GROW MORE®

HUMIC ACIDS

BIOTECHNOLOGY FOR SOIL AND PLANTS

Grow More Inc. has offered humic acid-based products since 1984 for use in agriculture, horticulture and ecological bioremediation. We produce Humic Acids and their derivatives from Leonardite. We are one of the largest manufacturers in the Western U.S.A.

What Are Humic Acids

Humic Acids are the water soluble organic acids naturally present in soil organic matter. Humic Acids are not a single compound, but rather a collection of different molecular weight compounds with similar characteristics. They are usually defined by the process through which they are isolated, rather than by a particular chemical structure. Humic Acid provides a source of soil building carbon.

Soil organic matter can exist as:

- Living Plant & Animal Matter
- Identifiable Dead Tissue - Detritus
- Decomposed - Non Living, Non Tissue Humus

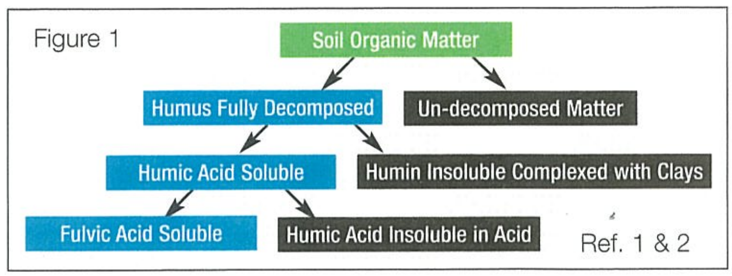
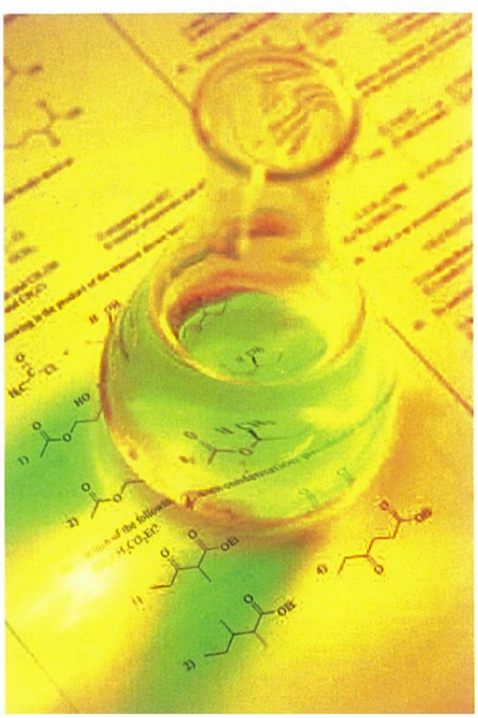


Figure 1

Not all organic matter is Humus! Four ways to identify Humus are:

- Origin or parent material cannot be identified.
- All sugar, fiber, cellulose, lignin, gums, protein, etc, have been decomposed.
- The material resists further decomposition.
- It is highly concentrated and a condensed form of the parent material.



Humus can be further classified:

- Humic - the soluble portion of humus
- Non humic - the insoluble portion called humin.

The soluble Humic Acids have three major fractions.

1. Humic Acid - A long chain polymer of high molecular weight that is dark brown to black that is soluble in alkaline solutions.
2. Ulmic Acid - Also known as Hymatomelanic Acid, is an alkaline extractable, alcohol soluble minor fraction of humic acids.
3. Fulvic Acid - A short chain polymer of low molecular weight that is yellow in color and soluble in both acid and alkali.

(Continued on Page 2)

Compared to other organic products, Leonardite is very rich in humic acids and very bioactive through its molecular structure.

The biological activity of Leonardite is about four times stronger than other humic matter.

Compared to other organic matter, Grow More Humic Acids offer long term effectiveness that does not dissipate as quickly as animal manure, compost or peat. Because humic acid is already decomposed, it does not compete with plants for nitrogen as does incompletely decomposed compost. Furthermore compost and light peat are rather rapidly decomposed by soil microbes and mineralized with very little humus formation. Grow More humic acids provide improved soil structure for years, in particular our granular humic up to 10 years.

