Applied Soil Ecology xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Applied Soil Ecology

journal homepage: www.elsevier.com/locate/apsoil

Soil CO_2 response to organic and amino acids

Richard L. Haney[a,*], Elizabeth B. Haney[b], Michael J. White[a], Douglas R. Smith[a]

[a] USDA-ARS, Grassland, Soil and Water Research Laboratory, 808 East Blackland Road, Temple, TX 76502, USA[1]
[b] Texas A&M University, Texas AgriLife Research and Extension Center, 720 E. Blackland Road, Temple, TX 76502, USA

ARTICLE INFO

Keywords:
Cover crops
Microbial activity
CO_2
Respiration
Organic acids

ABSTRACT

Soil samples were obtained from under actively growing Austrian winter peas and from 2 m away in a plot that had no winter peas or other legumes growing in its cover crop mix. Soils were treated with 5 carbon (C) compounds (oxalic, malic, citric, glycine and arginine) and a control (deionized water). Microbial response was measured using an automated soil respiration system (ASRS). The soil under winter peas evolved a higher amount of CO_2 than the soil without winter peas across all treatments. The winter peas soil showed an increased response to oxalic and citric acids indicating that these compounds may be released by winter peas and that the microbial community is adept at assimilating them. We may be able to determine the C compounds and associated vegetation to which the indigenous microbial population is frequently exposed. Cover crop recommendations may be made based on microbial response rates to increase the diversity of the microbial community and health of the soil.

1. Introduction

Soil scientists have been studying soil respiration for nearly 100 years (Corbet, 1934). Analysis of soil respiration can be a powerful means to help us understand the microbial activity of a given soil. Drying and rewetting (D/R) cycles affect the activity of soil microorganisms, which can be analyzed as a diagnostic tool (Jenkinson and Powlson, 1976). As awareness grows that soils are a critically important component of our food production system, evaluating the quality and health of soils has been encouraged (Glanz, 1995). Cover crops have been shown to regenerate soil function (Fageria et al., 2005) and increase soil productivity. With the increasing focus on growing cover crop mixes to enhance soil health, there is a need to plant the appropriate mix of species best adapted to varying climatic and soil regions in the United States. The suitability of cover crop mixes for a given area is usually evaluated with on-farm trial and error because no scientific technique is available.

Plant roots manufacture and exude an assorted range of organic compounds that regulate the microbial community and soil properties around them (Walker et al., 2003). We have designed an instrument that may help us understand the C sources that soil microbes utilize. By monitoring microbial activity under the influence of different organic compounds and cover crops, we may be able to correlate CO_2 respiration with plant root exudates and custom design cover crop mixes. We hypothesize that soils that have been exposed to certain organic and amino acids will react with a microbial response observed with increased CO_2 respiration. This information may be used to determine the cover mixes the indigenous microbial population needs to become more diverse and efficient at cycling nutrients.

2. Material and methods

2.1. Soils

The soils used in this study were a Houston Black (fine, smectitic, thermic Udic Haplustert) (Soil Survey Staff, 2010), both with a pH of 8.3, organic matter content of 2.3%, and contains 55% clay. Organic matter content was determined using a Elementar Vario Max C:N analyzer, which measures organic C. Soil samples were taken from 2 sites, both had actively growing cover crops, one with Austrian winter peas (WP) and one with no winter peas (NWP). Soil were dried overnight at 50 °C then ground to pass a 4.75 mm sieve. Eighteen 40 g samples were weighed into 50 ml disposable beakers equipped with a glass microfiber filter. The beakers had several 3 mm holes drilled in the bottom to allow for capillary action to wet the sample based on the method of Haney and Haney (2010). Three replications of each sample were treated with one of the following compounds: DI water (the control) or the equivalent of 500 mg C kg^{-1} in the form of Oxalic acid,

* Corresponding author.
E-mail address: rick.haney@ars.usda.gov (R.L. Haney).

[1] The USDA is an equal opportunity provider and employer. Mention of trade names or commercial products is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA.

https://doi.org/10.1016/j.apsoil.2017.12.016
Received 25 September 2017; Received in revised form 4 December 2017; Accepted 12 December 2017

