

Applied Field Research Article

The nutrient-primed incremented substrate degradation principle. A novel method and an automated tool to assess and correct agricultural soil deficiencies to optimize its fertility and crop productivity

Giuseppe Concheri*, Stefano Tiozzo, Piergiorgio Stevanato, Andrea Squartini

Department of Agronomy, Food, Natural Resources, Animals and Environment DAFNAE, University of Padova, Agripolis, Viale dell'Università 16, 35020, Legnaro (PD), Italy

ARTICLE INFO

Keywords:

Fertimetro

Soil fertility

Crop productivity

Soil microbial activities

ABSTRACT

Is my land fertile? Do I need to add fertilizers? Which nutrients are needed and how much of each? A shift of perspective to the microbial point of view provides novel insights on these themes and prompts a method with a corresponding tool to probe the soil and obtain answers to each of these questions. The principle has been defined and patented (International patent PCT WO2012/140523/A1) and allows the comparative assessment of soil vitality and fertility and the amount of fertilizers needed to bring it to optimal levels without wasted excess. The living microorganisms are in nature the actual mediators of the organic matter mineralization which results in nutrient turnover to the benefit of cultivated plants. Soil fertility strictly depends on the promptness at which soil microbes can process organic matter, thus liberating its soluble nutrients that will be absorbed by plant roots. Using buried 'bait' filaments made of cotton (= cellulose) or silk (= proteins) and recording the change in their tensile strength after an appropriate period of persistence in soil, one can obtain a direct information on the state of its potential activity and on the possible deficiencies of key nutrients. All is deduced as a function of the speed of activity of the soil microbial communities on nutrient-spiked cotton or silk fibers in comparison to their plain un-spiked versions. The method and the ensuing devices go under the name of Fertimetro. In the present report the automatization of a tool suited to store this information and offer it to the farmer is presented.

1. Introduction

The method proposed is based on the observation that soil fertility, or the ability to support the production of a given crop, does not depend solely on the availability of nutrients (chemical fertilizers containing nitrogen, phosphorus, and potassium and/or organic soil conditioners such as manure or compost), but also on the actions of microorganisms that can help plants absorb nutrients through mineralization and mobilization processes (Lavelle and Spain, 2002). The living microorganisms diversity is huge (Torsvik et al., 2002; Roesch et al., 2007) and they are in nature the actual mediators of the organic matter mineralization which results in nutrient turnover to the benefit of cultivated plants (André et al., 2001). Soil fertility strictly depends on the promptness by which soil microbes can process residues, thus liberating soluble nutrients that will be absorbed by plant roots (Klironomos, 2002). This concept can be better exemplified by an anthropomorphic example (Fig. 1). A restaurant is the place where humans can eat; but in spite of a pantry full of food, if there were no chefs nor waiters, dishes would not self-assemble nor could they become available to customers.

A soil is seen as the restaurant for plants, where organic matter is the coffer which engages the nutrients that a plant is seeking: nitrogen, phosphorus, potassium, iron, etc. But in order for a plant to acquire them they need to be freed from the organic carbon backbones via microbially-mediated mineralization. Microbes are therefore the 'chefs' that will serve the plants their desired 'dishes'. In sustainable ecosystems such passage is the one that ensures cyclic stability to the whole environment. Since all living beings depend on the same macro-nutrients, microbial cells do need as well N, P and the other elements to build their own cells and reproduce. Unlike plants, the majority of them also need an organic form of carbon which is found in the organic litter by which plants have 'pre-paid their bill' to soil. This way microbial chefs 'eat first' and the mineral dishes they serve to the plant customers are the ones that are left once they have satisfied their (moderate) assimilation needs. Where the plant residues cyclic deposition is not interrupted, as in many terrestrial natural ecosystems, the kitchen will be plentiful and the service will be regularly ensured. If instead cycles are forcefully open, as in agriculture, soil chefs will starve and plants will have to be fed by an external outsourced catering: the man-made

* Corresponding author.

E-mail address: giuseppe.concheri@unipd.it (G. Concheri).