Table 1

	Fulvic	Humic
Leonardite Grow More	14	85
Black Peat	3.5	40
Sapropel Peat	3.5	20
Brown Coal	3.5	30
Dung	1.7	15
Compost	0.70	5
Sewage	0.30	5
Soil	0.30	5
Coal	0	1

* Data calculated from many sources

Not All Humic Acids Are Alike

Soluble Humic Acid products all produce black liquids when dissolved in water. However the properties and activities of the various sources differ.

The properties and activities of these soluble extracts are dependent on several factors:

1) Type of organic parent material.

2) Reagent used to extract the soluble fraction and

3) Conditions of final quality control and storage of finished product.

Higher or lower organic carbon content of the parent raw material will produce a stronger or weaker final extract. The humic acids extracted will differ as the raw material varies in its state of oxidation. Peat is highly oxidized, lignite coal has a lower oxidation state. The oxidation state of the raw materials imports the cationic exchange capacity (CEC) of the humic acids, with lower CEC resulting from the less highly oxidated material.

Strength and pH of extracting reagents determine the species of the resultant humic acids. Grow More employs a method of extraction that keeps the humic, fulvic and ulmic acids in solution. The Grow More Humic Acids product line includes:

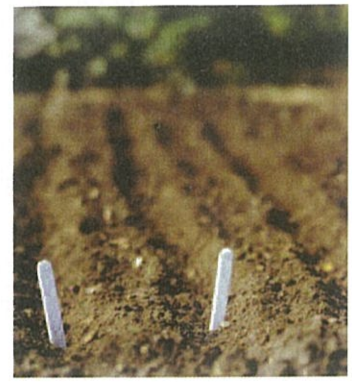
1) Fresh water or alkaline extracted solutions

2) Spray dried 100% soluble powder

3) Fine granular Humic Acid for soil application

4) Powdered Humic Acid for seed zone placement.

5) N-P-K & micronutrient fortified powders, granular & solutions.



Benefits of Humic Acids

University and agricultural industry studies have proven the value of using Humic Acids in soils low in organic carbon matter. Silt, sand, loam or silt clay soils show the most improvement.

Physical: Humic Acids physical modify the structure of the soil.

- Very small clay particles called floccules, along with charged organic humic acids form bridges that bind to each other and to fine silt particles creating much of the long term stability for the small micro aggregates in soils.
- Soil water retention is improved, when organic matter increases, both the infiltration rate and water holding capacity is enhanced. The water holding capacity of humus on a mass basis (not volume) is four to five times that of silicate clay soils.
- Makes soil more friable or crumbly by forming complex humus molecules thus increasing aeration of soil. and improving soil workability.
- Darker soil, greater absorption of solar energy, warmer soil on average.
- Stimulates microbial flocculation of soil.

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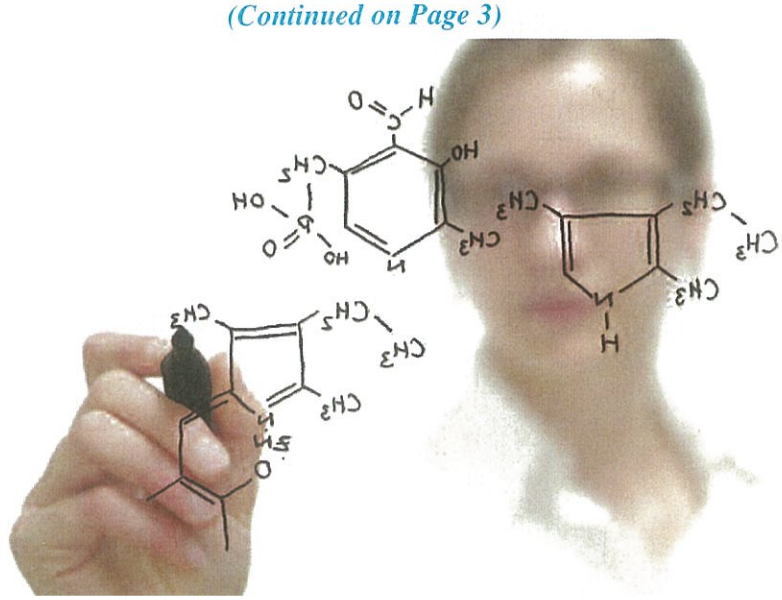

