Innovation Basal Soil Respiration (BSR) Method for Assessment of Microbial Activity

Zouheir Massri, Ph.D.
Soil Physics & Fertility Research Manager

Introduction:

Soil respiration is a complex process that results from several sources of CO_2 in the soil. These sources can be grouped in two main types: **autotrophic respiration, which is** linked to the activity of roots, and **heterotrophic respiration, which is** linked to the activity of soil microorganisms. Research proved that soil CO_2 flux includes a large component of autotrophic (root) respiration, which can vary substantially with plant growth and vegetation. To assess the biological activity of soil per se, we need to conduct soil incubation assessments of microbial respiration.

Application of the PrimAgro line in NCRS long-term research requires advanced methods and research tools to fill the gaps in soil-plant interactions. These methods will also integrate the impact of soil physical and chemical properties with soil microbial communities, as well as decompose and recycle organic matter left by previous crops. This research will allow evaluation of the impact on microbial-mediated processes influencing plant nutrient availability and the importance of the processes and drivers influencing release and uptake of nutrients.

Therefore, we have a Gel-Spectrometry method for assessing the steady rate of CO_2 emissions linked to the microbial decomposition of soil organic matter in a root-free soil. This method is referred to as a Basal Soil Respiration (BSR) method to assess the main efflux of the heterotrophic respiration. It has been newly used as a replacement for Solvita test, which is an expensive method. BSR is a microbial indicator to monitor the impact of agricultural practices on soil biological activities and monitoring of soil health evolution

Objective:

The soil is a dynamic and complex material in which many physical, chemical, hydrological, and biological processes interact. A major challenge for soil scientists is to identify a set of soil properties sufficiently simple and robust enough for routine measurement, yet provide enough information to give meaningful insights into the state of the soil. Such information will aid in the interpretation of soil functions and determine whether application of PrimAgro line is increasing the soil microbial biomass (SMB) and further basal soil respiration (BSR).

Therefore, the BSR method will help to effectively and quickly respond to a lot of questions and inquiries brought by PrimAgro line upon application and use during 2017 season. The method, as well, will enable to test BSR for imported soils from different locations through the country.

Material and methods:

The method consists of a 24-h incubation in the field/ and or Lab. at ambient field temperature of a fresh soil sample with a pH-sensitive color gel filled in a 4.5 mL spectrophotometer macro-cuvette.

Figure 1. Cuvettes are kept in a desiccator in the dark at room temperature with an excess of soda lime and water for one week to absorb atmospheric CO_2.

Figure 2. A Cuvette with gel in a standard measurement of the CO_2 released by basal soil microbial respiration in Lab. conditions. Gel absorbance (Abs. T_0- Abs.T_{24}) is measured after calibration with blank cuvette.

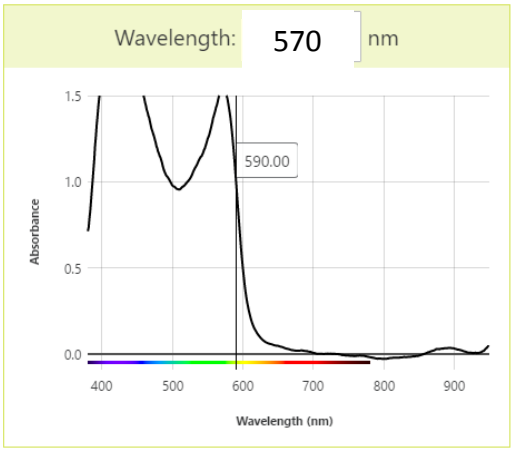

Figure 3. Software showing the wavelength was set to measure the absorbance of Gel after soil incubation.

Figure 4. SpectroVis® Plus Spectrophotometer for calibration and measurement of the CO_2 released by the Basal Soil Microbial Activity Respiration.

The color of the gel changes along the incubation process as the result of the reaction between bicarbonate in the gel and the CO_2 concentration in the headspace of the jar, which can be linked to CO_2 emitted from the soil. The change in the gel color is quantified by measuring the absorbance of the gel at 570 nm with a portable spectrophotometer (Figures 1, 2, 3, and 4).

Results and discussion:

We have tested the BSR method in the field and Lab conditions. After calibration of a cuvette without gel at 570 nm wavelength to set the Zero-value of absorbance, cuvettes with gel were measured for their initial absorbance at DT0 (DTzero), put in a standard jar with 100 gr. of sieved soil and incubated for 24 hours (DT24) at room temperature.

The difference in absorbance before and after the incubation (DT24 - DT0) was measured and fitted with following equation (Figure 5).

$$y = 14.975e^{1.8699x}$$

Where x = (DT24 - DT0)

So, it is easy to correspond the values of absorbance to the actual values of CO_2 released by the basal soil microbial respiration activity, i.e., to replace the value with x (which is the difference in the absorbance at 570 nm) and multiply it with the exponential ($e^{1.8699x}$) value to get Y value of CO_2 soil respiration over 24 hour incubation which calculated and converted in CO_2-C.kg^{-1} soil (using the ideal gas law).

