Nutrient Management Newsletter for the Western U.S.

# Nutrient Digest

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## ARE "HANEY TESTS" MEANINGFUL INDICATORS OF SOIL HEALTH AND ESTIMATORS OF NITROGEN FERTILIZER CREDITS?

***By Dan M. Sullivan, Oregon State University; and David Granatstein, Washington State University-Wenatchee***

"Active" soil organic matter and the mineralization of plant-available nitrogen from soil organic matter are important apects of soil health. Nitrogen mineralization from soil organic matter under typical management is already factored into existing fertilizer guides published by western U.S. land-grant universities.

Because of the current spike in interest in soil health, a special session was organized at the Western Nutrient Management Conference on March 5, 2015. The conference was attended by over 120 participants from Hawaii to Colorado. This Conference, organized by Western Region land-grant university faculty and fertilizer industry partners, strives to extend research findings on soil fertility and nutrient management to practitioners, including Certified Crop Advisors.

Dr. Rick Haney, USDA-ARS was the invited keynote speaker. Dr. Doug Smith spoke in Dr. Haney's place and presented data on the Haney methods. Also in this session, Dr. Bob Miller (Agricultural Laboratory Proficiency Program) and researchers from UC Davis (Jordon Wade, Martin Burger, & Will Horwath) presented data on soil N and C testing.

The proposed Haney tests provide an alternative method to estimate N credits from

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## BIOCHAR AND MANURE EFFECTS ON NITROGEN NUTRITION IN SILAGE CORN

***By Rick Lentz and Jim Ippolito, USDA-ARS Northwest Irrigation and Soils Laboratory, Kimberly, ID; and Kurt Spokas, USDA-ARS Soils and Water Management Unit, St. Paul, MN***

Biochar, a carbon-rich charcoal derived from the pyrolysis of photosynthetically fixed carbon (C) biomass, is of interest because biochar-C is extracted from the atmosphere, can increase productivity in tropical soils, and persists in soils for >100-1000 years. Biochar could help mitigate climate change if it were applied to soils at a wide scale. However, its effects on irrigated, calcareous soils, like those in the U.S. Intermountain West are poorly understood. We evaluated the influence of one-time fall application of hardwood biochar, dairy manure, or their combination on N uptake and yield in silage corn, net N mineralization, and greenhouse gas emissions in the following three years of sprinkler-irrigated silage corn. Organic treatments were applied only once, in fall 2008, and included a (1) control (no organic amendment); (2) manure (18.7 ton $ac^{-1}$ dry wt.); (3) biochar (10 ton $ac^{-1}$ dry wt); and (4) manure + biochar (at single treatment rates). Annual preplant soil tests determined inorganic N fertilizer rates. In manure plots, these rates were adjusted to account for the additional N mineralized from manure,

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Head Editor – Amber Moore, University of Idaho; Guest Editor – Dan Sullivan, Oregon State University

management practices like organic amendment application and cover cropping that enhance soil nitrogen cycling. But the accuracy of the Haney N credits in western cropping systems has received little or no evaluation.

Two of the primary outcomes of the "Haney tests" are a "Soil Health Score" (1 to 50; higher is better), and an estimate of N fertilizer savings provided via enhanced soil health. A few commercial laboratories already offer the Haney tests, and the Natural Resources Conservation Service (NRCS) is offering incentives for this method of soil health testing through a Conservation Security Program (CSP) "enhancement" (SQL-15) in some states. Haney also developed an alternative extractant (H3A) for P and other nutrients, but we focus only on N and C tests here.

Dr. Smith's presentation explained that Haney testing methods and interpretations are based on the observation that the drying and rewetting of soil triggers a burst of respiration. This microbial burst is quantified by measuring carbon dioxide ($CO_2$) evolved during the first day after rewetting a dried, ground soil sample. Carbon dioxide evolution, together with other laboratory C and N measurements are used in an equation to predict the Soil Health Score and estimate N fertilizer credits. Haney tests for determination of a Soil Health Score include: 1) Solvita test (microbial respiration/activity as determined by $CO_2$ evolution), 2) Water soluble organic C (microbial food), and 3) Water soluble organic N. Smith presented data showing that across a wide range of soils, the soil respiration test values were linearly correlated to the overall Soil Health Score. Over 95% of the variation in Soil Health scores among soil samples were attributed to respiration test results. Therefore, the Haney Soil Health Score was roughly equivalent to a respiration test score.

