

## GUIDELINES FOR INTERPRETATION:



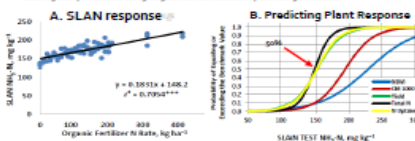
TECH MEMO 0327-3

### SOLVITA SLAN IN RELATION TO CO<sub>2</sub>-BURST

CO<sub>2</sub>-Burst and SLAN provide different but related insights into soil quality. CO<sub>2</sub>-burst is the raw biological activity of microbes. SLAN shows biochemical measures of nitrogen in amino forms. Both represent factors associated with soil health but not necessarily mutually exclusive. Recent research shows how SLAN results may modify interpretation of CO<sub>2</sub> respiration (see *in vivo*). Thus, by performing the tests together more information may be obtained than by one test alone.

Research plots at UCAn continue to indicate that CO<sub>2</sub>-Burst and SLAN appear co-indicators of biological soil quality and plant response. The graphs below show SLAN test results to added organic-N (N) and plant response to observed SLAN levels (B). Fig. A confirms "optimal" by soil of the org-N fraction applied (as composted turkey manure). SLAN also yields a distinct probability curve (B).

For each soil type there is likely to be a distinct "SLAN" baseline plus increments attributable to new soil management practices or amendments to the extent that they interact with soil biology. In the same track, CO<sub>2</sub>-Burst (not shown) did respond significantly but at a slower\* and shallower production range. So CO<sub>2</sub> respiration responded less distinctly to this form of added organic matter. Therefore, both tests together provide interesting insights into microbial activity and nitrogen reserves.\*



These data confirm a strong relationship of Solvita SLAN to accumulated soil organic-N from recent management and which closely relates to yield, N-uptake and plant photosynthesis. Solvita CO<sub>2</sub> also gave a significant response to amendment but at a smaller scale (compared to background). This implies that the stable manure-compost was not substantially increasing soil biological activity. The relationship of the two tests helps explain actual behavior in the soil-plant system.

The findings have been determined in CT on Pacatan fine sandy loam soil, which has been in agriculture for 40 years and received composted manure as the sole source of fertilizer nutrients.

\*Goulden, D. Moore, and W. Wilson. (2014) SOLVITA SOIL TESTS TO CATEGORIZE TURF GRASS SITE RESPONSIVENESS TO NITROGEN FERTILIZATION - and RESULTS UCAn Turf Plant Research Report

## GUIDELINES FOR SOIL DILUTION



TECH MEMO 0327-3

### SOLVITA CO<sub>2</sub>-BURST: ORIGINAL RANGE VS HIGH RESPIRING SOILS

Solvita CO<sub>2</sub> is a test protocol based on an expected "normal" amount of soil CO<sub>2</sub> respiration. Many people are curious about how the range was established and what to do in high OM soils which generate sufficient CO<sub>2</sub> to saturate the optical scale. Normally, it is not considered good lab practice to read any results in the steep part of the optical curve (see Fig. A). This case illustrates this since the different methods are magnified. This memo shows a method to dilute soil to make high Solvita readings appear more normal.

Solvita was originally calibrated for a 35 mg/dg daily CO<sub>2</sub> output. The numeric range is found in Britton's work in Sweden from a 12-yr field study which observed values over this range for depleted and enriched soils under traditional farming. Doner's work in Nebraska was also recorded for CO<sub>2</sub> rates on tilled, prairie soils which were observed from 4 to 60 μg CO<sub>2</sub>-C/g soil/day. Thus, a range of 0 - 100 seemed appropriate for most farm soils.

When soil is particularly active due to high OM or from heavy manuring, respiration can be quite high, and it is advisable to use less soil. Generally, Solvita colors over 4 μ indicate a highly active soil where the Solvita optic curve becomes too steep. Digging works best at this point. Graph (B) shows the excellent linearity of Solvita CO<sub>2</sub> when diluting 4 μg soil down to 20 g. It is not advised to use an 80 g jar if it is difficult to adjust moisture properly. Using 20-30 g may be sufficient to bring high respiring soils into an acceptable Solvita detection range. If CO<sub>2</sub> is still high after this, using a larger jar size is the best approach instead of further reducing soil. This is because Solvita employs the Ideal Gas Law so volume of the airspace determines CO<sub>2</sub> concentration to which the probe reacts. Changing the jar size has a similar effect as altering weight.

Recommendations: (1) using less Soil: For Solvita Color over a 4 μ (40 μg/g), use 35 g soil and correct the result by 1.44 (40/35) to also use correction.

