Solvita® for Soil Respiration: Influence of Various Soil Factors

William F Brinton, Bob Burger
Woods End Soil Laboratories, Inc. - Mt. Vernon Maine

Solvita® : A means to measure soil microbial CO_2 respiration

- Introduced in 1996 with focus on fresh unprocessed soil (Brinton, 1996, Doran et al. 1997) (Photo A)
- Adapted for commercial labs using dried, processed soil that is remoistened to activate respiration (Haney & Brinton 2008).
- Method developed to obtain rapid wetting of pre-dried soil using capillary force based on perforated-bottom beakers (Haney & Haney 2010). (Photo B).
- Re-wetting dry soil (<5% H_2O) simulates “Birch effect” first observed by Birch (1958) also called “CO2-Burst”.

A.

B.

Inconsistencies in water behavior which can influence respiration

3 Trials initiated to evaluate grinding and sieving effect on soil respiration

- Structured soils (LEFT IMAGE) remoistened to field capacity
- Unstructured soils (RIGHT) tend to over-saturate
- CO_2 rate of over-saturated soils 2-3x less than structured soils
- Difficult to predict

Soil Processing

- Soil labs have machine-based soil processing procedures
- Handling designed primarily for chemistry (nutrients), and not for biology
- Soil proficiency programs grind, sieve *finer than 1mm to >80% less-than 0.5mm*
- Reports of inconsistent respiration NAPT/ALP soils

Microbial respiration for soil health must be a repeatable test

- Re-wetting mimics natural drying-wetting with CO_2-burst expected
- How soils are handled affects aggregate structure and may reduce structure
- Grinding may also expose surface area previously recalcitrant to respiration
- Excessive wetting linked to unstructured soils and known to affect soil biology via reduced oxygen availability

Dried, not-ground, 2 mm

75 ppm CO2-C

Dried, ground, <1 mm

22 ppm CO2-C

Premise: Uneven wetting is a likely cause of inconsistent inter-lab results and underestimation of actual respiration.

Observations:

- Unstructured soil results from natural and unnatural causes
- Grinding, pulverization, sieving can disrupt natural aggregates and cause potential artifacts
- Previously, flush of CO_2 shown to be significantly reduced as soil water content approaches saturation (Franzluebbers 1999)
- Fine milling of soils is considered advantageous for “better performance” in soil nutrient proficiency programs (Miller 2010)
- Soil health testing increasingly popular but interaction of commercial soil handling with soil biology results has not been researched

