

Field and Laboratory Solvita Soil Test Evaluation

Nov. 19, 1997

John Doran, Tim Kettler, Maria Tsivou

USDA-ARS, University of Nebraska, Lincoln

September 25 - October 3, 1997

Introduction

Soil fertility is an important component of soil quality. Soil fertility is linked to the biological activity occurring in soil, which in turn is linked to important soil quality parameters such as plant nutrient and energy cycling, soil aggregation, and general soil tilth. Measurement of soil respiration is a way of gauging biological activity of living microorganisms in the soil.

Currently available laboratory and field methods of measuring soil respiration are time consuming, labor intensive, require specialized knowledge and equipment, and involve fairly extensive calculations.

A simple, inexpensive, and relatively quick method of measuring soil biological activity and/or respiration, in both laboratory and field, would be a valuable tool for soil quality assessment by both agricultural specialists and farmers.

Objective

To evaluate the Solvita system for soil respiration measurement in the laboratory and in the field using USDA-ARS standard methods as references for comparison. To assess feasibility of using the Solvita test kit for in-field measurement of soil respiration.

Experimental Summary

Laboratory evaluations compared Solvita test kit measurements with those of the same soil incubated in a closed system of known headspace, using gas chromatography (GC) for analysis of the headspace CO₂. Field evaluations compared the Solvita test kit detector paddle placed in the field for 24 hours inside a covered 15 cm diameter, 15 cm length aluminum ring installed to a soil depth of 7.6 cm, with 30 minute CO₂ flux measurements taken from the headspace of these same rings immediately before and after the 24 hour Solvita incubation period. The headspace CO₂ of field samples was analyzed using Draeger detection tubes and by gas chromatography (GC).

Conclusions

The Solvita system offers great promise as a substitute for more refined methods of quantitatively measuring soil respiration both in the laboratory and the field. The detection range of the Solvita system is from 12 to 78 ug C/g soil/day. This is an optimal range for determining ecological relevance of soil respiration values as background respiration levels for most soil are generally below 1.0 ug/C/g soil/day and soil respiration is generally not considered excessive until rates exceed 50 to 60 ug C/g soil/day. Further research is needed to resolve quality control problems associated with variation in initial color of the indicator paddles when they are first removed from their foil packs.

Laboratory Comparisons

1 Soil

- Sharpsburg silty clay loam, A horizon, from benchmark site.

3% sand, 63% silt, 34% clay. 16 g organic C/kg soil. pH = 6.5, E. C. = 0.10 dS m⁻¹

2 Treatment

- soil amended with 5 mg g⁻¹ glucose (2000 ugC g⁻¹ soil).
- soil without glucose amendment.

3. Methods

- a) Solvita brand" Soil Life Test".

"To measure biological activity and organic matter fertility"

- b) Soil respiration by GC as described in Qian, et.al., 1.995, Determination of Soil Microbial Biomass C and N, Mineralizable C and N, and Nitrifiable N (incubation T=25C).

4. Experimental units

- 4 replicates of each treatment with each method.

5. Period of measurement

Both methods were compared over 24 hour incubation periods. Incubation periods were measured beginning at 20, 92, 124, and 164 hours after soil water status adjustment (60% WFPS) and glucose amendment (2000 ug Cg⁻¹ soil). Incubation vessels were flushed with air after each time of CO₂ measurement.

6. Data and Summary (attached)

Results and Discussion

The adjusted soil respiration values obtained with the Solvita system were in the same ranges as those measured using the GC (4.1 and 96.2 ug CO₂-C / g soil! day). Problems with the Solvita system were encountered with the starting (t=0) color of the indicator paddle gels. Many of the paddles were at color levels above zero (according to the color key which was provided with the Solvita system). This creates

Report - Solvita System - Page 2 - reprinted with permission of the authors

difficulty in obtaining quantitative estimates of actual respiration rates. Results may be improved by subtracting the initial respiration value indicated by the paddle at $t=0$ from the final respiration. Using the Solvita system for measurement when the respiration rate reaches the upper level of the color indicator (>5) becomes difficult as the scale of the color indicator appears to follow an increasing exponential function, and the size of potential errors can increase in like fashion when attempting to extrapolate color indicator results beyond the ranges specified in the Solvita user instructions.