Recommendations: (2) using larger Jar: Use USA-pint canning jar (#22) and use soil correct by 1.84. For very high respiration use USA-OT (#40) and use soil correct by 3.79 factor.

Note: This method has been validated for ppm WPGF method. Labs using multi-casting jars (see Jar CO<sub>2</sub>) for Solvita are concentrating CO<sub>2</sub> by a factor of 2.0 and the correction should be x 0.50.



\*Britton, Britton B., Wasth, Johansson, E., 1999. Effects of Organic and Inorganic Nitrogen on Soil and Long-Term Results of a long term field experiment in Sweden. Swedish Farming, Malmköping, Sweden 151, 20-30.  
\*Doner, J., Thielke, M., 2009. Soil and Laboratory Solvita Soil Test Production. USDA ARS, University of Nebraska, Lincoln

## GUIDELINES FOR RANKING TEST RESULTS



TECH MEMO 0327-3

### SOLVITA CO<sub>2</sub>-BURST AND SOLVITA SLAN

Solvita CO<sub>2</sub> and SLAN are soil tests designed to indicate biological factors generally associated with changes in soil quality and plant response. An appreciable research effort went into selecting the practical measurement ranges for Solvita. Additionally, a fairly large body of work on soil respiration already exists from European studies tracking biological farming effects dating to the 70's and continuing into the present along with several long-term plot studies. This dataset was also useful to aid selecting meaningful ranges to interpret CO<sub>2</sub> rates.

To further improve interpretive criteria for a range of soils and farm conditions, Woods End Laboratories has launched a proficiency-reference program for commercial labs with Solvita soils. This will serve to improve understanding of CO<sub>2</sub> rates in relation to known farm-soil conditions, and to monitor capabilities of labs in distinguishing differently managed soils.

Table 1 indicates suggested interpretation of Solvita by the type of test grouped into "low", "mid", and "high" categories all for 30-24°C tests. These ranges may change over time. Data for Low and High are consistent with proficiency results for all commercial labs for a poor and enriched soil.

Solvita Test	Method	Suggested Interpretation		
		LOW	MEDIUM	HIGH
LAB	CO <sub>2</sub> -Burst (dry soil)	50% WPGF: 0-40	40-180	180-300
	Capillary Weeting	0-20	20-50	50-100
FIELD	BASAL	Field Meter: 0-5	5-45	45-120
	SLAN	kg/100cm <sup>3</sup> NO <sub>3</sub> -N: 0-40	40-150	150-300

\*NOTE: consider using less soil or higher jar

Basal respiration is a field test with minimally disturbed soil. To obtain similar ranges the mean difference between CO<sub>2</sub>-burst and field rates was determined. Additionally, the ranges and median values for basal CO<sub>2</sub> reported for published field respiration studies was tabulated and yielded 2.5 to 15 μg/har/day as CO<sub>2</sub>-C. This value is consistent with the MED rank category shown for Basal in Table 1.

From all these data, it can be appreciated that the CO<sub>2</sub>-Burst with ppm WPGF shows maximum potential respiratory activity and is often 2-4x higher than basal rates. These numbers represent different soil types and field rates were determined. Additionally, the ranges and median values for basal CO<sub>2</sub> reported for published field respiration studies was tabulated and yielded 2.5 to 15 μg/har/day as CO<sub>2</sub>-C. This value is consistent with the MED rank category shown for Basal in Table 1.

It is recommended that soils which test consistently over a Solvita CO<sub>2</sub> of 4 μ (see \* in Table 1) are candidates for dilution, to improve readability. A previous Technical Memo\* described how to do this.

\*Leigh & Johnson Eds. (2002) Long Term Experiments in Agricultural and Ecological Studies. CAB Press  
\*Soil Dilution. 2007. Technical Memo 0327-3. Woods End Laboratories

## DOES LIMESTONE AFFECT CO<sub>2</sub> RESULTS?



TECH MEMO 0327-4

### SOLVITA CO<sub>2</sub>-BURST: ORGANIC VS INORGANIC CO<sub>2</sub>

Solvita CO<sub>2</sub> is a test protocol based on a burst of soil CO<sub>2</sub> respiration following wetting of dried soil, or a natural release of CO<sub>2</sub> with field-moist soil. The release of carbon dioxide during lab tests is considered to be microbial in origin - due to bacterial, fungal and other soil micro- and macro- organisms that respire C from consuming organic matter for energy. (If respiration is measured "in situ", i.e. undisturbed in the field, then up to 50% of the CO<sub>2</sub> may be due to living plant root respiration.)

