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DO BIOLOGICAL SOIL INOCULANTS HAVE A PLACE IN FOREST NURSERY PRODUCTION?

by
Tom Starkey and Scott Enebak

INTRODUCTION

With the recent emphasis on living and conducting business in a "green environment", companies that market biological pest management products are frequently approaching nurseries to test their products. The definition of "biological soil inoculants (BSI)" as we discuss in this Research Report is 'a product composed of microorganisms and other organic compounds.' These products are marketed to either control the soil microflora, enhance plant growth, or bolster the physical, chemical and nutritional status of the soil environment.

The use of BSI to protect plants from pathogenic soil micro-organisms is not a new idea. Microbiologists have known for many decades that organic wastes and manures contain their own indigenous populations of microorganisms which in theory may be a good idea, but in practice has resulted in unpredictable and inconsistent results (Parr et.al. 1994). Biological Soil Inoculants act against soil pathogens through several methods; the production of antibiotics; by competing for space and utilization of substances needed for growth, by directly parasitizing the soil pathogen; or by the production of toxins or compounds needed by the microorganism for normal metabolic activity (Baker 1968, Parr et al 1994).

Microorganisms present in the root zone can also affect plant development. These organisms can increase the availability of nutrients to the plant, increase the ability of plants to take up nutrients, or produce plant hormones (IAA e.g.) thereby increasing plant growth, (Vonderwell et. al. 2001). A commonly know effect is the presences of certain mycorrhizal fungi which make phosphorus more readily available to the plant.

A web search of companies selling "biological soil inoculants" reveals many products. A Google® search of the broader term "soil inoculants" yields 6,100 hits or web pages. One product, which is typical of those listed, indicates the benefits their product will provide (Table 1).

All of these BSI must be added to an 'inert' carrier in order to be applied to the soil or containers. Sometimes the carrier is indicated on the label or the Material Safety Data Sheet (MSDS), many times it is not. Humic acid is a common carrier used in BSI. Humic substances are not a singular compound but rather a naturally occurring, heterogeneous organic substance which can be divided into humic acids and fulvic acids. Humic acid is a high molecular weight, long chain molecule dark brown and soluble in an alkaline solution. Fulvic acid is a low molecular weight, short chain molecule yellow in color and soluble both acid and alkaline solutions. Both humic and fulvic acids are known to increase plant growth (Senn and Kingman 1973).

A web search of companies selling humic acid reveals many products. A list of the benefits associated with humic acid which can be found on these web sites shown in Table 1.

Table 1. Web search list of benefits of biological soil inoculants and humic acids.

Biological Soil Inoculants	**Humic Acids**
Colonizes the root zone	Addition of organic matter to organically-deficient soils
*Increases nutrient uptake	*Improved nutrient uptake
*Increases soil friability	*Increases soils more friable
*Improves drought tolerance	*Helps resists drought
*Reduces soil compaction	Stimulates root growth
*Increases water holding capacity	*Increases water holding capacity
Stimulates indigenous soil biology	Stimulate beneficial microbial activity
Restores microbial activity after droughts, floods or soil sterilization.	Better seed germination
Reduces salinity	Increased fertilizer retention
Converts dead vegetation / thatch into nutrients and organic matter	Healthier plants and improved yields

Comparing the two lists shows similar benefits noted with an asterisk. The question then becomes; are the positive affects reported due to the microorganisms or to the carrier, for example, humic acid? To complicate the issue, many BSI are combinations of more than one organisms or organic products. For example one product says "Formulators start with" XXXXX "as the core microbial "ingredient" then blend in additional ingredients such as plant nutrients (including conventional and/or organic fertilizers), additional bio-stimulant nutrients, specific soil additives, or a combination of all." Another says "All biological products manufactured by" XXXXX "are from a fermentation process producing a soil inoculant containing a diverse population of live, naturally occurring, beneficial soil microorganisms and enzymes. Our

products consist of microorganisms/enzymes (aerobes, facultative anaerobes, and anaerobes), and microorganisms/enzymes with humus."

As the number and complexity of the ingredients increases, generally so does the price. It is virtually impossible to determine if the positive affect reported is due to any one ingredient or a combination of more than one ingredient, or perhaps the carrier alone. The purpose of this study was to compare two BSI which the senior author had used in the past with a humic acid and fertilizer control on the growth of loblolly pine in the greenhouse.

METHODOLOGY

Two BSI were included in this study. Inoculaid® (Applied & Experimental Microbiology™, Jacksonville, FL www.inoculaid.com) is described as a "microbial product composed of a living consortium of microorganisms including photosynthetic strains proven to enhance plant growth." The second BSI, SC-27 Soil Inoculant® is manufactured by Natural Science Center – USA. No specific company location for this product is provided, only telephone numbers for 'Sales.' SC-27 does not have a web site, however a link to a publication is found at http://www.rcfarms.net/technical_report_1.pdf. SC-27 is described as "a formulation that includes actinomycetes, bacteria and other beneficial live soil microflora, to enhance depleted soils." It has been shown to "consistently validate improvements in the growth, yield, and quality of..... commercial crops" Two controls were included in this study, humic acid (Hydra Hume® Helena Chemical Company, Collierville, TN) and Miracle Gro Fertilizer 30-10-10 (The Scotts Company, Marysville, OH).

