carbon and energy sources in humic substances, leading to increased processes like nitrogen mineralization and phosphorus solubilization. In one greenhouse trial, a single application of 1000 kg/ha humic acid significantly increased soil enzyme activities (like urease and phosphatase) within 140 days, corresponding with higher microbial biomass(*1). Healthier microbial communities improve nutrient cycling and even produce plant growth promoters. In short, humates jump-start the biological engine of soils.
- **Soil pH Buffering:** Humic substances can moderate soil pH swings. Research has shown humates can help slightly acidify alkaline soils (freeing up micronutrients) or buffer acidic soils by complexing aluminum, thus creating a more neutral and stable pH environment conducive to most crops(*1). The primary function humic substances serve in buffering soil pH is the fact they are the proper substrate for beneficial soil microorganisms.

In providing the proper substrate, or foundation, for these beneficial microbes, humic substances allow for not only increased populations of these soil microbes but, for their diversity as well. Increased diversity of microbes - which prefer either more acidic or more alkaline environments – allow for opposing microbial exudates to balance one another, which is the primary mechanism that drives soil chemistry. By restoring these aspects of soil health – structure, nutrient balance, organic matter, and microbes – oxidized lignite-based humates help regenerate fertility in degraded soils. Farmers using humates often describe their fields as "coming back to life," with darker, richer soil that is more crumbly and teeming with earthworms and micro-fauna. All these improvements create a more resilient soil system that supports high-yield agriculture sustainably.

Enhanced Nutrient Uptake and Fertilizer Efficiency

Humic acids are well-known for their role in improving nutrient availability and uptake by plants. They act as natural chelating agents and biological stimulants, making both macro- and micronutrients more accessible to crop roots(*1)(*2). Key nutrient-related benefits include:

- **Micronutrient Chelation:** Humic and fulvic acids form soluble complexes with important micronutrients. Iron, zinc, copper, manganese and other trace elements often become locked in insoluble forms in soil (especially in alkaline pH). Humic molecules can bind to these ions and keep them in a form that plant roots can absorb(*2). For instance, humic acid applied to calcareous soil can chelate iron, preventing iron chlorosis in crops. Studies have noted that humic substances co-transport micronutrients to plants, effectively increasing the concentration of these nutrients in plant tissues(+1). In practical usage, farmers have seen greener, healthier crop growth after humate application due to alleviation of micronutrient deficiencies.
- **Improved Phosphorus Availability:** Phosphorus fertilizer efficiency is often low because phosphate binds with calcium in high-pH soils or with iron/aluminum in low-pH soils, making it insoluble. Humic acids can reduce this fixation by complexing with those metals. The polycyclic functional groups of humic and fulvic acids carry a negative charge (above pH 5.0) which allows them to chelate the various cations bound to phosphorus. This weakens the bond between phos and calcium / iron / aluminum which "fractionates" the bond phos has with those cations, resulting in phos becoming more mobile and bio-available to the plant. They also stimulate soil microbes (like phosphatase-producing bacteria) that help convert organic P into plant-available forms(*1). Research has shown that combining humic substances with phosphate fertilizers can lead to greater P uptake in plants than fertilizer alone(*2). In one study, incorporating humic acid into a phosphate fertilizer significantly enhanced maize growth and P absorption versus using the fertilizer alone(*2). Thus, humates help unlock native and applied phosphorus, reducing the need for high P application rates.
- **Nitrogen Use Efficiency (NUE):** Nitrogen is a costly and environmentally critical input, and humates have demonstrated an ability to improve nitrogen use efficiency. They can influence nitrogen in multiple ways:

- **Slower N Release:** Increasing the humic substances in the soil to 20-60ppm enables urea or ammonium fertilizers to slow down their hydrolysis and nitrification. Humic substances can bind to ammonia or complex trace metals like nickel that are involved in urease enzyme activity, thereby moderating the conversion of urea to nitrate(*1). By keeping nitrogen in the ammonium form longer, humates reduce leaching losses (nitrate is highly leachable) and extend the time N is available to plants. While "marrying" humic products and nitrogen fertilizers is one approach, simply applying humic products to the soil to build these levels of humic substances creates this beneficial and symbiotic activity with all forms of nitrogen in the soil.
- **Enhanced Uptake:** Humic acids stimulate root growth (discussed further below), leading to larger root systems that can take up more nitrogen. They also increase the activity of nitrate transporters in roots and the enzymes involved in nitrogen assimilation in plants(*1). The result is a higher fraction of applied N ends up in the crop rather than lost.
- **Evidence of NUE Gains:** A recent meta-analysis of 120 studies quantified the impact: adding humic acid in conjunction with normal fertilization increased crops' nitrogen use efficiency by an average of 27%(*2). At the same time, nitrogen uptake by plants rose ~17% on average, indicating more of the soil N was absorbed into biomass(*2). These are significant improvements that can allow growers to achieve the same yields with less fertilizer or achieve greater yields with the same fertilizer. In regions like China where NUE is traditionally low (~30% in many areas), humic acids are being adopted to raise efficiency and curb excess fertilizer use(*2). By improving NUE, humates not only boost profitability (less wasted N) but also reduce environmental problems like nitrate leaching and greenhouse gas emissions.
- **Biostimulant:** Humic substances serve as a biostimulant for nitrogen fixing bacteria in the soil. Increased populations of nitrogen fixing bacteria make use of nitrogen directly from the atmosphere. Fulvic acid increased the growth rate of rhizobium trifolii by over 200% and sodium humate produced a 52% greater growth rate of rhizobium trifolii than control (Bkardwaj and Gaur et al 1972).