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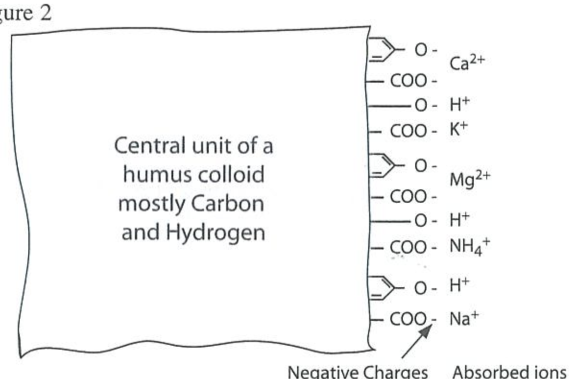
Chemical: Humic Acids chemically change the fixation properties of the soil:

- Buffers and helps neutralize both acid and alkaline soils by charged colloidal particles, referred to as micelles (micro-cells) which give rise to a phenomena known as the ionic double layer. Helps improve cation - anion exchanges.
- In acid soils humic organic complexes alleviate aluminum toxicity by binding the aluminum ions in non toxic complexes.
- Improves uptake of nutrients and water by plants.
- Attack soil minerals and accelerate their decomposition, thereby releasing essential nutrients as exchangeable cations.
- Possesses high cation-exchange value, humic acids form organic soil colloids, that are surrounded by a swarm of cations Ca^{2+}, H^+, Mg^{2+}, K^+ etc. The colloids are actually convoluted chains of carbon bonded hydrogen, oxygen and nitrogen. The negative charges of humus are created by dissociated phenolic groups - OH, Carboxyl Groups - COOH and phenolic groups ⬡- OH

Figure 2



Ref. 4

- Absorbed cations attract water molecules, which play a critical role in determining both the physical and chemical properties of soils.
- In humid regions colloids typically are composed of Ca^{2+}, Al^{3+}, H^+, Na^+, NH_4^+, Mn^+. In arid regions colloids are typically Ca^{2+}, Mg^{2+}, K^+, Na^+, NH_4^+, Mn^+.
- A natural chelator for metal ions, promotes uptake of metal ions by roots. Humic acids and fulvic acids contain carboxyl and phenol groups that chelate or bind cation (Fe^{3+}, Cu^{2+}, Zn^{2+}, Mn^{2+} etc.) into stable organo-mineral complexes. Some of these metals are made more available to plants, because they are kept in soluble chelated form. Soil humus colloids are a focal point for cation exchange reactions, which have profound effects on soil & plant growth.

Biological: Direct influence on plants and soil micro organisms.

Various growth promoting compounds such as vitamins, amino acids, auxins and gibberellins are formed as organic matter decays. These substances may at times stimulate growth in both higher plants and soil microorganisms. Small quantities of both fulvic and humic acids in the soil solution are known to enhance certain aspects of plant growth.

- Provides source of organic carbon - a substrate for soil microbs.
- Stimulates growth and proliferation of beneficial heterotrophic soil micro organisms.
- Enhances plants natural resistance against disease and pest.
- Stimulates root respiration, root growth vertically to enhance uptake of nutrients.
- Increases germination of seed and viability.
- Stimulates overall plant growth and biomass development by accelerating cell division for thicker cells walls in fruit and vegetables for prolonged storage and shelf life, with improved appearance of crop and higher yields

Table 2

Organic Carbon in the World Soils

Organic Carbon in Upper 15-100 cm

Soil Type	% Range	% of Global
Entisols	0.06-6.0	9
Inceptisols	0.06-6.0	22
Histosols	12.0-57.0	23
Andisols	1.2-10	5
Vertisols	0.5-1.8	1
Aridisols	0.1-1.0	7
Mollisols	0.9-4.0	5
Spedosols	1.5-5.0	5
Alfisols	0.5-3.8	8
Ultisols	0.9-3.3	7
Oxisols	0.9-3.0	8

1) Organic matter can be estimated as 1.72 times above value, organic Nitrogen can be estimated from organic carbon value by dividing by 12 for most soils. For Aridisols & arid region divide by 10, for Histosols & humid or wetland divide by 20.