Dr. Robert O. Miller, leader of a national program to evaluate soil test laboratory performance (Agricultural Laboratory Proficiency Program), presented data collected from participating commercial laboratories on the precision and accuracy of several of the Haney tests. Miller reported that participating laboratories had difficulty with getting reproducible test results using a common set of soil samples. Based on ALP performance data, Miller concluded:

1. Haney soil health methodology requires standardization. Specifically: carbon dioxide evolution method(s) require optimization for moisture content, temperature and labware to resolve performance issues.
2. Haney methods require cross-lab validation to resolve intra-laboratory issues, and lab performance testing to assure quality soil analysis data.

Miller also pointed out that standardizing the lab methods is only the first step. He concluded that "extensive field calibration research is required for confirming interpretative (Haney) models, using both field experiments and observational data analysis".

UC-Davis researchers (Jordon Wade, Martin Burger, & Will Horwath) reported on their research evaluating $CO_2$ evolution and N mineralization from dried, ground soil samples in the laboratory. They collected samples from diverse California soils and cropping systems. They found that soil respiration test results were strongly affected by soil moisture content at the time of testing. Relatively low soil respiration values were obtained with the Haney protocol (soil wet by capillary action). The optimum soil moisture content for maximizing respiration rate was not the same across the soils tested. Overall, their research showed that soil respiration measurements were not a strong predictor of measured N mineralization in California soils. Respiration tests predicted less than 15% of the measured variability in N mineralization across soils.

Based on presentations given at the Western Nutrient Management Conference (March 2015), we conclude that:

1. Lab procedures used in con ducting the battery of tests that go into the Soil Health Score are still undergoing standardization. Soil Health Scores currently have high random variability (associated with test methodology). Therefore, it is unrealistic to regard the current Soil Health Score as a reliable indicator of real change in measured parameters in a field over time.
2. Estimated nitrogen fertilizer savings reported with the Haney soil test data by some laboratories are not considered reliable. These projected fertilizer savings are strongly related to the highly variable soil respiration rate measured in the laboratory. The "N fertilizer savings" estimates provided with Haney test data have not been extensively validated in field trials in the Western Region.

For more information on this topic, contact Dan Sullivan at: dsullivan@oregonstate.edu which was derived using a manure mineralization series estimate (determined from a previous on-farm study). We measured net N-mineralization using buried soil bags (where the net value represents the gross mineralized-N minus gross immobilized-N).

**Corn Silage Yields and N Uptake**

Overall, corn silage yields averaged 8.6 tons ac$^{-1}$ (dry wt.) across the three years. The influence of biochar and manure on silage yield changed with time after application. Biochar increased corn yields slightly (5%) in 2009, decreased yields by 14% in 2010, and had no effect in 2011. Conversely, manure had no effect on yields in 2009, but increased yields substantially in 2010 (33%) and again slightly in 2011 (7%). In 2010, the effect of biochar and manure on silage N uptake followed the same pattern as that for yield, suggesting that treatment yield effects resulted from changes in N availability. Also intriguing was the fact that biochar's influence dramatically changed when combined with manure. Biochar decreased net N mineralization when added alone but increased net N mineralization when added with manure (Fig. 1). Similarly, in 2010 and 2011, biochar reduced silage N uptake without manure, but increased N uptake when combined with manure (Fig. 2).