- **Synergy with Fertilizers:** Rather than replacing conventional NPK fertilizers, humic products are typically used in tandem to enhance overall effectiveness. Fertilizer suppliers have found that blending humates with NPK can lead to synergistic effects. For example, in one field trial, wheat plots that received humic acid alongside the recommended NPK fertilizer had significantly higher shoot dry weight, chlorophyll content, and grain yield than plots with NPK alone(*1). The humic substances effectively magnify the fertilizer's impact by improving nutrient retention in soil and uptake by roots(*6). This synergy means a given amount of fertilizer yields more output, improving the return on fertilizer investment and enabling potential reductions in application rates over time.

Oxidized lignite-based humates act as a natural nutrient optimizer in the soil-plant system. They increase the bioavailability of existing nutrients, make fertilizer inputs work more efficiently, and ensure that plants can uptake and utilize a greater proportion of those nutrients. The outcome is better-fed plants, often achieving equal or greater growth with lower chemical fertilizer quantities – a win-win for producers and the environment.

Plant Growth and Crop Yield Improvements

Ultimately, the goal of any soil or fertilizer input is to improve plant performance and crop yields. Humic and fulvic acids have been shown to exert direct biostimulant effects on plants, in addition to their soil-mediated benefits. These effects translate into improved plant vigor, resilience, and productivity:

- **Root Development and Architecture:** One of the most consistent observations in humate research is the stimulation of root growth. Humic acids can act similarly to plant growth hormones, enhancing root elongation and branching(*1). They have been found to upregulate auxin and cytokinin production in plants, which are hormones that drive root and shoot development(*1). For example, studies on various crops (from vegetables to ornamentals) have documented increased root mass when leonardite-derived humic acid is applied(*1). In greenhouse experiments, leonardite humic acid additions led to larger root systems in gerbera flowers and canola plants compared to controls(*1). A more robust root network allows plants to explore a greater soil volume for water and nutrients, contributing to better growth aboveground.
- **Shoot Growth and Physiology:** With improved root function and nutrient uptake, aboveground growth also benefits. Humic substances have been reported to increase leaf chlorophyll content and photosynthetic activity, likely due to better micronutrient nutrition (like Fe and Mg for chlorophyll) and direct hormone-like effects(*1). In one study, moderate rates of humic acid application increased pepper plant yields along with higher chlorophyll levels in the leaves(*1). Enhanced photosynthesis and plant metabolism ultimately lead to greater biomass accumulation and improved crop quality (e.g., higher protein content in grains, better fruit size and uniformity). Some research also indicates humic acids can improve a plant's stress tolerance – e.g., by increasing proline levels and antioxidant enzyme activity, thereby helping plants cope with drought or salinity stress(*1). Farmers often observe treated crops having a healthier green appearance and sometimes better resilience in adverse weather.
- **Yield Increases:** The cumulative effect of all the above factors (healthier soil, more nutrients, larger roots, and vigorous growth) is higher crop yields. Numerous field and greenhouse studies have evaluated yield outcomes from humate or humic acid applications:
    - On average, yield improvements in the range of 10–15% are commonly reported. A comprehensive 2023 meta-analysis encompassing hundreds of field trials worldwide found that using humic acid fertilizers increased crop yields by about **12% on average**(*2). This included a variety of crops and conditions, illustrating a broadly positive effect.
    - In long-term farm applications, even larger gains have been documented. Over 30 years of on-farm research in Idaho, consistent use of quality leonardite-derived humic products led to yield increases ranging from **6% up to 30%** in various cropping systems(*3). Such significant improvements accrued over time as soil health built up and humate benefits compounded season after season.

- Specific crop examples highlight the potential: In California, a 2019 case study on bell peppers observed a **+26% yield increase** in a humate-treated field compared to the control field, despite the treated field having sandier (less fertile) soil(*5). The treated peppers also had lusher foliage, which provided greater canopy shade and likely contributed to the yield boost by lowering plant stress(*5). Likewise, trials in cereals and vegetables have shown yield bumps of 5–20% with the addition of humic acid, depending on application rate and baseline soil conditions(*1).
- Importantly, yield improvements are not limited to quantity; quality metrics often improve too. In sugarcane experiments, humic acid not only increased cane tonnage per hectare but also raised the sugar content in the juice (measured as Commercial Cane Sugar yield) significantly above the standard fertilizer control(*4) . Higher sugar yield means better crop quality and higher market value.
- It should be noted that results can vary with context. Extremely high application rates or poor-quality humate products sometimes yield diminishing returns, and in a few cases no significant yield change is seen if soil fertility is already optimal(*2). However, the preponderance of evidence and farmer experience indicates that in most real-world scenarios – where soils have some limitations – humates provide a clear boost to crop performance.