Studies Conducted

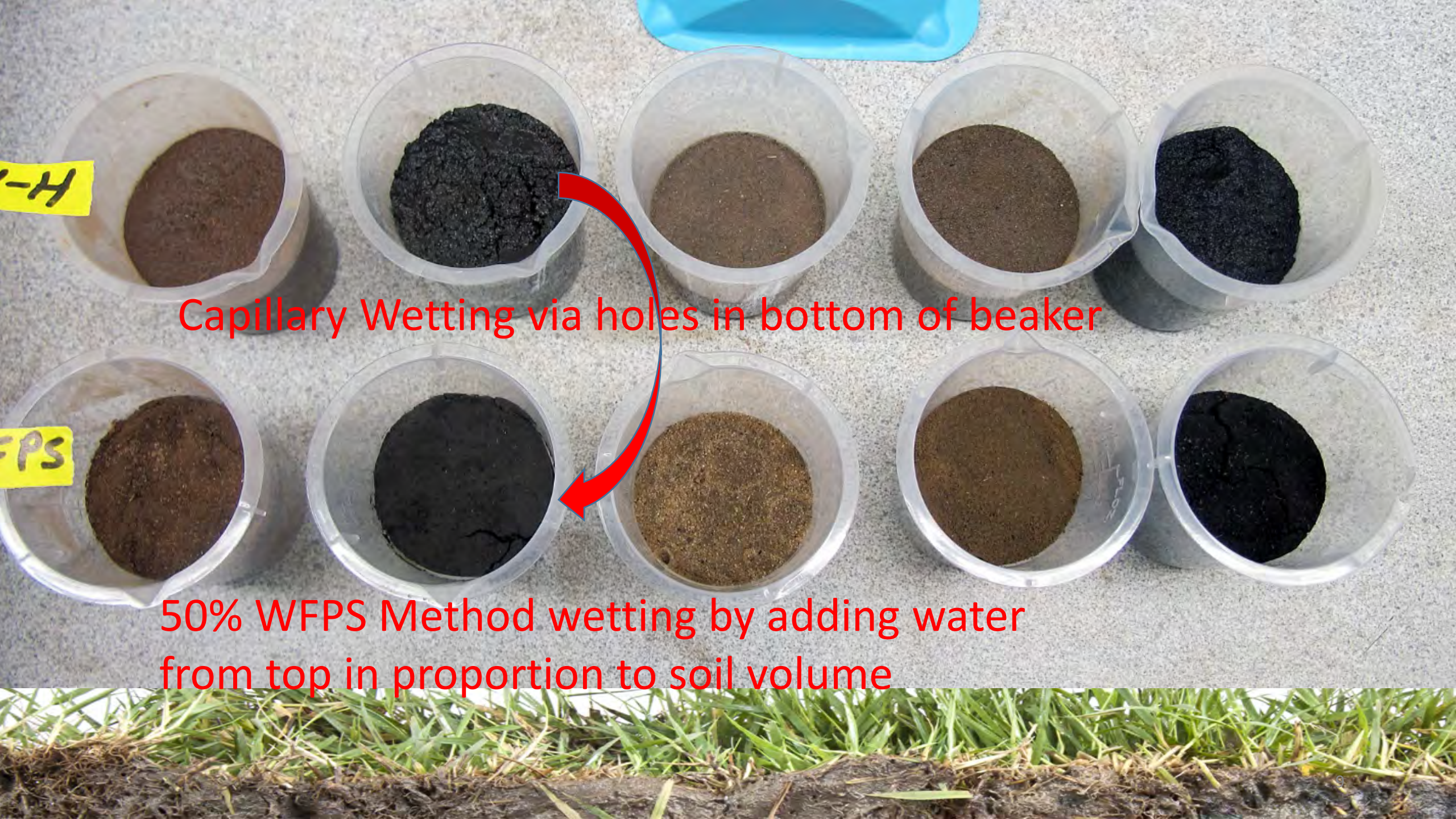
- Study 1 – proficiency soils examined for structure, particle size and CO_2 response
- Study 2 – Intensity of grinding evaluated for capillary re-wetting and respiration
- Study 3 – Field screened (3.5mm) soil tested for capillary and top-down wetting respiration

STUDY 1. Structure, Particle size and CO_2 response of ALP* Soil

- 5 ALP Soils compared. Grinding process resulted in extremely fine, unstructured soil. Only one soil did not over-moisten with capillary method. (n=3 reps ea)

	Soil Fractions		WHC	Capillary
Test Soil	>0.7mm	< .5mm	g · g-1	Saturation
1501 NB	1%	91%	0.46	95%
1502 KS	7%	35%	0.48	79%
1503 TX	0%	94%	0.21	100%
1504 ID	0%	98%	0.36	140%
1505 IA	8%	79%	0.9	47%

*ALP – Agricultural Lab Proficiency, by CTS Inc. Columbia MD


Capillary Wetting via holes in bottom of beaker
50% WFPS Method wetting by adding water from top in proportion to soil volume