Field Comparisons

Site Location: Lincoln Municipal Sludge Injection Facility. (" Sludge Farm "). Lincoln NE. Lancaster county, which is located 0.2 km north of US Interstate 80 on north 70th street. Site descriptions: At the Sludge Farm two locations were chosen:

Site 1: located at the foot slope of a field planted to corn. Two pairs of rings were installed, one pair was installed in the inter-row area of a suspected wheel track (WT), the other in the inter-row area of an adjacent non wheel track (NWT), rings in each pair were placed 30 cm apart.

Site 2: located on the crest of a hill in a field planted to soybeans. This field was reported to have had sludge injected in the spring of 1997. Two pairs of rings were installed, the pairs were 1.5 m apart in the inter-row area of a non wheel track, rings of each pair were placed 30 cm apart.

The soil type of both sites was a Sharpsburg silty clay loam. Initial quickie electrical conductivity (1: 1 H₂O:soil) at sites 1 and 2 were 0.11 and 0.23 dS m⁻¹ respectively.

Sampling Methods

Gas Sampling

After the rings were installed at both sites they were covered with lids fitted with rubber septa for gas sampling with hypodermic needles and syringe. The rings were covered for a 30 minute period after which a 23 ml sample was collected from the headspace and injected into an evacuated 12 ml lypholization vial for GC analysis in the lab. The headspace CO₂% was then measured using Draeger 0.1 % detection tubes. Soil temperature (uC) was also taken (depth 4 cm) inside the ring at the time of each gas sampling. Gas samples were collected from all rings at site 1, and from one pair at site 2.

After the initial gas sampling, one ring in each pair at both sites was irrigated with one inch of distilled water, and the infiltration time recorded. A Solvita test paddle was then placed in the soil in the center of each ring at site 1, and in one pair of rings at site 2. At this time ($t= 0$), the initial color of the paddle was noted for later adjustment of the results for a starting indicator color other than zero. All rings were then covered for a 24 hour period, after which (at site 1 only), gas samples were drawn from the headspace and CO₂% was analyzed by GC and Draeger methods. The lids were then removed from the rings and the Solvita test paddle color indicator level was recorded. Immediately after recording the Solvita results, the

rings were again covered for 30 minutes and gas samples taken for analysis by GC and Draeger methods as described above.

Soil Sampling

During the time of the initial 30 minute gas flux measurement, soil samples were collected at both sites 30 cm from each ring to a depth of 7.6 cm using a 3 inch diameter aluminum tube. After the final gas sampling, soil samples were also collected in the same manner from the inside of each ring which had received one inch of irrigation water. The bulk density, gravimetric water content, and water-filled pore space of each sample were determined.

Field Study: Results and Discussion

Results obtained with the Solvita system were different between the two sites, probably due to temperature at the time of sampling. The corn field (site 1) had respiration of 19 kg C ha⁻¹ d⁻¹ for the WT, and 30 kg C ha⁻¹ d⁻¹ for the NWT (both non-irrigated) as measured by Solvita, and 26 and 22 kg C ha⁻¹ d⁻¹ for WT and NWT as measured by the GC method. The Draeger measurements were considerably higher than either of the other two methods at site 1. At the soybean field (site 2), Solvita measured 11 kg C ha⁻¹ d⁻¹, GC measured 20 kg C ha⁻¹ d⁻¹, and Draeger 25 kg C ha⁻¹ d⁻¹ for the non-irrigated ring. The lower value measured by the Solvita system probably represented a cooler median temperature over the 24 hour period of measurement (15-17C), which should have resulted in almost a two-fold lower average level of respiration as compared with measurements by GC and Draeger which were taken at about 25 C.

Use of the the Solvita test paddles to estimate soil respiration in conjunction with USDA- ARS Soil Quality Test Kit infiltration/respiration rings requires a correction factor to allow for differences in the head-space to soil ratio of the Solvita incubation container, and the 15 cm diameter ring used in the ARS test kit. Following the assumption that all measured respiration was coming from the 7.6 cm layer of soil which the ring is installed in, a calculation factor of approximately 0.5 times the Solvita indicator results will give an estimate of the field soil respiration rate in ug C/ha/day, which can be converted to kg C ha⁻¹ d⁻¹ using soil bulk density and depth of activity. Details of the calculation of this factor, as well as data from the field experiment are attached.