Taken together, these findings make a compelling case that humates function as effective plant growth promoters. They essentially provide a biological yield lift on top of what traditional inputs achieve. For a grower, an extra 5–15% yield due to humates can be the difference between profit and loss in tight margin conditions, and the higher-end improvements (20–30%) represent a transformative gain in productivity. The fact that these yield increases come from a natural substance (often approved for organic farming) rather than an additional chemical input is even more attractive from a sustainability and marketing standpoint.

Environmental Benefits of Humic Amendments

Beyond direct agronomic gains, leonardite-based humates confer several environmental and sustainability benefits that are increasingly important in modern agriculture:

- **Building Soil Carbon (Climate-Smart Farming):** Regular application of humic substances adds stable, aromatic forms of carbon to the soil, contributing to long-term soil organic carbon (SOC) buildup(*1). Unlike fresh crop residues that decompose within months, the carbon in humic acids can persist for years, even decades, in soil humus. This makes humate application a form of carbon sequestration. One study noted that humic amendments increased the recalcitrant carbon fraction in soil, correlating with higher total carbon sequestration over time(*1). Higher SOC is synonymous with improved soil health – it means better structure, water retention, and fertility – and it also means agriculture is returning carbon to the land (helping offset emissions). As the industry and regulators emphasize climate-smart practices, using humates to boost soil carbon is a tangible strategy for growers to improve their carbon footprint while enhancing productivity.
- **Improved Water Retention and Drought Mitigation:** Humic substances greatly enhance a soil's ability to hold water. They act like sponges due to their colloidal nature and high surface area, binding water molecules that plants can later use.

- Research has shown that for each 1% increase in soil organic matter (which humates help achieve), soils can hold significantly more water per acre. In practical terms, fields treated with humates have stayed more moist during dry spells. The Idaho potato field study mentioned earlier not only quantified a 6–11% increase in water-sequestering capacity, but also observed reduced “tare dirt” (the clods and dry soil that cling to harvested potatoes) in humate-treated plots(*3). Farmers reported that crops in treated soil showed less wilting under heat stress. Thus, humates contribute to better drought resilience and can potentially reduce irrigation requirements. Some farm input providers claim up to 20–30% reduction in irrigation needs when humic amendments are used consistently(*5), as the soil’s water-holding improvement translates to fewer watering cycles. While actual savings will vary, the direction is clear: humates help capture rainfall and irrigation water in the soil, making agriculture more water-efficient.
- **Reduced Nutrient Leaching and Runoff:** By holding nutrients in the root zone through chelation and cation exchange, humates decrease the loss of fertilizers into groundwater and surface water. Nitrates from fertilizers are notorious for leaching into aquifers and causing pollution (e.g., algae blooms) downstream. Humic acids, by improving nitrogen retention and slowing its conversion to highly leachable forms, help keep more nitrogen in the soil profile for plant use(*1). Similarly, phosphorus runoff is mitigated since humates bind phosphorus and associated soil particles. A healthier, humus-rich soil also has better structure to resist erosion, meaning less sediment and nutrient runoff overall. The environmental payoff is a reduction in fertilizer pollution – a key goal for regulatory agencies and communities. Farmers using humates as part of their fertility program can tout this benefit as evidence of adopting best management practices for environmental stewardship.
- **Lower Dependence on Synthetic Chemicals:** Although humates are often used in tandem with synthetic fertilizers, their ability to boost nutrient efficiency means that over time farmers may achieve the same yields with lower chemical inputs. There are documented cases where growers have cut back fertilizer application rates by a certain percentage after humate use, without sacrificing yield. For example, some trials indicate that coating conventional fertilizer (like urea or DAP) with humic substances allows a 10–20% reduction in the fertilizer rate while maintaining crop performance, as the humate makes the fertilizer more effective. In China, a case study on rice found that replacing a portion of the urea nitrogen with humic acid fertilizer still led to yield gains – the highest humic treatment (with greatly reduced chemical N) increased rice yields by ~6% and biomass by over 20% compared to the all-urea treatment(*2). These findings suggest humates can partially substitute for synthetic NPK, moving farming toward a more organic and regenerative model. Less chemical fertilizer use also means lower input costs and reduced risk of fertilizer-related soil degradation (such as salt buildup). Additionally, humic substances can remediate certain soil issues – for example, they can complex and immobilize heavy metals or toxins in polluted soils(*2), thereby reducing plant uptake of those contaminants. Overall, integrating humates contributes to a cleaner and more sustainable agricultural ecosystem.

The environmental services provided by humates align well with global sustainability trends. They improve soil’s natural capital (carbon and water), decrease agriculture’s pollution footprint, and help create a regenerative loop where the soil becomes more fertile with each season. For agribusinesses, this not only meets corporate sustainability goals but also appeals to consumers and regulators who are increasingly concerned about how food is grown. Humates thus position farming operations to be environmentally resilient and compliant with future ecological standards.