Table 3

Direct Effects of Humic Substances on Plant Growth

Effect on Plant	Humic Substance	Concentration Range Mg/L
Accelerated water uptake and enhanced germination of seeds	Humic Acid	1-100
Stimulated initiation & elongation	Humic Acid & Fulvic Acid	50-300
Enhanced cell elongation	Humic Acid	5-25
Enhanced growth of plant shoots & roots	Humic & Fulvic Acid	50-300

Ref. 5

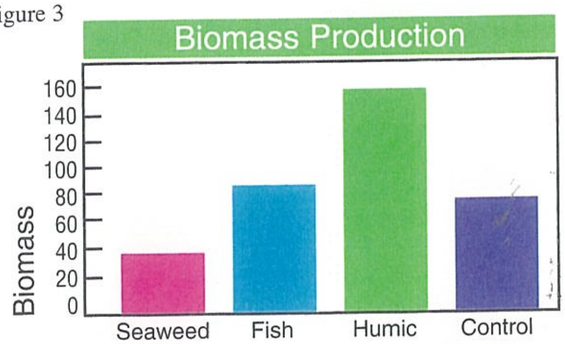
Importance of Soil Organic Carbon

To define the quality of soil organic matter, it must be generally recognized that there are two types of soil carbon, that are susceptible to microbial metabolism.

Metabolic Carbon - from quite readily metabolized plant residues such as sugars, proteins and starches.

Structural Carbon - Other components of plant residues, mostly

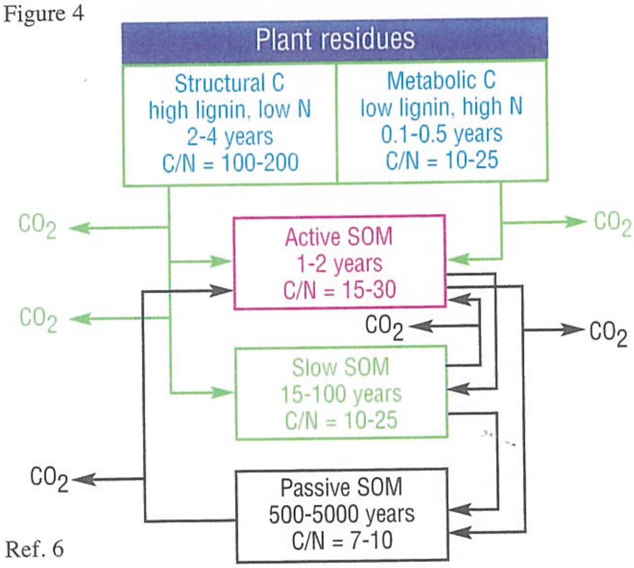
Figure 3



cell wall structures that are resistant to decomposition such as lignin, polyphenols, cellulose and waxes.

Soil organic matter (SOM) can be divided into three different pools of organic matter active, slow and passive fractions, which can be useful in explaining and predicting real changes in soil organic matter (carbon) levels and soil productivity properties.

Figure 4



Ref. 6

The active fraction with high carbon to nitrogen (C/N) ratios and short half lives are metabolized in a matter of a few months or years and include the living biomass, detritus, most of the polysaccharides, non humic substances and more easily decomposed fulvic acid. This active fraction provides the most readily accessible food for soil organisms and most of the readily mineralized Nitrogen. This fraction rarely comprises more than 10 to 20% of total soil organic matter. The slow fraction includes finely divided plant tissues, high in lignin and other slowly decomposable components with half lives measured in decades, an important source of slowly mineralizable nitrogen and other plant nutrients, and it provides the underlying food source for the autochthonous soil microbes which effect the active fraction

The passive fraction consists of very stable materials, most of the humus clay complexes, humin and much of the humic acid. This fraction is responsible for most of the CEC and water holding capacity to the soil and comprises from 60 to 90% of soil organic matter.

