Effect of Potassium Humates on Soil Fertility

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PhD student, Albert U. Imbufe, eluting fulvic acid extracts from a XAD-8 column with an alkaline solution

This research project focused on humic acids, and how the potassium salts of these naturally occurring organic compounds can be used to improve soil fertility. The investigation included field trial applications in an acidic vineyard soil, laboratory analyses of treated samples, characterisation of soil and soil extracts and plant growth experiments.

Humic substances are formed naturally when biomass materials undergo natural decomposition and transformations to form a complex mixture of organic molecules. They vary in composition, depending on their origin and method of extraction, and are generally classified into three sub-fractions known as fulvic acids, humic acids, and humin according to their molecular size fraction and solubility in alkaline or acid media. Humic acids occur extensively in the environment, particularly in soils where they constitute 65-70% of the soil organic matter. High levels of humic acids are also present in composts, chicken manure, sewage sludge, and in low rank coals, such as Victorian Brown Coal. These complex organic materials are rich in acidic functional groups, and are believed to exert a beneficial influence on soil fertility and plant growth.

Appropriate application of humic acids, based on the 'green' approach, with an understanding of their properties such as poly-electrolytic nature, nutrient chelating ability, buffering properties, and ability to promote of soil microbial activity and plant growth. They may provide viable, and environmentally friendly additives to chemical fertilisers and enhance sustainability in modern agriculture.

Soil and plant treatments with very small amounts of Potassium Fulvate (KF) and Potassium Humate (KH) in both field and laboratory greenhouse experiments resulted in highly significant differences between treatment and control samples.

Beneficial effects on soil included increases in total organic carbon, increased pH, improved cation exchange capacity, water permeability and aggregate stability.

Beneficial effects on tomato and silverbeet plant growth were observed in seed germination, growth rates, biomass weight, and nutrient uptake. Compared to the controls, treatment of soil with small amounts of KF and KH resulted in highly significant increases in the fresh and dry biomass of shoot and fruits, with a foliar spray application giving the best overall yields (Figures A & B).

Figure A. Potassium Humate (KH) growth response of tomato in sand culture. Growth is significantly enhanced in treated plants (left and right), relative to the control (centre). Photo: Albert Imbufe

Figure B. Potassium-Fulvate (KF) growth response of tomato in an acidic soil medium. Chlorosis (yellowing) is observed in the control due to Fe or Mg nutrient deficiency. Photo: Albert Imbufe

Results from analysis of plant shoot nutrient content indicate that treatment of soil with low rates of KF and KH products significantly increased the concentration of the major nutrients (N,P & K). The highest increases were observed after the foliar spray treatment with 96% (N), 55% (P) and 29% (K) for KF, and 61% (N), 100% (P) and 42% (K) for KH.

Concentration of micronutrients (S, Ca, Na, B, Fe, Mn, Mg, Zn & Cu) in treated samples also increased significantly over the controls. The highest observed uptake was for Fe. A similar trend was observed in the uptake of other micronutrients, with the exception of Na where the uptake decreased with both the fulvate and humate treatments, relative to the controls.

Results from this study, coupled with a better understanding of the chemistry of these complex organic mixtures, their stimulatory growth effects and nutrient uptake mechanisms, may provide potentially viable strategies for more sustainable agricultural practices.

Aspects of our work with humic acids have been published in the “Geoderma” Journal, as well as in the refereed Conference Proceedings “SuperSoil 2004” at the University of Sydney in December 2004, where a poster paper was also presented.

Imbufe, A.U., Patti, A.F., Burrow, D., Surapaneni, A., Jackson, W.R. and Milner, A.D., “Effects of potassium humate on aggregate stability of two soils from Victoria, Australia”, Geoderma 2005, 125, 321-330.

Humic Substances as Amendments for Poor Fertility Soils

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Natural organic matter (NOM) occurs abundantly in soils, waters and sediments, and is the key to improving the fertility of degraded soils affected by salinity and sodicity. Humic substances are the main components of NOM. By characterising the physical, chemical and biochemical nature of humic substances, we hope to gain an improved understanding of their role in soil fertility.

Humic substances are a main component of the natural organic matter that occurs in soils, water and sediments. A complex mixture of organic compounds derived from decaying biomass, humic substances play an important role in soil fertility, binding soils together and controlling the release of nutrients.

This project assessed the viability of different sources of humic substances as organic amendments for poor fertility soils. Field trials were conducted initially, but difficult drought conditions limited the results, and work was continued with glasshouse based experiments.

Field trials

Six commercially available organic amendments were assessed for their physical and chemical properties, including total humic substances (HS), fulvic acid (FA) and humic acids (HA). The characteristics of the carbon present in amendments were determined by Solid State $Carbon^{13}$ Nuclear Magnetic Resonance (SS C^{13} NMR) spectroscopy. FA and HA from soils and amendments were separated by alkaline extraction according to the International Humic Substances Society (IHSS) method. Infra Red (FTIR) spectra, microanalyses and Thermo-Gravimetric Analysis (TGA) of the freeze dried HA samples completed the organic carbon picture for the selection of amendments. The three amendments chosen were 'Omnia' organic humate, 'Swanpool vermicast', and Coles supermarket waste.