But what about other sources of CO<sub>2</sub> in soil? Limestone is often cited as a potential source of "inorganic" CO<sub>2</sub> as opposed to the organic CO<sub>2</sub> derived from living organisms. If CO<sub>2</sub> evolved from lime was large, then it could be an interference with the test for microbial respiration, leading to potential misinterpretation. This would be like the large error in soil total-carbon (C) if limestone presence is counted along with organic-C. The analysis method may release all limestone instantly as the CO<sub>2</sub>, but microbes do not. Some calculations may illustrate this. Limestone CaCO<sub>3</sub> has a molecular weight of 100 with 44% CO<sub>2</sub> in carbonate CO<sub>3</sub> form. Upon acidification in soil, the CO<sub>2</sub> is converted stepwise to CO<sub>2</sub> via bicarbonates, neutralizing acidity and producing water. Hypothetically, if all the limestone reacted instantly in the soil, then we would observe a large spike in CO<sub>2</sub> which could confound a respiration test. Bacteria is not likely to happen. As farmers know well, limestone reacts only very slowly in soil over weeks or months, depending on how acid the soil is and on how finely-ground the lime is. At a maximum, if all the lime is to be factored into detection merely by calculation it would affect the Solvita CO<sub>2</sub>-Burst by 14 mg/kg soil (ppm), which is measurable. However, if the lime dissolves over 90 days (which is optimistic) the effect would be < 1 ppm in a 24-hr CO<sub>2</sub> test, less than a margin of detection.

An interesting caveat is that lime addition to soil often increases soil microbial activity\*, causing a rise in biotic CO<sub>2</sub> which should not be mistaken for inorganic CO<sub>2</sub>. It is also true that use of limestone worldwide is causing a measurable rise in atmospheric CO<sub>2</sub> and that liming past soils may cause a more rapid release of CO<sub>2</sub>. In conclusion, inorganic sources of CO<sub>2</sub> are not likely to influence interpretation of Solvita soil biological CO<sub>2</sub> respiration tests.

Limestone	potential effect on soil CO <sub>2</sub> as determined by Solvita
liming rate	lb/ha
light	5
medium	20
heavy	35
ppm effect	
light	0.25
medium	0.95
heavy	1.52
ppm effect	
light	0.25
medium	0.95
heavy	1.52

\*J.P. Harshbarger et al. Microbial activity affected by lime in a long term soil test. Soil & Tillage Research 88 (2005) 107-110  
\*C.P. West, A.C. Johnson. The contribution of agricultural inputs to CO<sub>2</sub> emissions in the United States. Agri. Res. Environ. Sci. (2002) 19: 25-34  
\*C. A. Cerco. Carbon dioxide flux from the Mississippi River to the Gulf of Mexico. Science 298 (2002) 1513-1516

## WHAT IS CO<sub>2</sub>-BURST vs 3 OR 7-DAY RESPIRATION?



TECH MEMO 0327-5

### SOLVITA CO<sub>2</sub>-BURST: ORGANIC VS INORGANIC CO<sub>2</sub>

Solvita CO<sub>2</sub> is based on a flash of soil microbial CO<sub>2</sub> which occurs after moistening dry soil. It is measured at 24°C and is ideally used in soil health labs to gauge microbial soil activity. The original discovery of CO<sub>2</sub>-burst around 1955 was made simultaneously in Africa and Germany\*. While some soil explorations have been advanced to the cause of the burst, a common popular view is that microbes accumulate organic matter during prolonged dryness and then are dumped into the soil solution at the onset of rewetting (triggering a microbial burst of growth). The phenomenon is fairly robust and is repeatable over several drying-rewetting cycles.

Recent discussions on soil health indicators have considered at least 3 modes of testing respiration (see figure). When dry soils are re-wetted, the large surge of CO<sub>2</sub> within 24 hrs in the CO<sub>2</sub>-Burst (see Fig. A). Another mode is to measure the decline over 3-4 days (see Fig. B). A final approach is to wait an impaction approach (see Fig. C). The 180-day rate often called "basal" respiration (see Fig. C) and is reported only after capping the first 24-hr spike. It is now established that the 24-hr burst is highly correlated with the later measurements\* whether in the "B" or "C" form. This is not hard to grasp since the same microbial population is involved.

While the Solvita test is used mostly in labs it is not ready, it need not be limited to this and may be readily adapted to be a 3-day or even 7-day test simply by changing the jar size. Solvita behaves like a buffer to CO<sub>2</sub> concentration in the airspace, a reaction quantified by the Ideal Gas Law. Changing the jar volume proportional to the difference in time means the accumulated Solvita result will be the average rate for that period of time. The following table illustrates the desired length of time and jar size needed with soil volume held constant at 20 g, the normal amount for a Solvita test.