Diminishing Soil Productivity

The presence of an easily decomposed metabolic pool (active) explains why conversion of native land (forest or grassland) into cultivated crop land, results in a very rapid decline in soil organic

Table 4

Typical Carbon - Nitrogen Ratios

Organic Material	C/N Ratio
Hardwood Sawdust	400:1
Wheat Straw	80:1
Corn Stover	57:1
Sugar Cane Trash	50:1
Grow More Humic Acid	38:1*
Rye Cover Crop	37:1
Blue Grass from Lawn	31:1
Mature Alfalfa Hay	25:1
Rotten Barnyard Manure	20:1
Finished Household Compost	15:1
Young Alfalfa Hay	13:1
Digested Municipal Sewage	7:1

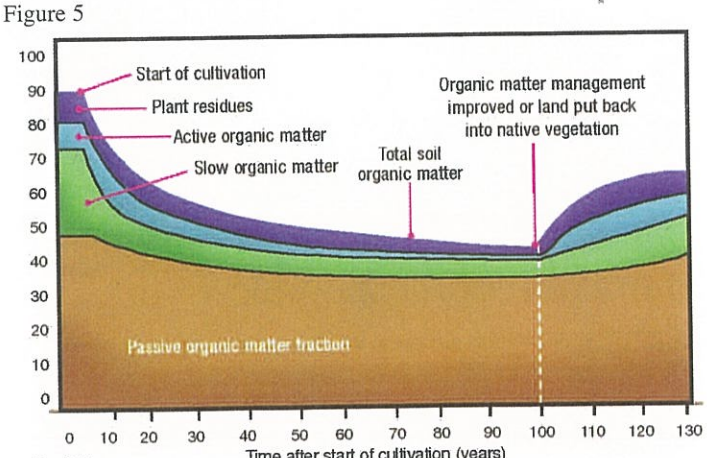
*Data calculated from many sources

matter during the first few years of cultivation. This occurs because the relatively small pool of active organic matter (carbon) undergoes a larger percentage decrease without having a major effect on the much larger pool of total organic matter (slow & passive).

Scientists have consistently observed that the more productive agricultural soils are managed with conservation-oriented practices and that these soils contain relatively high proportions of active organic fraction components that allow biological metabolism to constantly enhance soil tilth and nutrient cycling.

Good farm managers know that a continuous supply of organic materials must be added to the soil to maintain productivity of the active fraction pool. Plant residues, animal manures, composts and other organic inputs can be used. But it is almost always preferable to use Humic Acid, because of its readily available source of organic carbon, longer lasting and higher stimulating effect on plant growth and bio mass production.

Figure 5



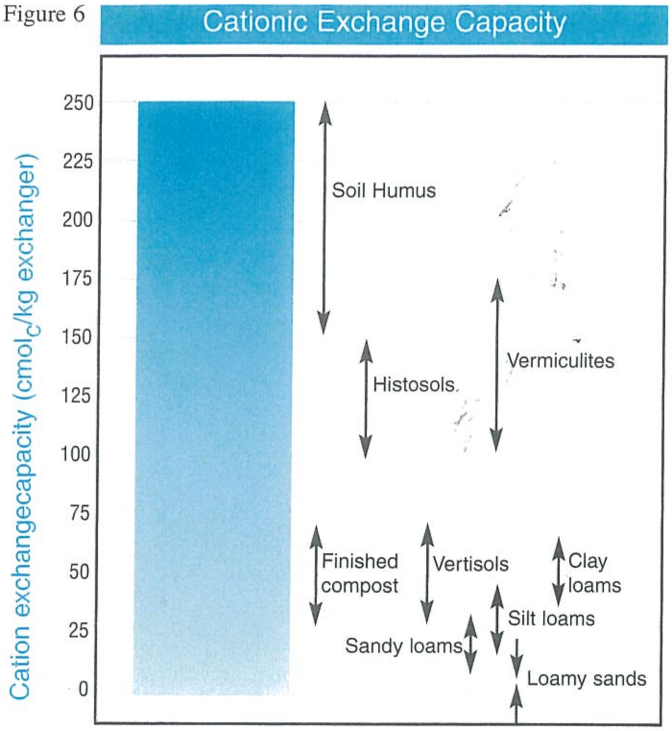
Ref. 7

Changes in the upper 25 cm of virgin soil after bringing under cultivation. Most of the organic loss came at the expense of the active fraction. This fraction quickly improved after application of organic matter i.e. (Humic Acids), bringing dramatic improvement in soil properties. Depending on soil classification the active fraction can be depleted in less than 10 years i.e. oxisols.