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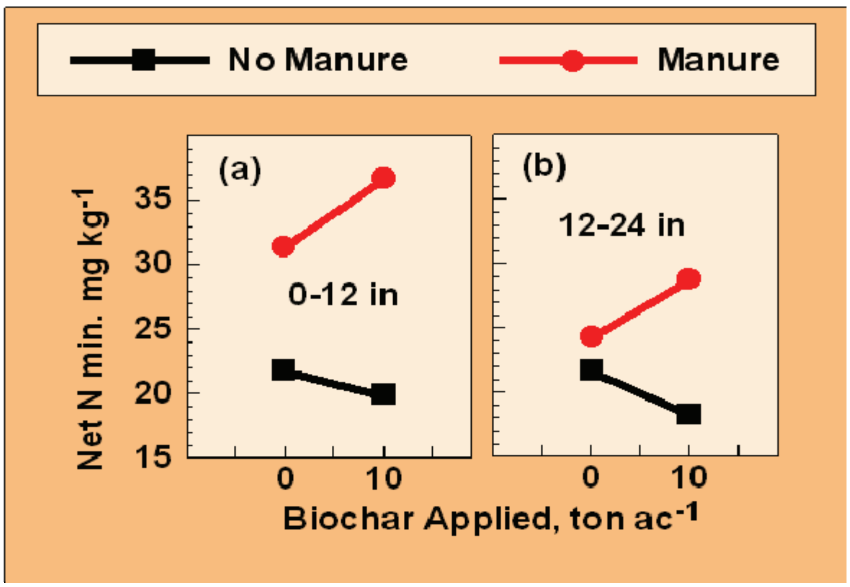


**Figure 1.** Biochar decreased mean season-long, net-N-mineralization at both 0-to-12 (a) and 12-to-24 in (b) depths when added alone, but increased net N mineralization when added with manure, in three years after a one-time, fall 2008 manure/ biochar application.

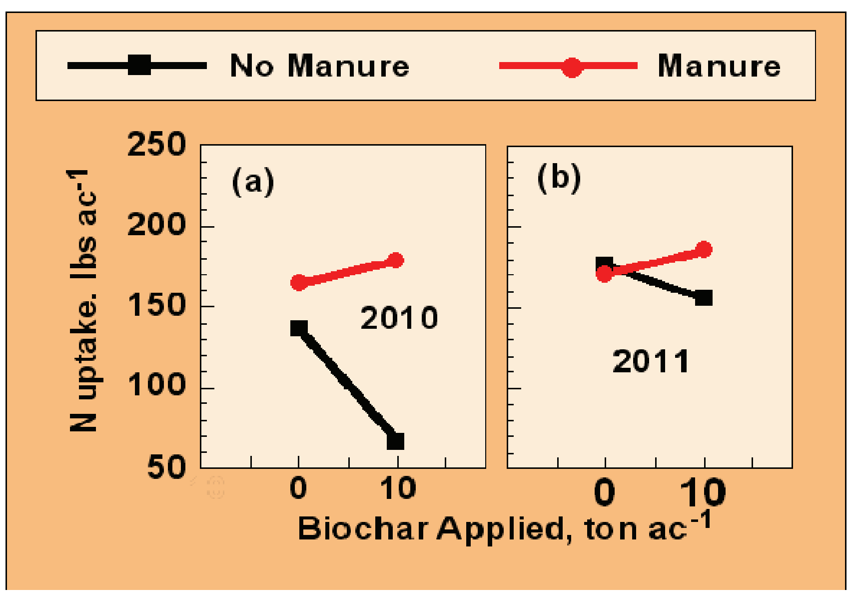


**Figure 2.** Biochar decreased corn N-uptake when added alone, but increased N-uptake when added with manure in 2010 (a) and 2011(b), the 2nd and 3rd growing seasons after a one-time, fall 2008 manure/ biochar application.

**Why did biochar reduce silage yields only in 2010?**

Results suggest that biochar's physiochemical characteristics may have changed with time and contributed to reduced 2010 yields by decreasing N availability. It is known that soil aging increases the number of negative charged sites on biochar, which increases its capacity to bind and act as a sink for $NH_4$-N. Furthermore, the 2010 season was unique because 1) crop residue was from corn (relatively low C:N ratio) and not a previous barley crop (relatively high C:N ratio) as in 2009, and 2) soil temperatures in 2010 were substantially less than those of other years (Fig. 3a). These two factors combined to inhibit nitrification in soils, which caused an increase soil $NH_4$-N concentrations relative to $NO_3$-N in late summer 2010 compared to earlier times (Fig. 3b and 3c). We hypothesize that this predominance of $NH_4$-N in soil, combined with biochar's increased capacity to sequester $NH_4$-N in 2010, led to a shortage of available inorganic N for crop uptake.