Return on Investment (ROI) and Cost-Benefit Analysis

For any agricultural input, adoption at scale depends on a clear economic benefit to growers and businesses. Leonardite-based humates and humic acid products have demonstrated strong return on investment (ROI) potential by boosting yields, enhancing fertilizer efficiency, and providing cost savings over the long run. Here we analyze ROI from multiple angles, supported by quantitative data:

- **Yield Increases and Revenue:** As detailed earlier, humic substances can increase crop yields by a significant margin (often 5–15% or more). This directly translates into higher revenue per acre. For example, if a corn farmer typically yields 180 bushels/acre, a 10% increase would add 18 bushels. At a market price of, say, $5 per bushel, that's an extra $90 per acre earned. Even a more modest 5% yield bump would add $45/acre, which can cover the cost of humate application (as we will see, application costs are often in the tens of dollars per acre). In high-value crops like fruits and vegetables, the dollar gains from a yield improvement are even greater. The bell pepper case in California, with a 26% yield increase, would have substantially boosted that grower's income per field(*5). Moreover, improvements in quality (like the sugarcane sugar content increase(*4) or higher protein in grains) can sometimes fetch premium prices or bonuses, adding to income.
- **Reduced Fertilizer Costs:** By improving nutrient uptake and efficiency, humates can maintain yields with lower fertilizer inputs over time. If a farmer is able to reduce nitrogen application by 20% due to better NUE, that's 20% savings on the largest fertilizer expense line. In regions with heavy fertilizer subsidies or high costs, this is a huge incentive. For instance, a wheat farmer using 150 kg/ha of N might drop to 120 kg/ha without yield loss after incorporating humic substances, saving 30 kg of N per hectare. At $1 per kg N (for urea), that's $30/ha saved. Similarly, if phosphorus or potassium rates can be trimmed due to better soil retention, those are additional savings. Some commercial programs report that long-term humate users have cut their NPK fertilizer requirements by up to 30%(*5), which not only cuts costs but also buffers against fertilizer price volatility. Even when fertilizer rates are not reduced, humates ensure more bang for the buck – effectively increasing the return on each dollar spent on fertilizer by increasing the fraction utilized by the crop(*6).
- **Improved Water Efficiency and Savings:** Especially for irrigated agriculture, water is a major cost and limiting resource. As discussed, humate-treated soils retain more water, potentially allowing for less frequent irrigation. Cutting just one or two irrigation events in a season (or using less water each time) saves on energy for pumping and conserves water. Some case data suggest up to 10–20% irrigation savings is attainable in certain systems with improved soil water holding capacity(*3)(*5). In addition to cost savings, this can be invaluable in drought-prone areas or where water is scarce. There is an ROI in terms of risk mitigation – farms with better water retention have lower risk of crop losses in drought, which is an economic benefit (avoided loss) that, while harder to quantify, is very real.
- **Benefit-Cost Ratios (BCR) from Studies:** Several studies have explicitly calculated the economics of humate use:

- A multi-year field experiment on sugarcane in Asia tested humic acid applied at different rates alongside regular fertilization. The treatment with 10 kg/ha of humic acid (applied at planting) achieved the highest benefit-cost ratio of **3.94,** meaning every $1 invested in humic acid returned $3.94 in additional profit(*4). This treatment increased cane yields from about 115.7 t/ha (in the standard practice) to 140.0 t/ha, a roughly 21% increase(*4). The net returns from the extra yield far outweighed the cost of the humic product. Notably, the 10 kg/ha rate was deemed most economical; higher rates with foliar sprays yielded similar production but at higher cost, underscoring that moderate application can be optimal for ROI(*4).
  - Another study on sugarcane reported that adding humic acid increased the benefit-cost ratio from 2.5 (with regular NPK alone) to around 2.9–3.0 when humic was included, thanks to better yields (this is in line with the above data, showing a clear economic gain).
  - Research on other crops like mung beans and sugar beets has similarly found higher net profits and BCRs for plots treated with humic substances compared to controls, largely due to yield and quality improvements offsetting the input cost.
- **Long-Term Payoff (Soil as an Asset):** An often overlooked aspect of ROI is the long-term benefit of improved soil health. While fertilizer gives one-time returns in the season of use, humic amendments are an investment in the soil's productive capacity. By restoring organic matter and soil structure, humates can boost yields not just in the application year but in future years as well, through carryover effects. They effectively rehabilitate degraded soils, which can raise the yield baseline and reduce the need for other costly interventions (such as deep tillage, gypsum for compaction, or additional organic matter inputs). If one were to calculate the net present value of using humates over a decade – including the avoidance of yield declines due to soil degradation – the ROI would be even more impressive. Healthy soils are a form of capital, and humates help build that capital.