Jar Size or Option A Solvita 1, 2, 4 or 20g test result	Adjusted SDP - To obtain a Solvita result equivalent to the indicated number of days from 3-day to 7-day burst, place soil in indicated jar size and read after the given time period. The longer the period, the more the actual CO <sub>2</sub> -burst effect is integrated into the basal rate. For more information please contact the technical team at Solvita.		
Size	EMPM <sup>2</sup>	EMPM <sup>3</sup>	Solvita CO <sub>2</sub>
20g	28	127	1.0
10g	7.5	31.2	1.8
2g	1.46	5.04	2.7
0.5g jar	0.360	1.06	7.5

\*West 1953. Effect of Soil Temp. on Respiration and on Soil Fertility. Ph.D. thesis, Iowa State Univ. (see page 108)  
\*Leigh & Johnson Eds. (2002) Long Term Experiments in Agricultural and Ecological Studies. CAB Press  
\*C.P. West, A.C. Johnson. The contribution of agricultural inputs to CO<sub>2</sub> emissions in the United States. Agri. Res. Environ. Sci. (2002) 19: 25-34  
\*Cerco, C.A. Carbon dioxide flux from the Mississippi River to the Gulf of Mexico. Science 298 (2002) 1513-1516

## GUIDE FOR INDEXING COMPOST MATURITY



TECH MEMO 0327-6

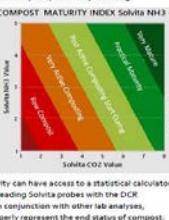
### SOLVITA CO<sub>2</sub> AND NH<sub>3</sub>-CO<sub>2</sub>-VARIATES TO DETERMINE MATURITY

Carbon dioxide (CO<sub>2</sub>) and ammonia (NH<sub>3</sub>) emissions from active composts jointly provide critical clues for the status of the composting process as it moves out of "active" into what is commonly called "curing" or "maturing" stages. Measuring CO<sub>2</sub> and NH<sub>3</sub> rates together yields information which single tests like C:N, heating and O<sub>2</sub>-demand cannot do, since composting is both a carbon and nitrogen stabilization process. CO<sub>2</sub> release represents the raw energy of organic matter decomposition without which compost would not stabilize. Ammonia escape represents the initial imbalance of decaying protein and urea as it passes into intermediary amino-N forms, generating high pH's and free NH<sub>3</sub> easily detected by the nose. While these factors are normal in early stages of composting, they should eventually subside before reaching true "maturity". At this point CO<sub>2</sub> release should approach "basal" background levels and ammonia should have been largely sequestered by microbes and converted by "nitrification" to non-volatile, plant-available nitrate (NO<sub>3</sub>).

Solvita provides a unique and reliable approach to gauge maturity by simultaneously indicating the CO<sub>2</sub> rate and the presence of ammonia. It is determined by a Solvita "HI-CO<sub>2</sub>" probe, calibrated for a very wide range of 0-20% CO<sub>2</sub> since compost can deplete all oxygen in the compost (normal content is 10 to 15 %). Additionally, the HI-CO<sub>2</sub> probe is calibrated also for a wide range of ammonia which in compost can climb to 20,000 ppm or more in early stages. As a note, Solvita color numbers relate to concentration of CO<sub>2</sub> and NH<sub>3</sub> on an exponential scale, early color step doubling.

The Maturity Index is calculated by reading both probes and determining the interrelation of the two indicators (see figure). This indexing serves two purposes. It factors the interference of high NH<sub>3</sub> in CO<sub>2</sub> determination and the advancement to true maturity\*. Since compost never fully subsides in release of CO<sub>2</sub>, the concept of "fractional maturity" is applied whereby a status of satisfactory maturity is recognized when compost is unlikely be phytotoxic to plants †. This is a maturity = 6.

Statistical analysis of the interaction of CO<sub>2</sub> and ammonia has revealed in a highly significant equation (r<sup>2</sup>=0.86) relating maturity level to the ratio of the two Solvita indicators, as shown (see figure). Laboratories performing Solvita compost maturity can have access to a statistical decision which determines the precise location on the grid after reading Solvita probes with the DCX photometer. Solvita tests should always be performed in conjunction with other lab analyses, particularly moisture and bulk density as a means to properly represent the end status of compost.



\*Chang et al. (2002) Assessment of the Reliability of a Commercial Maturity Test Kit for Composted Manures. Compost Science & Utilization, 10(4), Vol. 10, No. 4, 145-148  
†Wang et al. (2004) Maturity Index for Composted Dairy and Pig Manure. Soil Biology & Biochemistry 36 (2004) 269-279  
Britton B. & Doner J. (2006) How compost maturity affects certain green plants. BioCycle 19 a 61