While the biochar-only treatment demonstrated a potential to minimize $CO_2$-C and $N_2O$-N gas emissions in these calcareous soils, biochar also caused decreased corn yields under certain soil nutrient conditions. If farmers wish to apply biochar to these soils, combining it with manure appears to be an effective method of utilizing these soil amendments as it eliminated potential yield reductions from biochar and maximized net N mineralization potential of the added manure.

**REFERENCES**

Lentz, R.D, J.A. Ippolito, and K.A. Spokas. 2014. Biochar and manure effects on net nitrogen mineralization and greenhouse gas emissions of a calcareous soil. Soil Sci. Soc. Am. J. 78:1641-1655.

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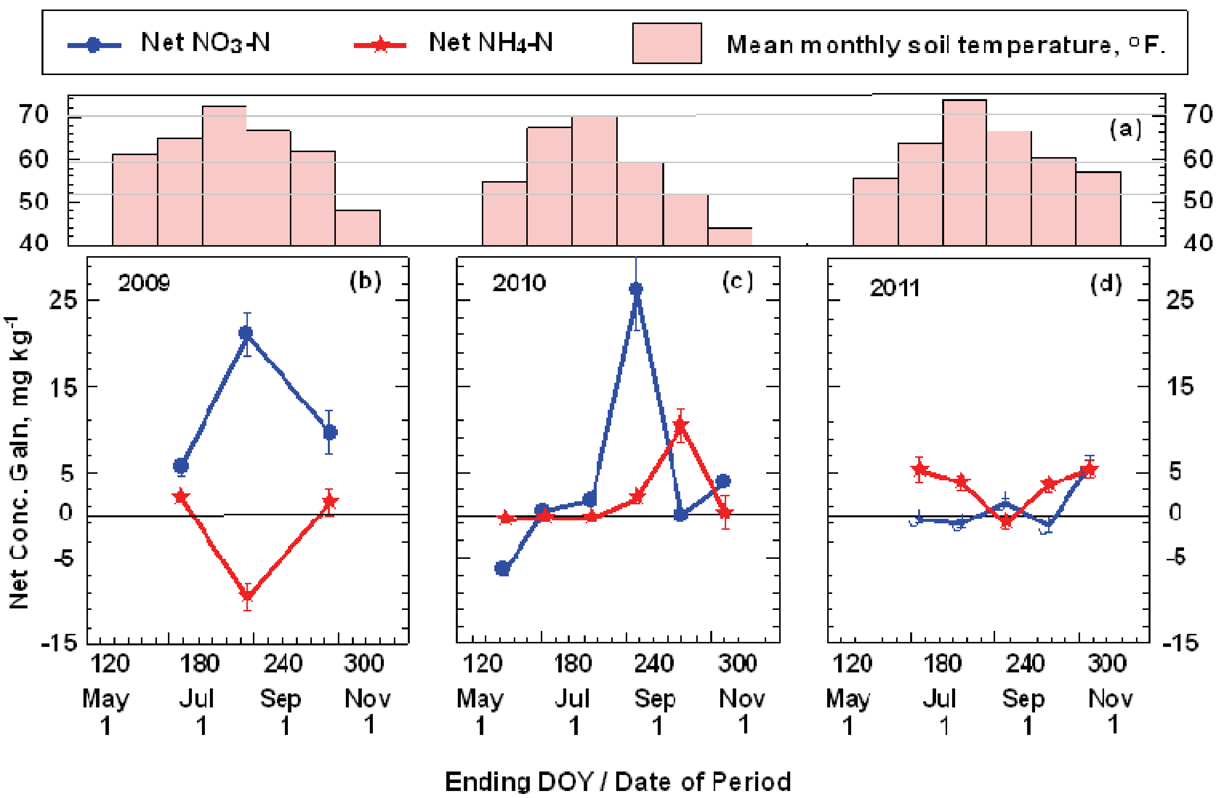


**Figure 3**. Shown are the overall average gains in soil $NO_3$-N and $NH_4$-N in 0-to-12-in buried bags for 2009 (b), 2010 (c), and 2011 (d), following a one-time manure/biochar application in fall 2008. Relatively cool mean monthly soil temperatures at 3-in depth in the late-2010 and early-2011 growing seasons (a) coincided with a rise in the dominance of soil $NH_4$-N (c, d).