The economic analysis strongly favors the inclusion of leonardite-based humates in fertilization programs. They create multiple value streams: higher output (yield/quality), lower input needs, and risk reduction, all of which contribute to farm profitability. For fertilizer companies and agri-businesses, humates represent an opportunity to offer more value-added solutions to customers. Blending humic products with traditional fertilizers can differentiate product lines and improve customer loyalty by delivering better on-farm results (and ROI). As we move toward agriculture that must be both high-efficiency and sustainable, humates stand out as a technology that checks both boxes in cost-benefit terms.

Case Studies and Field Examples

Real-world examples across different crops and geographies illustrate how humate and humic acid applications have been successfully implemented:

- **Long-Term Soil Rejuvenation in Idaho, USA:** University Extension trials in southern Idaho have documented the effects of humates over 30+ years on various crops (potatoes, small grains, corn, etc.). By using leonardite-derived humic products annually, researchers observed cumulative yield increases of **6% to 30%** and marked improvements in soil properties(*3). In one three-year on-farm study on **potatoes**, a liquid humate was applied through irrigation.

- The treated fields showed not only higher yields, but also improved tuber quality and less "tare" soil during harvest (an indication of better soil aggregation)(*3). The farmer also noted improved water infiltration and reduced need for additional organic matter amendments. This case exemplifies how consistent humate use can gradually restore productivity to soils that were previously showing signs of fatigue and declining yields.
- **Specialty Crop Yield Boost in California, USA:** A bell pepper grower in California's Coachella Valley conducted a trial comparing a humic substance treatment (derived from peat in this case) against a control in 2019. The humic product was applied via drip irrigation monthly during the growing season(*5). The result was a **+26% yield increase** in marketable pepper yield on the treated 15-acre block(*5) An interesting aspect is that the treated block's soil was actually sandier and less fertile than the control block, yet it outperformed the controls after humic treatment(*5). The treated plants had larger canopies (more foliage), which provided better shade and likely reduced heat stress on fruits(*5). This case study gave the grower confidence to expand humate use to other vegetable fields. It's a powerful demonstration that even in high-value horticultural crops, a relatively inexpensive humate treatment can yield substantial financial returns via increased grade-A produce.
- **Rice Production and Fertilizer Reduction in Northeast China:** The Songnen Plain in China is a major rice-growing area with fertile "black soils" that have been degrading due to intensive farming. A field experiment was conducted to see if humic acid could partially replace chemical fertilizer for rice. Treatments ranged from 100% chemical fertilizer to majority humic acid inputs(*2). The findings showed that plots receiving a high dose of humic acid (with much lower chemical N) still achieved a slight **increase in rice yield (~5–7%)** and over 20% higher biomass compared to the conventional fertilizer-only plots(*2). Essentially, humic substances compensated for reduced synthetic fertilizer and even stimulated greater plant growth through improved light utilization and leaf area index(*2). This suggests that humates can be a cornerstone of more organic or reduced-chemical farming models. The case is spurring interest in "functional fertilizers" in China – blending humic acids into NPK fertilizers to improve efficiency and cut total chemical use(*2).
- **Sugarcane and Soil Fertility in India:** As mentioned earlier, trials at a sugar institute in India applied leonardite-derived humic acids to sugarcane fields. With only 5–10 kg/ha of humic acid added, cane yields jumped significantly (from ~116 to 140 t/ha at the best treatment) and sugar recovery improved(*4). From a practical standpoint, this meant higher sugar production per acre for the mill and growers, with the economics yielding a nearly 4:1 return on the cost of humic input(*4). This case has led local extension services to recommend humic acid as a supplement for cane growers seeking to maximize yield on existing land, rather than expanding into new acreage.
- **Greenhouse and High-Value Floriculture:** Humates are not only for broad-acre crops; they have found use in intensive greenhouse cultivation and ornamentals. For example, gerbera (ornamental flower) growers in Europe observed that adding humic acid to their nutrient solution increased root mass and ultimately led to more robust flower production(*1). In hydroponic or soilless systems, humic and fulvic acids serve as bio-stimulants that improve nutrient uptake and stress tolerance of plants, often leading to better quality produce (e.g., larger tomatoes, more uniform lettuce heads, etc.) as reported in various case anecdotes. While these systems require careful management to avoid biofilm issues, the right quality of fulvic acid (highly soluble fraction of humic substances) can be a game-changer in organic hydroponics.

These cases, among others, underscore a few common themes. First, humic substances are versatile and have delivered positive results in diverse environments – from arid vegetable fields to paddy rice and long-term no-till systems. Second, success often comes when humates are integrated thoughtfully (proper rates, timing, and in combination with, not in exclusion of, basic fertilization). In each case, humates helped address a limiting factor: in one it was nutrient lock-up, in another water stress, in another declining soil organic matter. By ameliorating those underlying issues, humates unlocked greater productive potential.

For agricultural decision-makers, these examples provide a blueprint. Starting with pilot trials on a portion of acreage (as the pepper grower did) can validate the benefits under local conditions. Once confidence is built, scaling up humate use can lead to system-wide improvements. Importantly, even in the cases where soil or climate conditions were less than ideal, humates helped level the playing field (e.g., the sandier soil yielding more than the richer soil when humates were applied). This suggests humates are a tool for resilience – allowing crops to better cope with variability in soil quality and climatic conditions.

