THE EFFECTS OF MICROALGAE ON SOILS: A LITERATURE REVIEW

Edited By:

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MICROP®, as offered by Soil Technologies Corp., is a mixture of soil algae of the *Chlamydomonas* and *Cyanophytes* groups which is transplanted from our nurseries for use as a “green manure” cover crop and has been used for over twenty years, by hundreds of farmers to improve aeration, increase soil aggregation, reduce fertilizer needs, and improve crop yields.

Soil algae constitute the initial successional stage on substrates which are poor in plant nutrients, for example, recent volcanic deposits, eroded hillsides, and disturbed soils. Soil algae can have dramatic effects on soils that have mechanical problems caused by intensive agricultural use as well.

This collection of papers documents the general and specific effects of algae on soils, both chemically and physically, that have been collected and studied over fifty years.

The existence of a definite algal flora of the soil seems very well established even though some of the algae also occur in water (Shields and Durrell, 1964). Several species of algae constitute an initial stage in plant succession by the formation of an algal crust over hundreds of acres in the south central U.S.A. (Booth, W.E., 1941). Booth found soil losses greatly reduced when afforded the protection of an algal crust, and a higher moisture content under the algal crust compared to bare soil with no loss of infiltration. Under windblown situations, a filamentous green algae was found to stabilize sandy wastes by forming a cohesive mat and reducing wind and water erosion (Mackenzie and Pearson, 1979). Fletcher and Martin, 1948, found an algal-mold crust in the desert near Tucson, Arizona, which grew well in desert conditions (with quick drying after it did rain) to increase organic carbon as high as 300 percent and organic nitrogen by 400 percent, while the author noted decreased erosion, improved infiltration, and improved establishment of plant seedlings.

Soil algae can grow under the canopy of macro-vegetation, including Pinus, as well as in the open (Metting and Rayburn, 1979), even with soil moisture content as low as 5-7% of field capacity. The optimum moisture range for growth is around 40%-60% of the soil-moisture holding capacity (Shields and Durrell, 1964). Soil algae are very small plants and are able to survive under wide ranges of environmental conditions on the soil, by forming resistant cells and mucilaginous polysaccharide sheaths and have been shown to survive as much as ten years of drying (Trainor, 1970). The surviving algae included *Chlamydomonas* and the Cyanophytes *Anaebena* and *Ulothrix*.

The ability to withstand great variation in environmental conditions in the soil by algae is without a doubt associated with the ability of the algae and other microbes to secrete external metabolites, polysaccharides, organic acids, and other organic compounds. Fifteen different *Chlamydomonas* species isolated from soils or mud near lakes have been shown to secrete polysaccharides as much as 57% of the total organic matter they produce, including the plant cell itself (Lewin, 1956). The excretion of these polysaccharides parallel the normal growth of the algae, and Allen found polysaccharides secreted by six *Chlamydomonas* species under varied conditions (Allen, 1956). Other external metabolites, including a highly reducing substance
(ascorbic acid) have been found to be produced by green algae and blue-green algae (Vaidya, Patel, and Joni, 1970). The fixation of nitrogenous substances by blue-green algae (cyanophytes) has been reported by many authors, and their secretion of these compounds into their immediate environment can influence other microbes as well as major crops, including rice (Shields and Durrell, 1964; Fogg, 1952; Wilson, Eskew, and Habte, 1980; Mayland, McIntosh, and Fuller, 1966; and Watanbe, Nishigake, and Konishi, 1951).

The interest in living organisms affecting the environment around them, especially in restructuring the physical matrix of soils by polysaccharide production, has received attention by several authors. Soil humus contains polysaccharides with values ranging from 5%-25% of total organic matter (Martin, 1971). “It has long been known that organic residues applied to soils improve structure or tilth. The most active binding substances synthesized by effective microbial species were polysaccharides. Most microbial polysaccharides in concentrations of .02%-2% exert a marked binding action on soil particles,” Martin stated. Water stable aggregates were produced in a short period of time (6 weeks) by three algal species, two of them cyanophytes, which led Bailey, Mazurak, and Rorowski, 1973, to conclude “…the fact that algae are frequently important pioneer vegetation, it is believed that algae are important in stabilizing and improving the physical properties of soil as a medium for plant growth.” When *Chlamydomonas* was inoculated repeatedly on selected Washington state soils, carbohydrate concentration was higher in the surface 1cm and the upper 30cm over controls, water retention was statistically greater in inoculated fields, both wet and dry aggregate stability were greater in the three irrigated soils (Metting and Rayburn, 1983). In a comparison using extracted *Chlamydomonas* polymer and the commercial polyvinyl alcohol Krilium® , the stability of soil aggregates using algal polysaccharide were significantly greater than either the controls or the aggregates stabilized with the Krilium®, (Metting and Rayburn, 1983). On a microscopic level, the mechanism for improved soil structure by addition of algal polysaccharide has been photographed by electron microscopy as fibers and gels of polysaccharide that are in crevices and between stacks of clay platelets that bind them together, even forming box-like structures which resist dispersion or collapse (Foster, 1981). The polysaccharides even fill spaces too small for bacteria to get to them, eliminating microbial decomposition, enmeshing large volumes of soil and giving evidence to why small quantities (.02%-2%) of added polysaccharide markedly stabilizes clay aggregates (Foster, 1981).