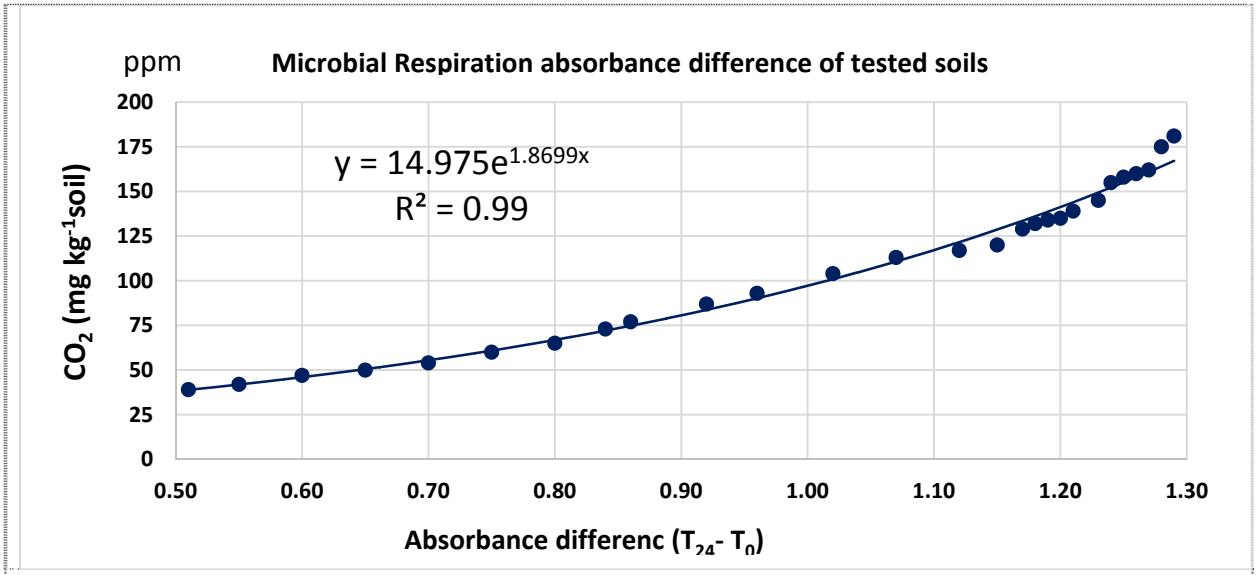

Figure 5. A fitted mathematical equation was developed to correlate the color changes of pH-sensitive gel absorbance after 24-h of incubation with CO_2 as (mg kg^{-1}soil) released by soil microbial activity respiration.

In Table 1, basal soil microbial respiration is presented and showing the process for calculating the amounts of the of CO_2 capture by Gel Spectrometry technique of soil samples taken at 0-6“(October 17, 2018) before harvesting the soybean, NCRS- Farm 18- 903.

Table 2. BSR measurements of CO_2 capture by Gel Spectrometry technique resulted by the basal soil microbial activity respiration of soil samples taken at 0-6“(October 17, 2018) prior harvesting the soybean, NCRS- Farm 18- 903.

Treatments of		Reps	DT0	DT24	Av. DT0	Av. DT24	Absorbance (DT24 - DT0)*	CO_2 (mg kg^{-1}soil)
(2017): Pro-Germ + Kalibrate +M 500 + Sure K (2018): Kalibrate + M- 500 (3.0 + 0.5)	On Row	Rep-1	1.745	0.960				**70.3**
		Rep-2	1.740	0.815	1.742	0.902	0.840	
		Rep-3	1.741	0.930				
	Bet. Rows	Rep-1	1.742	0.933				**37.2**
		Rep-2	1.747	1.084	1.745	1.030	0.714	
		Rep-3	1.745	1.074				
(2017): Pro-Germ + Kalibrate +M 500 + C-TECH + Sure K (2018): Kalibrate + C-Tech (3.0 + 0.5 + 0.5)	On Row	Rep-1	1.750	0.707				**218.7**
		Rep-2	1.745	0.690	1.745	0.681	1.065	
		Rep-3	1.741	0.645				
	Bet. Rows	Rep-1	1.750	0.913				**50.3**
		Rep-2	1.745	1.009	1.745	0.971	0.774	
		Rep-3	1.741	0.991				
(2017): PrimAgro P + PrimAgro K + M500 + + Sure K (2018): Prim-K + M-500 (3.0 + 0.5)	On Row	Rep-1	1.739	0.619				**309.1**
		Rep-2	1.741	0.592	1.742	0.609	1.133	
		Rep-3	1.745	0.615				
	Bet. Rows	Rep-1	1.614	0.906				**56.9**
		Rep-2	1.737	0.930	1.698	0.899	0.799	
		Rep-3	1.743	0.862				

* X value in the equation

Conclusion:

The BSR method is reliable for performing a cheap, rapid, and efficient assessment of soil microbial activity in the field. It also validated the EC measurement of the passive sampler (alkali-trap method used in NCRS during 2107). Please, refer to our report entitled "Mathematical model for calibration of CO_2 released by soil microbial respiration captured by passive sampler in field conditions" in this edition. This method referenced by literature as a strong correlation between the two methods (BSR vs Solvita) and yielded similar results (R^2 =0.90).

Knowing that no method makes it possible to appraise the BSR through an easily and freely accessible proxy measured directly in the field, i.e. without the need of soil preparation, systematic spectrometer calibration, and laboratory incubation. Using the spectrophotometer (commercially SituResp®) provided an excellent indicator for soil health monitoring.

Therefore, BSR method will help to validate the long-term application of PrimAgro line in corn and soybean crops and for other soil microbial studies, assessment of soil microbial activity and soil organic matter decomposition process, soil nutrient release, and further the long-term valuation and monitoring of soil health.