Integrating Humates into Fertilizer Programs

For those convinced to give humates a try, a logical question is how to incorporate them into existing agricultural practices. Oxidized lignite-based humates and humic acids are available in various forms (solid and liquid), and they can be applied in multiple ways. Here are strategies for integrating humates into fertilizer programs effectively:

- **Granular Humate Blends:** One common approach is to mix granular humate products (often sold as dry, dark granules or powder) directly with conventional granular NPK fertilizers. Fertilizer blending companies can create custom formulations – for example, a 15-15-15 NPK fertilizer that includes 5% humic acid granules. These granules will be spread along with fertilizers during planting or topdressing. The advantage is convenience and uniform distribution. Farmers can apply their fertilizer as usual, and the humate is delivered to the soil simultaneously, where it will improve nutrient retention and soil quality around the fertilizer prill. Many fertilizer wholesalers now offer products like “humate-coated urea” or “NPK + humic” as value-added lines, meeting a growing market demand. When blending, it’s important to ensure the humate material is dry and free-flowing to avoid clogging equipment; high-quality leonardite humate granules are well-suited for this.
- **Liquid Humic Concentrates in Fertigation or Spray:** Liquid humic acid concentrates (typically 6–12% humic acid by weight) can be injected into irrigation water (fertigation) or sprayed foliar/soil at various crop stages. In irrigation, adding 1–2 liters of liquid humic per acre per irrigation cycle (or every few cycles) can continually dose the soil with humic substances. This works well in drip irrigation, center pivots, or even through fertigation in paddy fields. Foliar spraying of humic or fulvic acids can also be done, especially with the more soluble fulvic fraction which is easily absorbed by leaves. Foliar application is usually at lower rates (e.g., 0.5–1 L/acre of concentrate in sufficient water) and is often targeted at stress periods or critical growth stages to stimulate the plant. Some agronomists suggest a combination approach: a soil/seed application at planting to enhance root establishment, followed by a foliar humic/fulvic feed during mid-season to boost growth and stress tolerance(*4).

- Liquid applications are flexible and can be easily integrated with existing liquid fertilizer or crop protection applications, as long as compatibility is checked (humic acids mix well with most fertilizers except highly acidic solutions or those with concentrated calcium that might precipitate).
- **Seed or Transplant Treatments:** Humates can also be applied at the very start of a crop's life. For row crops, dry humate powder can be applied in-furrow with seeds or as a seed coating. For example, mixing a small amount of humic powder with talc/graphite planter box treatments is one simple method; the humic acid surrounds the seed and improves the immediate soil environment as the seed germinates. This can lead to better early root development and vigor. In transplant production (like vegetables or tree saplings), dipping roots in a humic solution or incorporating humate into potting mix can reduce transplant shock and accelerate establishment. Such early-stage applications are relatively low-dose but can have outsized effects on how well the crop later performs, essentially "settting the stage" for robust growth.
- **Application Timing and Frequency:** To integrate into a program, timing can be aligned with normal field operations. Many farmers will apply humates at planting (with starter fertilizers or in the planting furrow) and then again mid-season (e.g., side-dress, top-dress, or through irrigation) to reinforce the effects. Humic substances are not one-and-done fertilizers; think of them more as soil conditioners and biostimulants that can be replenished. Thus, a split application strategy often works best – some early to get the roots going, and some later to sustain soil biological activity and nutrient uptake. In perennial crops like orchards or vineyards, a common practice is a post-harvest or pre-bud-break soil application to enrich the soil before the next growth cycle, and possibly a foliar feed during fruit development for quality. Each operation can find an integration method that fits their logistics, but the key is consistency (regular use yields cumulative benefits).
- **Dosage and Product Quality:** From a program perspective, using the right dose and a reputable product is crucial, though specific recommendations vary. It's advisable to follow product guidelines or consult agronomists who can tailor rates to soil conditions. Equally important is product quality: humic products should be well-characterized, with a guaranteed humic/fulvic acid content. Poor-quality or heavily diluted products may not deliver noticeable results. Reputable suppliers will provide analysis of humic content (often using standard methods like the ISO or AOAC humic acid extraction protocol). As one review recommended, humic products for research and use should be **physically and chemically well-characterized** to ensure consistency(*2). Agribusinesses looking to carry humates should vet sources and possibly seek those with certifications (e.g., Organic Materials Review Institute - OMRI listing for organic use, which many leonardite humates have **including those from Green Wave Enterprises**).
- **Monitoring and Adjustment:** When integrating humates, it's a good practice to monitor soil and crop responses. Soil tests over time may show improvements in organic matter or nutrient levels. Plant tissue tests might indicate higher nutrient content. Of course, yield and quality at harvest are the ultimate metrics. By monitoring these, farmers can adjust their main fertilization plan – for instance, if humates have clearly improved nitrogen efficiency, the next season's N rate might be cautiously trimmed, saving cost without sacrificing yield. This adaptive management leads to an optimized program where humates and fertilizers complement each other for maximum efficiency. It's in line with precision agriculture: apply only what is needed, when and where it is needed, and humates help make better use of every unit applied.