USDA SOIL RESPIRATION TABLE

Table 1. General soil respiration class ratings and soil condition at optimum soil temperature and moisture conditions, primarily for agricultural or managed soils. This table does not reflect soil respiration ratings if measured shortly after soil disturbance (tillage).		
Soil respiration (lbs CO ₂ -C/m/d)	Class	Soil condition
0	No soil activity	Soil has no biological activity and is virtually sterile.
< 5.03	Very low soil activity	Soil is very depleted of available organic matter, and contains little biological activity.
5.03 - 8.39	Moderately low soil activity	Soil is somewhat depleted of available organic matter, and biological activity is low.
8.39 - 16.8	Medium soil activity	Soil is approaching or declining from an ideal state of biological activity.
16.8 - 33.6	Ideal soil activity	Soil is in an ideal state of biological activity and has adequate organic matter and active populations of microorganisms.
> 33.6	Unusually high soil activity	Soil has a very high level of microbial activity and has high levels of available organic matter, possible from addition of large quantities of fresh organic matter or manure.

Information taken from Woods End Research (1997) and Doran et al. (1997). Conversion of Woods End Solvita respiration levels to Draeger respiration levels: (mg CO₂/kg/wk) x 0.039 x 0.53 x (1.2 g/cm³) x (7.6 cm depth) / 10 x 0.89 = (lbs CO₂-C/acre/day). It was assumed all respiration was coming from a 7.6 cm depth with an average bulk density of 1.2 g/cm³, and a correction factor of 0.53 (Doran et al., 1997).

References

- Doran, J. W., T. Kettler, M. Liebig, and M. Tsivou. 1997. Solvita soil test evaluation, personal Communication.
- Parkin, T.B., J. W. Doran and E. Franco-Vizcaino. 1996. Field and laboratory tests of soil respiration p.231-246. In: J. W. Doran and A.J. Jones (eds.) Methods for assessing soil quality. Soil Sci Soc. Am. Spec. Publ. 49. SSSA. Madison. WI.
- Woods End Research. 1997. Guide to sol vita testing and managing your soil. Woods End Research Laboratory. Inc. POBox 297, Mt. Vernon, ME 04352 (solvita@woodsends.org).

Field Data Calculations

Solvita kit

Container volume = 265 ml

Packed soil volume in container = 100 ml

wgt. of OD soil = $(120.9 \text{ moist soil} / (1 + (0.235 \text{ g H}_2\text{O/g OD soil})) = 97.9$ Bulk density of soil in Solvita container = $97.9 \text{ soil}/100 \text{ ml} = 0.97 \sim 1.0 \text{ g/cm}^3$

Water filled pore space of soil in Solvita container.

H₂O cont. of 97.9 O.D. soil packed to volume of 100 ml at bulk density ~ 1.0 , and WFPS = 0.6 $= [(0.6) * (1 - (1.0/2.65))] / 1.0 = 0.37 \text{ g H}_2\text{O/g OD soil}$ mls H₂O to add to 120.9 soil @ 0.235 g H₂O/g OD soil to adjust to 0.37 g H₂O/g OD soil = $(0.37 - 0.235) * (120/1.235) = 13 \text{ mls}$

Solvita container Net headspace

= 265 ml total - 100 ml soil volume + 25 ml air filled pore space volume = 190 mls

Solvita container (Headspace cm³: g Soil ratio) = $190/97 = (1.96 : 1)$

Field Infiltration Ring, 6 inch diameter x 6 inch length

Ring is inserted in soil to depth of 7.6 cm, Headspace height = 7.6 cm Headspace volume = bulk soil volume = 1332 cm³average field measured soil bulk density = 1.2 g / cm³Wgt. of O.D. soil in ring @ 7.6 cm depth and 1.2 g/cm³ BD = $1332 * 1.2 = 1598 \text{ g}$ Soil Total Porosity = $1 - (1.2/2.65) = 0.55$ Soil total Pore volume = $1332 \text{ cm}^3 * 0.55 = 729 \text{ cm}^3$ average measured Soil WFPS = $(\text{H}_2\text{O cont. g/g} * \text{bulk density g/cm}^3) / \text{total porosity} = (0.25 * 1.2) / 0.55 = 0.545$ Air filled pore space = $1 - \text{WFPS} = 1 - 0.55 = 0.45$ Air filled pore volume = air fill pore space * total pore vol. = $0.45 * 729 = 328 \text{ cm}^3$ Net Headspace = Ring Headspace + soil air filled pore vol. = $1332 + 328 = 1660 \text{ cm}^3$ 6"x6" Field infiltr. ring (Headspace cm³: g soil) ratio = $1660/1598 = (1.04 : 1)$ Factor to convert Solvita apparent reading to actual value when using 6x6 inch rings = $6x6" \text{ ring (headspace cm}^3\text{: g soil)} / \text{Solvita container (headspace cm}^3\text{: g soil)} = 1.04/1.96 = 0.53$