Economic Benefits of Humic Acids

The best economic results of Humic Acid applications can be achieved in soils of low organic matter (carbon). Adding humic acid helps build cation exchange capacity (CEC) by forming

Figure 6



Ref. 8

colloids, the relative amount of these colloids in soil determine CEC. Sandy soils, loamy sands, silt loams are generally low in colloidal material and have low CEC, other soils that can have low CEC are entisoils formed in alluvium or sandy condition, inceptisoils low in organic matter. Also geologically recent volcanic or cinder soils low in organic matter, (these soils may also tightly bind phosphorous) which Humic Acid application help remedy. Arid soil that have hard layers that act as impediment for plant root growth or soils with accumulation of clay, calcium carbonate, gypsum, soluble salts (salic) or exchangeable sodium (Natric) type soils can all benefit from application of Humic Acid and the subsequent organic carbon and soil building colloids that are formed.

Knowing your soil classification will enable Grow More representatives to make recommendation.

VERTISOLS - which are dark, swelling and cracking clay-typed soils, the dark color does not necessarily indicate organic content which can range 5 to 6% to as little as 1%. These soils are very sticky, plastic and tillage is difficult. In the tropic's vertisols can produce greatly increased yields with improved soil management and Humic Acid application.

ALFISOLS - found in cool to humid areas in the semi-arid tropics and Mediterranean climates that have accumulations of kandite clay have a low cationic exchange capacity and benefit from Humic Acid application.

ULTISOLS - under warm to tropical climates in old land surfaces or under previous forest vegetation, savanna or swamps with kandite clay benefit from humic acids applications.

OXISOLS - highly weathered soils, generally found in hot tropical rain forests, contain low activity clays that have a very limited capacity to hold nutrient cation such as Ca^{2+}, Mg^{2+} and K^{+}, the high iron and aluminum oxides of their soils may also tightly bind phosphorous. Humic Acid applications are recommended.

Recommendation for Managing Soil Organic Matter

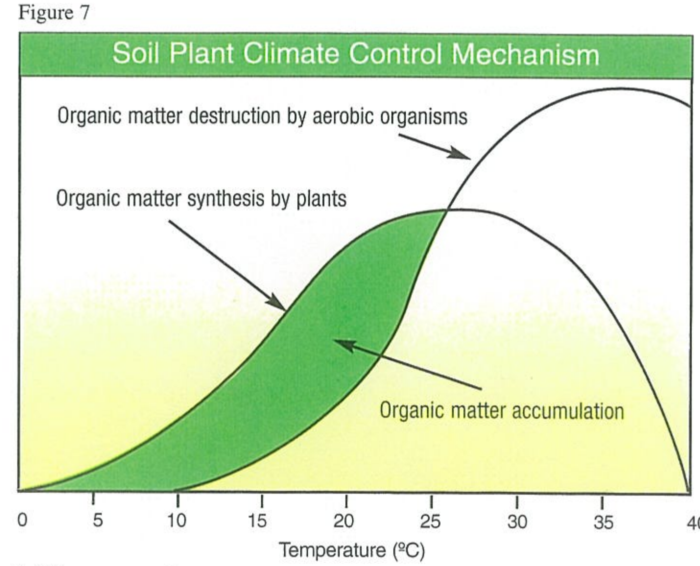
1) It is important to maintain a substantial proportion of soil organic matter in the active fraction thus allowing biological metabolism to constantly enhance soil tilth and nutrient cycling. On average soil microbes must incorporate into their cells about 8 parts carbon for every part of nitrogen. A continuous supply of organic materials must be added to the soil to maintain an appropriate level of soil organic matter, plant residues, animal manure, compost or humic acid.
2) It is not practical to try to maintain higher soil organic matter levels than the soil-plant climate control mechanism indicates. At low temperature plant growth out strips decomposition. In warm soils mineralization is accelerated, nutrient release is rapid, residual organic matter accumulation is lower.
3) Adequate Nitrogen inputs are necessary for adequate organic matter levels. Minimize Nitrogen loss by leaching, erosion or volatization.
4) Tillage accelerates organic matter losses by increasing oxidation of organic matter and by erosion. Conservation tillage that leaves much of the plant residue on or near the soil surface leads to higher organic matter levels.

The Grow More Advantage

Our rich source of readily available Humic Acid is in many respects identical with soil humus, having essentially the same source - residual organic matter from decomposed plants, practically identical in chemical and physical properties and indistinguishable by spectroscopic examination.