Variability greater and respiration lower in capillary wetting samples

Wetting Method: Capillary Bottom Wetting

	SUMMARY COLORIMTERY			SUMMARY CO2- RATE		
ID	COLOR	±	CV%	PPM	±	CV
1501 NB	3.27	0.25	7.7%	36.3	7.49	20.6%
1502 KS	4.05	0.11	2.7%	70.9	6.64	9.4%
1503 TX	0.97	0.15	15.5%	4.7	0.63	13.2%
1504 ID	2.14	0.08	3.8%	13.2	0.93	7.0%
1505 IA	3.48	0.13	3.8%	43.1	4.86	11.3%
				33.7	< Means >	12.3%

50% WFPS Approach

	SUMMARY COLORIMTERY			SUMMARY CO2- RATE		
ID	COLOR	±	CV%	PPM	±	CV
1501 NB	4.50	0.03	0.6%	104.6	3.12	3.0%
1502 KS	4.34	0.03	0.7%	91.5	2.25	2.5%
1503 TX	1.66	0.28	17.2%	9.3	1.15	12.4%
1504 ID	3.10	0.20	6.3%	31.0	5.09	16.4%
1505 IA	3.98	0.08	1.9%	66.7	4.53	6.8%
				60.6	< Means >	8.2%

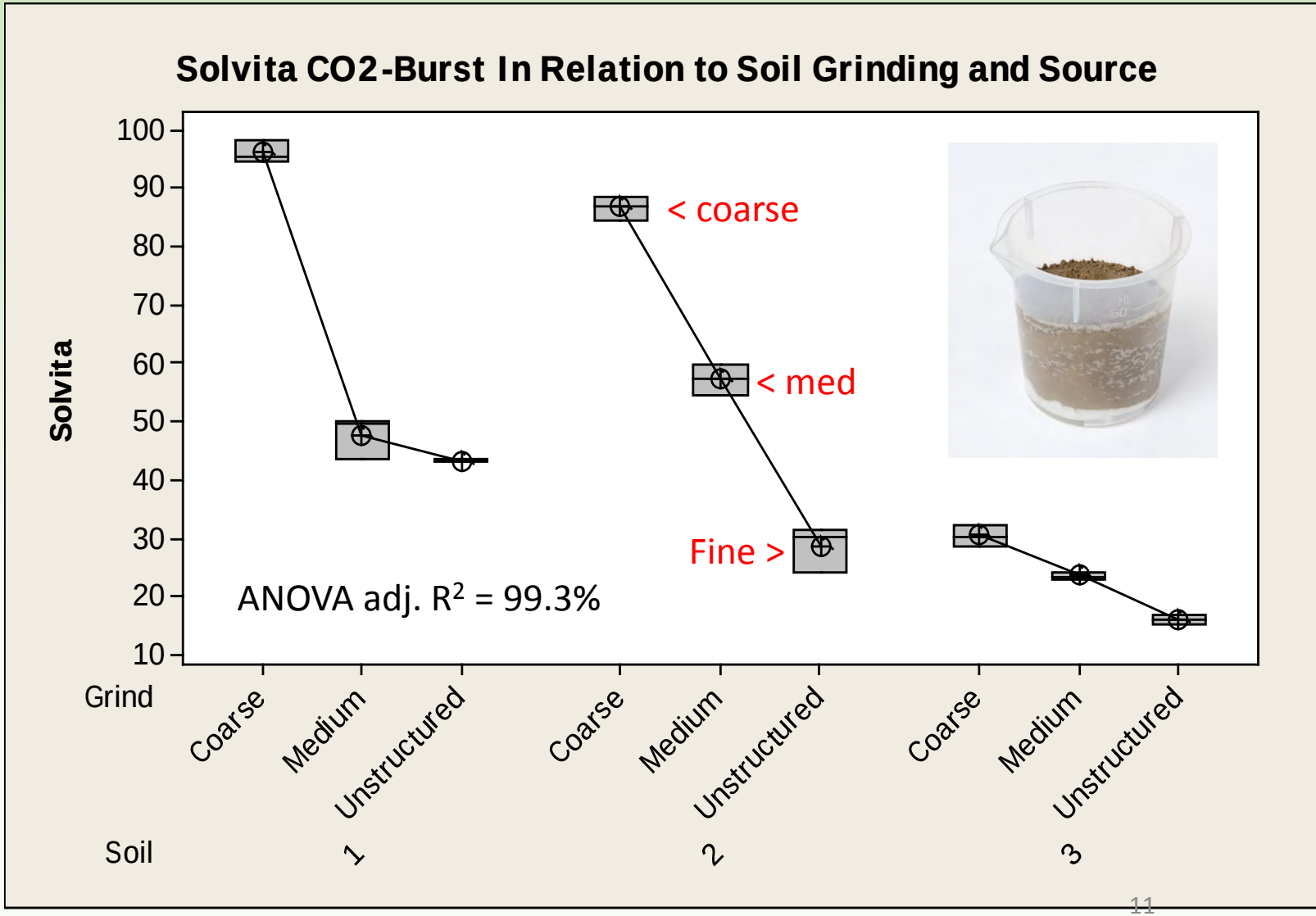
Study 2: Intensity of Grinding vs. capillary-wetting respiration response