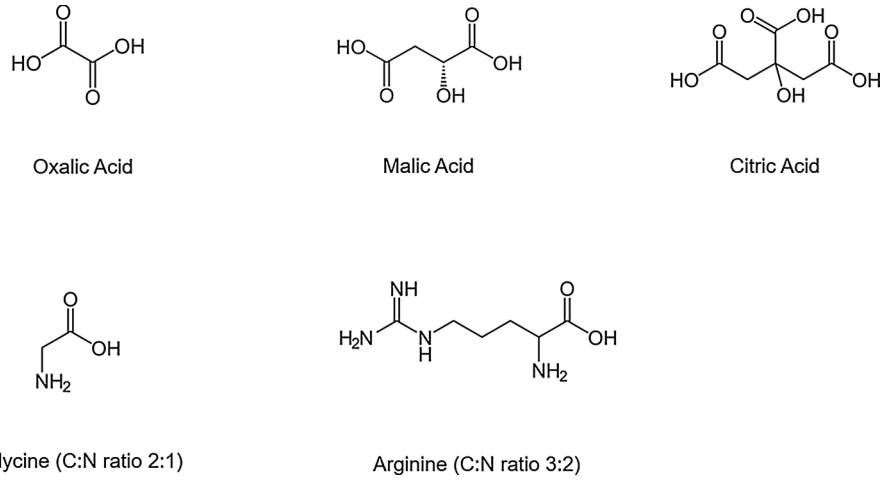

Fig. 1. Compounds used in the study. Oxalic (2 C) is the simplist carbon compound and therefore the easiest for microbes to break down followed by Malic (4 C) and Citric (6 C). Glycine (2 C for every N) is easier for microbes to break down than Arginine (6 C for every 4 N).

Malic acid, Citric acid, Glycine, and Arginine (Fig. 1). We chose these organic and amino acids to mimic plant exudates based on their commonality across cropping systems and their simplicity (Rengel, 2002; Baudoin et al., 2003). Soil samples were allowed to absorb the treated water through capillary action until wet. After wetting, the samples were placed in 0.5 L glass jars and mounted to the automated soil respiration system (ASRS).

2.2. Automated soil respiration system (ASRS)

We designed and built a 42-chamber programmable respirometer to detect near real-time soil CO_2 respiration (Fig. 2). The instrument can be set to run from 1 to 42 chambers (0.5 L glass jars) and can be set to flush and record CO_2 from each sample at a minimum of every 30 min for 24 h. The machine is connected to a Licor 840 CO_2 detector with a magnesium chloride scrubber to remove water in the air stream prior to sample analysis. Room air intake is sent through a soda-lime column to remove CO_2. Detection software written in Visual Basic records CO_2 peak concentration and calculates the area under the peak curve for each sample after wetting. The instrument has 42 single way solenoids. Sixty check valves are used to force the CO_2 sample into the appropriate tubing to isolate analysis from each sample. The software has a leak check and automatic CO_2 flushing program that is triggered with the beginning of the program. In this study, we only used 18 of the chambers, even though it is capable of analyzing to 42 samples (Fig. 2). Each sample was flushed with CO_2-free air every hour for 24 h to capture CO_2 response. Graphs and statistical analyses were performed using Sigmaplot (2017) version 13.0.

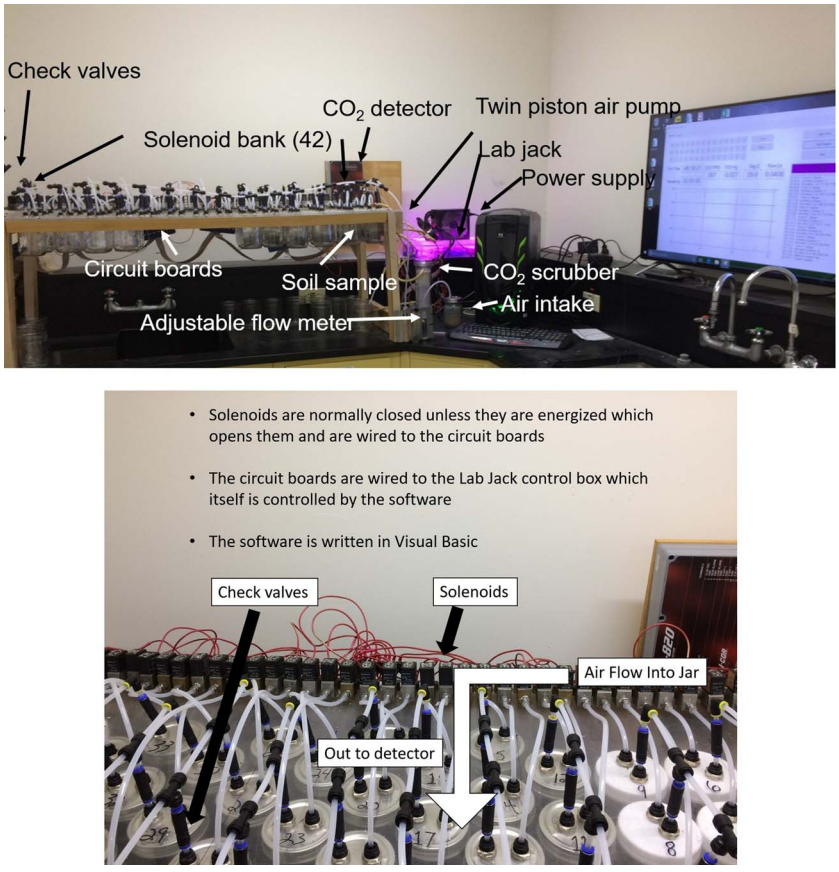

Fig. 2. Automated Soil Respiration System for soil CO_2 (ASRS).