Figure A. Field Trials at Mooroopna, Victoria.
Photo: Cornelia Bos Van-derZalm

A field trial was conducted on 40 plots of clover and rye pasture at Mooroopna, Victoria (Figure A). The field trial was started in December 2001 and was planned to continue for a 2.5 year period so that a statistical assessment could be made of any improvements in organic carbon content and soil structure. However, due to severe drought conditions and irrigation prohibitions, the lease of the field trial land was terminated in July 2002 and the study was moved to glasshouse experiments. Preliminary results (after 8 months) indicated that there is potential for commercial humates and other organic waste products to improve soil properties and yields.

Glasshouse experiments

One component of HS that may play a significant role in soil fertility is a reported glycoprotein, 'glomalin'. Glomalin is thought to be produced in the hyphae of mycorrhizal fungi and may reside in the humin fraction of HS. This compound was reported in the literature but its structure was unknown and its identity not clearly supported by scientific evidence.

Three soils and six organic amendments were investigated for Glomalin Related Protein (GRP). Organic material was extracted with a sodium citrate solution and autoclaved at 120°C for 4 hours. The extracts were centrifuged and the remaining pellets dialysed in dilute Na-borate solutions followed by dialysing in water, centrifugation and freeze drying.

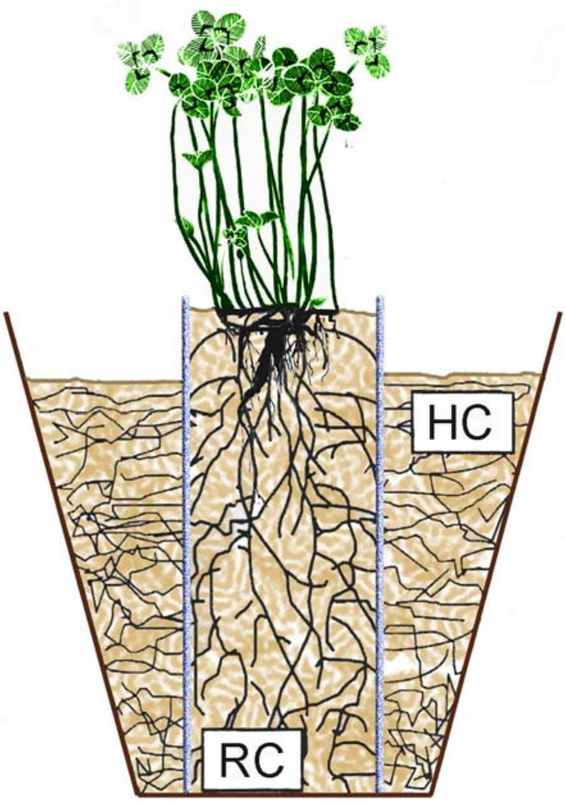

Figure B. Clover growth experiment. Isolation of mycorrhizal hyphae by 25μm membrane. HC = hyphae compartment. RC = Root compartment

A direct investigation of the hyphae of mycorrhizal fungi was also conducted to establish the presence of GRP. A clover growth experiment was set up with a membrane barrier which contained clover roots in sterilised sand, but allow hyphae to penetrate into the sterilised soil / sand (Figure B). The hyphae are less than 25μm in size and were encouraged to penetrate into the hyphae compartments (HC) by careful placement of fertiliser. After nine weeks the sand of HC, sand/soil of RC, mesh bag and clover roots were citrate extracted by the method previously described.

All samples were then analysed using Pyrolysis-Gas Chromatography Mass Spectrometry (Py-GC-MS). The products present in HC and clover root extracts indicated that a complex mixture is produced by clover plant roots, spores and hyphae of mycorrhizal fungi. The pyrolysis products were fragments of polysaccharides, minor proteins, fatty acids, and plant hormones. This illustrates that 'glomalin' appears to be a combination of many compounds which may all induce healthy soil microbial activity.

This research has implications for the sustainable management of soil fertility through the use of organic amendments derived from waste products otherwise destined for disposal.

Improved knowledge of the speciation of the organics in these amendments can lead to more specific and efficient fertiliser applications. Use of organic carbon compounds to improve microbiological activity, soil structure and fertility, are a potentially important step in the replacement of the non sustainable practices of super phosphate and gypsum fertilisation.

Centre of Green Chemistry award for Research Excellence November 2004.

Poster presentation: XI International meeting of IHSS, Boston, USA, 2002.

Combined national conference of the Australian Organic Geochemists and the IHSS, Blue Mountains, NSW, Australia, 2004. (Poster and Oral presentation).

Poster presentation: XII International meeting of IHSS, Sao Pedro, Brazil, 2004.


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