In implementing these integration strategies, support and education are key. Agribusiness executives can play a role by providing guidance to their clients or field representatives on how to use humic products effectively. Fertilizer blending companies might offer pre-blended humate products or kits for on-farm mixing. Custom applicators could have setups to spray or inject humates along with other services. By making humates convenient to use and integrating them into the normal workflow, adoption can be scaled up with minimal disruption.

It is also wise to start with pilot programs or side-by-side comparisons (e.g., treat half a field with humates, half without) to locally validate benefits. When the treated area consistently outperforms the untreated, it builds the case for full adoption. Many early adopters of humates started this way, and as evidence mounted, they expanded usage to all their acreage.

Oxidized lignite-based humates and humic acids represent a powerful yet natural tool for enhancing agricultural productivity and sustainability.

As detailed in this paper, their benefits range from rejuvenating soil health (improving structure, organic matter, microbial life) to boosting nutrient efficiency and crop yields, all while conferring environmental advantages like carbon sequestration and reduced runoff. For agri-business leaders and fertilizer professionals, humates offer an opportunity to innovate within both conventional and organic farming frameworks – effectively bridging the gap between high-yield agriculture and eco-friendly practices.

The scientific evidence, backed by decades of studies and a growing number of meta-analyses, supports the efficacy of humic substances. **Humates improve key soil parameters and plant growth metrics,** leading to healthier crops and higher outputs(*1)(*2). Equally important, the economic analyses consistently show positive returns on investment, sometimes dramatically so (as in the sugarcane example with nearly 4:1 BCR)(*4). In a farming era where input costs are rising and environmental regulations are tightening, humates provide a timely solution to get more from each input while also future-proofing the farming system.

Adopting humic products should not be viewed as a radical change, but rather as an **upgrade to existing fertilizer programs.** They work best in conjunction with sound fertility and soil management practices. As highlighted, integration can be straightforward – whether by blending with fertilizers, spraying in the field, or coating seeds. The path to implementation is well-paved by the experiences of many successful growers and trials worldwide. Early adopters often become long-term users after seeing improvements in their fields year after year.

For decision-makers evaluating the next steps, here are some compelling takeaways:

- **Versatility:** Humates are effective in a variety of crops (row crops, horticulture, pastures) and climates, making them a broadly applicable technology.
- **Soil as Foundation:** By investing in soil health through humates, you are safeguarding the productive base of agriculture. This leads to more resilient and sustainable yield trends, which is especially crucial under climate stress conditions.
- **Compatibility:** Humic products are compatible with both conventional and organic systems. They can enhance synthetic inputs or be part of all-organic regimes, offering flexibility in meeting market or certification requirements.
- **Market Differentiation:** Products or crops grown with humate-enhanced practices can be marketed as using advanced, sustainable techniques. This can improve brand value for suppliers and meet consumer demand for environmentally responsible farming.
- **Regulatory Alignment:** Proactive use of humates can position farming operations ahead of regulatory curves, such as nutrient management mandates or carbon farming incentives. There is potential for carbon credits or sustainability certifications by increasing soil carbon through humate use, for example.

Conclusively, oxidized lignite-based humates and humic acids should be viewed as an integral component of “future-ready” farming systems. They embody the principles of regenerative agriculture (rebuilding soil) while boosting efficiency in a way that appeals to the bottom line. The evidence and cases presented herein make a clear, compelling argument: integrating humates is not just an agronomic improvement, but a smart business decision for those aiming to thrive in the next generation of agriculture. Embracing humic substances today will help ensure fertile soils, bountiful crops, and a sustainable legacy for tomorrow.

Sources:

- *(*1) Ampong et al., Frontiers in Agronomy (2022) – Review on the role of humic acids in soil and crop health.*
- *(*2) Lyons & Genc, Agronomy (MDPI, 2016) – Discussion on commercial humates and their field effectiveness. Ma et al., Agronomy (MDPI, 2024) – Meta-analysis quantifying humic acid effects on yield and nitrogen efficiency.*
- *(*3) Seyedbagheri, University of Idaho Extension (2015) – On-farm research report on humic substances improving soil water retention and yields.*
- *(*4) Sugarcane humic acid trial, Int. J. Res. Agronomy (2024) – Field experiment data showing 21% yield increase and BCR ~3.94 with 10 kg/ha humic acid.*
- *(*5) Rogitex Inc. Case Study (2019) – Bell pepper trial with 26% yield increase using Humic Land™ humic product.*
- *(*6) Black Earth (2019 blog) – Overview of humalite vs leonardite and their complementary role with fertilizers.*
- *(*7) Humintech GmbH (2018) – Educational content on leonardite formation and composition.*
- *Additional cited scientific literature embedded throughout the text.*

Why New Mexico Humates and Humate based Products Are Superior!