Polysaccharides are influenced by the other component of soils, especially metal ions which are concentrated in polysaccharides and which can often decrease dramatically the rate of decomposition of the polysaccharide (Martin and Richards, 1972; Pollard and Smith, 1951). Also, the complexing of polysaccharides with humic-acid type polymers resulted in a great resistance to decomposition (Verman and Martin, 1976). So, by several mechanisms, complexing with humic-acid type polymers and metal complexing, as well as isolation of polysaccharides from bacteria in minute spaces between clay platelets, (mentioned in the last paragraph) the polysaccharide can remain in the soil with positive effects on soil structure for extended periods of time.

The cyanophytes, blue-green algae, are active participants in the soil flora and make up parts of the algal crust (Mayland, McIntosh, and Fuller, 1966; Fletcher and Martin, 1948); have been shown to secrete algal polysaccharide which form soil aggregates (Bailey, Mazurak, and
Rorowski, 1973), and “...may be the most important nitrogen-fixing agents in many agricultural soils” (Shields and Durrell, 1964).

The fixation of nitrogen by blue-green algae has been documented by many authors (Watanabe, Nishigaki, and Konishi, 1951; Wilson, Eskew, and Habte, 1980; Mayland, McIntosh, and Fuller, 1966). Nitrogen-fixation has been established for more than twenty species of Cyanophyceae (Shields and Durrell, 1964). There is really no question that blue-green algae fix atmospheric nitrogen, but rather whether the fixed nitrogen becomes available to crops, in what quantities, and if it can affect crop yields? The few articles included in this document answer all these questions. In the Far East, blue-green algae are a common additive to rice paddies. Wilson, Eskew, and Habte, 1980, irrevocably documented that nitrogen, as the tracer $^{15}$N, fixed by blue-green algae, can be taken up by higher plants within a few days, and at a high level of efficiency – 51% of total $^{15}$N was recovered in grain and straw in the first rice crop. Estimates of total nitrogen fixed by *Tolypothrix*, a cyanophyte, was about twenty pounds per acre in rice paddies (Watanabe, Nishigaki, and Konishi, 1951). N-fixation in desert soils, with limited water, was estimated close to ten pounds of nitrogen per acre (Mayland, McIntosh, and Fuller, 1966). Finally, the effect of nitrogen-fixation by blue-green algae on rice plants and yield in water, pot cultures, and paddy field experiments showed increases at number of leaves on plants, increasing 17% and number of ears, increased at 30%. Yield gains in well-drained and badly-drained fields increased 15% and 25%, respectively. Bushels per acre in well-drained fields were 44.9 bushels/acre (control) and 51.8 bushels/acre (algae); and in badly-drained fields control was 33.3 bushels/acre and with algae, 37.8 bushels/acre (Watanabe, Nishigaki, and Konishi, 1951).

**CONCLUSION:**

MICROP®, as offered by Soil Technologies Corp., is a product developed over twenty years which has been field tested on many thousands of farm fields under varied farming practices on a variety of soil types. MICROP® has been used with many different crops and the farmers have reported similar benefits including, increased soil aggregation, decreased erosion (water and air), improved aeration, improved water infiltration, increased soil “mellowness”, and improved soil tilth.

The scientific evidence presented gives us a further understanding of the mechanics by which MICROP® affects the soil. Soil algae are very tough plants that can grow under a wide range of environmental conditions and are an important part of the flora of all soils. The fact that soil algae produce external metabolites, primarily polysaccharides and organic acids, and that polysaccharides increase soil aggregation is most likely the basis for the benefits gained by using MICROP®. MICROP® is a mixture of *Chlamydomonas* that have been selected for and improved over the last twenty years to maximize benefits on the soil, and cyanophyte algae that produces external organic metabolites while also fixing atmospheric Nitrogen.