- Soils divided into coarse, medium, & fine via minimal to maximal grinding, sieving

RESULTS:

CO_2 burst of structured, *coarse* soil 2x to 3x <u>higher</u> than in medium and highly ground unstructured soils.

DATA: Woods End/ USDA-ARS



Study 3 – Solvita Proficiency*: CV% for methods Capillary vs. 50%-WFPS wetting (3.5mm soil)

Wetting Method:	**Grand MEAN**	Lab1 (n=6)	Lab2 (n=4)	Lab3 (n=4)	Lab4 (n=4)	Lab5 (n=4)
Capillary	45.7%	6.4%	61.9%	22.8%	72.1%	64.9%
50% WFPS	13.9%	1.9%	16.1%	11.4%	15.7%	24.1%
	ttest p =	0.228	0.001	0.000	0.004	0.051

Lab1 = Solvita (n-6); All other labs (NAPT or ALP labs) n=3 each

Sieved, unground soil sent blind to 5 labs for analysis by two methods of wetting, with n=4 or 6. Coefficient of variability (CV%) calculated from reported respiration results.

Study 3b – CV% for CO_2 Data: Ground vs. Unground for capillary v. 50%-WFPS wetting

Wetting Method	Not-Ground		Ground*	ttest p =
Capillary	**6.4%**	⟷	**50.5%**	0.097
50% WFPS	**1.9%**	⟷	**3.3%**	0.000
ttest p =	0.228		0.023	n =6

* Soil Hammermill, 2mm

Conclusion: Variability declines using 50% WFPS ,method as compared to capillary wetting for both soil handling methods but non-ground samples performed acceptably regardless of wetting

Protocol for 50%-WFPS wetting

	(1)	(2)	(3)	(4)	(5)
	40g Soil Settled Vol	Water, ml for 50% WFPS	calculated BD g/cc	solids PD x 40g	Avail. Pore Space
	20	**2**	2.0	15.2	4.8
	25	**5**	1.6	15.2	9.8
*	**30**	**7**	1.3	15.2	14.8
*	**35**	**10**	1.1	15.2	19.8
*	**40**	**12**	1.0	15.2	24.8
	45	**15**	0.9	15.2	29.8
	50	**17**	0.8	15.2	34.8

* most common range for ag soils

Conclusions

- Solvita CO_2 test repeatability influenced by soil handling and wetting method.
- Unstructured soils tend to over-saturate with increased variability (=lower respiration).
- Solvita 50% WFPS method appears to correct for respiration slump due to unstructured soils
- Coarser soil preparation (2mm) may allow continued use of capillary wetting method as a repeatable method.

Thank You!

Woods End Laboratories Inc.

290 Belgrade Rd.

Mt. Vernon, ME 04352

207-293-2457

will.brinton@woodsend.com