New Mexico Humates, sourced from unique geological formations in the San Juan Basin, are globally recognized for their unparalleled quality and consistency. Here's why New Mexico Humates stand out compared to other humate sources:

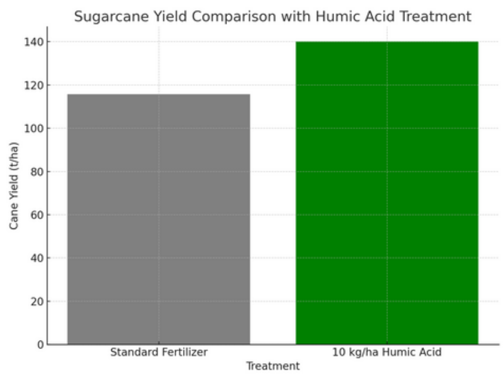
1. **Superior Humic Acid Concentration:** Analytical testing consistently shows New Mexico Humates containing 70-90% (by colorimetric method) humic acid (dry basis). This analysis is a combination of humic and fulvic acids. Typically, New Mexico deposits in the San Juan Basin contain approx.. 50%+ humic acids and 20% + fulvic acids of the total 70-90%. Other deposits, such as North Dakota, average 70% total combined acids, however; the fulvic acid fraction in those ND deposits reaches only 12-14% of the total 70%. This is due to the NM deposits having been exhumed and oxidized for longer periods of time than the ND deposits, which lends itself to a higher fulvic acid fraction by more extensive microbial oxidation of the humic acids. Humic shale deposits in Utah only contain 40-45% total humic acids. For New Mexico based humates, this results in stronger chelation capacity, improved nutrient exchange, and a more profound impact on soil microbial activity.
2. **Low Heavy Metal Content:** Due to the unique depositional environment, New Mexico Humates have minimal contamination of heavy metals (such as cadmium, lead, and arsenic), ensuring safer application for food crops and compliance with stringent global agricultural standards.
3. **Naturally Low Ash Content:** New Mexico Humates possess lower ash (mineral) content compared to other sources. This means a purer product with more bioavailable humic substances and fewer inert fillers.
4. **Proven Performance in Diverse Climates:** Field trials and farmer testimonials from arid regions (Arizona, New Mexico, Texas) to high-rainfall zones (Midwest, Southeast US) demonstrate that New Mexico Humates adapt well to varied soil types and climatic conditions, delivering superior results across diverse farming systems.
5. **Sustainability and Responsible Mining:** New Mexico's humate producers follow stringent land reclamation and environmental practices, ensuring minimal ecological disruption and a sustainable supply chain, a key factor as ESG (Environmental, Social, Governance) demands grow in agribusiness.

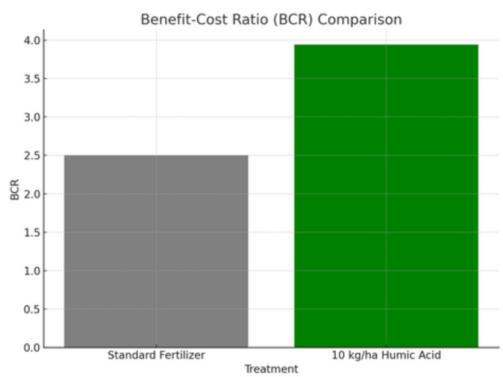
Green Wave Enterprises provides a wide array of best in quality, humate based products, sourced and produced with New Mexico humates. For more information, pricing or product information, contact Green Wave Enterprises:

Joel C. Reid | Owner
Green Wave Enterprises, LLC
70 SW Century Dr., Ste 100 PMB 1202 | Bend, OR 97702
Cell (505) 250-2801 | joel@greenwaveag.net | FB@greenwavehumate

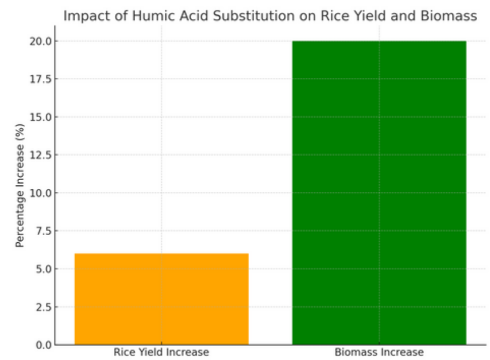
CHARTS

Sugarcane

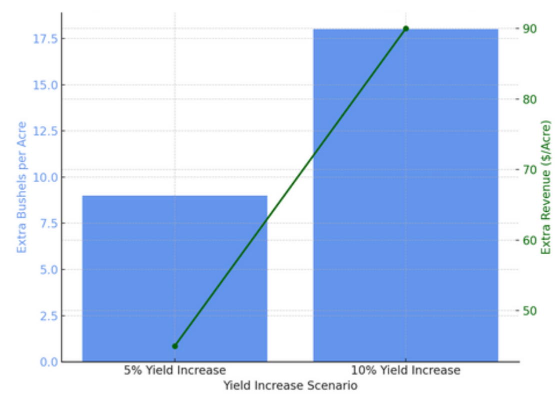




Lower Dependence on Synthetic Chemicals



ROI and Cost Benefit Analysis



Evidence of NUE Gains with Humic Acid