Soil organic matter (carbon) is normally regenerated by long-termed process. In contrast Grow More Humic Acid is in a concentrated form, easily applied by conventional methods, can be incorporated into the soil and is readily available to function as soil organic matter without delay to provide higher cationic exchange capacity, increased levels of active organic matter (carbon), higher biomass nitrogen levels (due to higher microbes levels) - minimized nutrient leaching and increased Nitrogen mineralization - the Grow More advantage - more efficient nutrient cycling.

Figure 7



Ref. 9

Climates with average temperature 25ºC and above benefit from Humic Acid.

Liquid Products - Soluble Humic Acids - Fulvic Acid

- Potassium Humate extraction process, filtered liquid concentrate for foliar application, drip irrigation, fertigation or sprinkler system. Available as 12 or 14% Humic Acids concentration. Use 1 to 4 quarts/acre (2 to 9 liters/HA) as foliar spray.
- Pure fresh water extraction process results in Humic Acids that meet the strict requirements of a 100% natural product, made with no man made ingredients. Use 1 to 4 quarts/acre (2 to 9 Liters/HA) as foliar spray.
- Fulvic acid extraction, a translucent amber colored liquid of 7.6% fulvic acid concentration. For foliar application, compatible with pesticide. Use 1 to 2 quarts/acre (2 to 5 Liters/HA) as foliar spray.

N-P-K Fortified Soluble Humic Acids

Foliar Spray: Use 2 to 4 quarts/acre, (5 to 9 liters/HA).

3-2-2 N-P-K with 4.5% Humic Acids plus EDTA chelated Fe, Mn, Zn & Cu.

1-2-2 N-P-K with 6% Humic Acids plus micronutrients.

12-6-6 N-P-K with 11% Humic substances plus micronutrients.

Spray Dried Powder - 100% Soluble Humic Acid

A potassium humate that has been chemically reacted to be soluble in both acid and alkaline aqueous solutions. Compatible with N-P-K fertilizer and pesticide for foliar drip irrigation or seed zone placement. Minimum 70% Humic Acids concentration.

Foliar Spray: 1 to 2 Lbs. per Acre (2.4 to 5 Kg. per HA)

Granular & Powder

Slowly mineralized in soil for use in seed placement banding or side dressing. Useful in both - horticultural and agricultural applications, minimum 75% Humic Acids concentration. Granule size is 14 mesh (1410 microns). Powder size is 150 mesh (100 microns)

APPLICATION:

Powder - directly in the furrow with seed. (35Lb./ Acre (38Kg/HA)
Granule - Average soil: 100 Lb./Acre (109 Kg./HA)
Clay or Hardpan: 150-175 Lb/Acre (164 to 191 Kg./HA)
Coarse, medium fine: 200 Lbs/acre (218 Kg./HA)

REFERENCES

1) Frimmel, F. H., and R. F. Christman. 1988 "Humic Substances and their Role in the Environment".
2) Stevenson, F. J. 1986. "Cycles of Soil".
3) Eswaran, H., E. Van Den Berg & P. Reich 1993. "Organic Carbon in Soils of the World." Soil Scie. Soc. American Journal
4) Dixon, J. B. and S. B. Weed. 1989. "Minerals in Soil Environments".
5) Chen, Y. and T. Aviad. 1990 - "Effects of Humic Substances in Plant Growth". I In P. Mac Carthy, C. E. Clapp, R. L. Malcolm and D. R. Bloom, "Humic Substance in Soil and Crop Science".
6) Paustian, K., W. J. Parton and J. Person. 1992. "Modeling Soil Organic Matter". amended and "Nitrogen Fertilized Long Term Plots". Soil Science Society American Journal..
7) Data re-calculated from Odell, R. T., W. Melsted and V. M. Walker. 1984 "Changes in Organic Carbon and Nitrogen of Morrow Plots Under Different Treatments 1904 to 1973" Soil Science Society of American Journal. Jenkinson D. S. and A. E. Johnson. 1977 - "Soil Organic Matter in the Hoosfield Barley Experiment" Rothamstead Experiment Station, Harpenden, England 1976.
8) Helling, C.S. 1964. -" Contribution of Organic Matter and Clay to Soil Cation Exchange Capacity" Soil Science Society of America. Proc.
9) Adapted from Mohr, E.C.J. and P.A. Van Baren 1954 "Tropical Soils"

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