<http://dx.doi.org/10.1016/j.apsoil.2017.07.001>

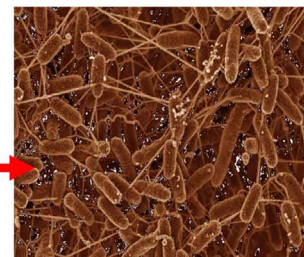
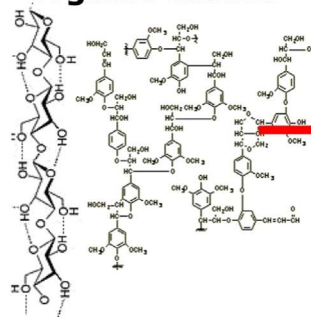
Received 27 January 2017; Received in revised form 29 June 2017; Accepted 1 July 2017
0929-1393/ © 2017 Elsevier B.V. All rights reserved.



Soil is a restaurant for **Plants**



Ingredients: Organic matter



Bacteria, fungi

Soil microbes are the **CHEFS** that prepare nutrients for plants



Fig. 1. A metaphor between the restaurant for humans and soil as a 'restaurant for plants'. The analogy introduces a comparison between traditional soil analysis methods and the in-vivo condition on which the reasoning of this report is based.

application of fertilizers. As a consequence, in most cropped soils microbes (just like plants) will be in a condition of dependency on outside inputs, and thence in competition, for the common targets (N, P etc.). Turning this ecological drawback into an opportunity to interrogate soil microbes on the extent of their 'hunger' we hereby introduce the concept of the nutrient-primed incremented substrate degradation.

1.1. The principle

The method is conceptually based on the following: 1) Since bacteria and fungi are the main decomposers of the dead organic matter reaching the soil, some microbial catabolic activities as cellulolysis or proteolysis are widespread and ubiquitous; 2) Since each dividing cell must duplicate its components, the kinetics of growth in a microbial population are dictated not only by nutrients availability but also on their balanced stoichiometry with respect to the growing species' molar composition; 3) As a consequence when a nutrient-imbalanced substrate (as for example a cotton thread, made of just cellulose and thus containing carbon, but lacking other macronutrients) is placed underground, if that soil is also poor in nitrogen, phosphorus etc., the possibility of microbial cells to use that carbon and energy source to multiply themselves will be hampered by the missing limiting nutrients; 4) But if instead a cotton filament, previously dipped in a solution of nitrogen or phosphorus, is offered to the same cells, their requirements will be satisfied by such 'complete' meal, population dynamics will be unleashed and the subsequent doublings, obeying to the power of 2 law,

will allow that cotton fiber to be chewed at an exponentially faster pace.

The basis of this reasoning is inspired by a classic empirical practice, the cotton strip assay, (Heal et al., 1974; Anonymous, 1986; Latter and Walton, 1988; Harrison et al., 1998; Correll et al., 1997) used to assess carbon turnover in cold natural biomes or, later, on polluted soils (Chew et al., 2001; Mendelsohn and Slocum, 2004), which involved the burial of a piece of fabric and the inspection of its fragility after a prolonged permanence in soil. The innovative aspects introduced by our patent are the following: (a) the adoption of an internal comparative procedure between a plain substrate and the same having been 'nutrient-primed', i.e. supplemented with a key compositional element required by the microbial (and plant) biomass; (b) using this built-in internal control (the plain 'non-dressed' fiber), beside the absolute control (the unburied, brand-new piece, of fiber), enables to draw conclusions relative to specific nutrient deficiencies by comparing the degradation undergone by the nutrient-pretreated thread to that of its plain counterpart. This aspect allows to uncouple the nutrient-assessing part of the assay from the parameters of temperature, drought, pH and overall soil conditions, as those will equally enact both on the plain thread and on the nutrient-primed ones; (c) being able to seize the actual bioavailability of N,P,K due to this differentially-incremented substrate degradation principle, the new method finds a primary field of application in the agronomical context; (d) instead of using the wide cotton bands of the classic cotton strip assay, that required 30-45-day-long incubations and bulky tensile strength-challenging machinery to

Download English Version:

<https://daneshyari.com/en/article/8846901>

Download Persian Version:

<https://daneshyari.com/article/8846901>

[Daneshyari.com](https://daneshyari.com)