Loblolly pine seed which was stratified for 45 days was sown on May 8, 2008. Each treatment consisted of 20 cavities per container replicated 14 times. A standard greenhouse potting media was used (SunGro Sunshine Mix #8 Professional Growing Mix, 70-80% Canadian sphagnum grower grade peat moss, coarse grade perlite, coarse grade vermiculite, dolomite limestone, gypsum and wetting agent). Beginning June 3, 2008 and continuing every two weeks for nine applications, the following treatments were applied. At each application the equivalent of 180 ml/3.8 l water of humic acid, Inoculaid®, and SC-27 were applied to the appropriate seedlings (280 seedlings/trt). To each of these amounts, beginning with the second application, 120 ppm Miracle Gro Fertilizer 30-10-10 was added and applied simultaneously. On the first application on June 3rd, 60 ppm fertilizer was applied. The approximate quantities of each treatment and water applied per seedling based on average water usage are shown in Table 2.

Table 2. Bi-weekly treatment applications **per seedling** beginning 6/3/08. Nine total applications

Treatment	Water (ml)	Hydra Hume® (ml)	Inoclaid® (ml)	SC-27® (ml)	Fertilizer[1] (mg N)
Humic acid + Fertilizer	46	0.64			1.8
Inoculaid® + Fertilizer	46		0.64		1.8
SC-27 + Fertilizer	46			0.64	1.8
Fertilizer alone	46				1.8

[1]Amount of fertilizer applied at the first application was 0.9 mg N

A normal greenhouse watering schedule was followed over the course of the study. Prior to application of treatments, the containers were allowed to dry to approximately 75% of field capacity weight. On August 5, 2008 each treatment was top-clipped to seven inches. On October 6, 2008 the seedling height, root collar diameter and dry weight of the shoots and roots were measured.

RESULTS

Initial growth was greatest on seedlings that received the humic acid plus fertilizer treatment as indicated by the percentage of seedlings that were top clipped to 7" on August 5. Approximately the same numbers of seedlings were top clipped for the treatments Inoculaid® plus fertilizer and fertilizer alone (Table 3).

Table 3. End of season seedling quality data.

Treatment	Percentage Top Clipped to 7" on 8/5/08	Final Height (in)	Final RCD (mm)	Dry Wt Shoot (g)	Dry Wt Root (g)
Humic acid + Fertilizer	42%	11.3 A	3.1 A	1.28 A	0.47 A
Inoculaid® + Fertilizer	25%	10.5 B	3.0 A	1.15 B	0.47 A
SC-27® + Fertilizer	11%	9.8 C	2.6 B	0.83 C	0.41 B
Fertilizer alone	27%	10.7 B	3.1 A	1.37 A	0.49 A
lsd		*0.4*	*0.1*	*0.09*	*0.05*

Within column means followed by the same letter do not differ at 0.05 level.

Humic acid plus fertilizer produced significantly taller trees than the other treatments at the end of the study. The treatment SC-27 plus fertilizer produced smaller trees in all aspects of seedling quality including percentage of top clipped seedlings. The use of fertilizer alone produced seedlings equal to or better than either the Inoculaid® or the SC-27.

DISCUSSION

The liquid carrier in the Inoculaid® was humic acid based while the carrier in SC-27® was a milky liquid. Since SC-27® resulted in significantly smaller seedlings; one should question its wide-scale use in forest tree nurseries. Within the parameters of this study, humic acid alone out-performed Inoculaid®. When seedling quality is considered, fertilizer alone produced similar seedlings to the Inoculaid®. The determination of which product to consider is focused on cost. The cost of Inoculaid® was approximately $48/g/a, SC-27® was $288/g/a and humic acid was $12/g/a. Based upon the results of this study and their cost, neither Inoculaid® nor SC-27® could be recommended as a soil inoculant.

Humic acid did provide better quality seedlings than fertilizer alone which could make the cost a consideration. Humic acid has been shown to increase the uptake of nutrients in plants, especially nitrogen, phosphorus iron and zinc (Hopkins and Stark 2003, Senn and Kingman 1973, Tan and Nopamornbodi 1979, Rauthan and Schnitzer 1981, Mackowiak et. al. 2001). The use of liquid humic acids is generally in conjunction with the application of a liquid fertilizer. Granular humic acids are also available and should be applied early in the season.

MANAGEMENT IMPLICATIONS

These products are generally safe when applied as directed, however, as a nursery manager one must decide if the benefits from applying BSI outweigh the costs. One fact that is certain, you will be contacted by a BSI salesmen. Be aware of the following points:

1. Salesmen make a living selling their product. Expect to be contacted at some time.
2. For some BSIs, we know the composition (ex. Plant Shield®, Root Shield®). However, for others the active ingredients are either proprietary or presented in such a general description that it is of no practical use. For example: "This product contains 5 beneficial, synergistic soil fungi." This sounds impressive but says little. The question I have learned to ask is "What is the composition of the inert ingredients?" I was told by a salesman of biologicals that companies include "inert" ingredients in their products that just by themselves are known to elicit positive plant response (i.e. fertilizers). So, ask if the response they report is due to the active or inactive ingredient?
3. Some products are well documented on the web others are not. It goes without saying that just because a company has an impressive web site; it does not validate the efficacy of the product. But, in this internet savvy world, I would question a product that cannot be found on the web.
4. Salesman will drop names of "well-know" people or institutions that have verified or back their product. Recently a salesman told me that a professor at Auburn tested his particular product. Later when I contacted this professor at AU, his memory was that he had tested the product over 15 years ago, but it was sold under a different name.
5. Some products have a history of name changing. Old name/product didn't sell? Try changing the name and marketing approach.

The German poet and philosopher, Friedrich von Schiller, said "Truth lives on in the midst of deception" When deciding whether to use biologicals, we must sort the truth from what may be deception.

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