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APPLICATION OF ANAEROBICALLY DIGESTED BIOSOLIDS EFFECTS SOIL PHOSPHORUS LEVELS



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EFFECTS SOIL PHOSPHORUS LEVELS

The Cities of Littleton and Englewood, Colorado
and the Colorado Agricultural Experiment
Station (project number
15-2924) funded this project.

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INTRODUCTION

Biosolids are an excellent source of nitrogen (N), phosphorus (P), and zinc (Zn) when applied at agronomic rates (Barbarick et al., 2017). One concern remains, the over-application of P resulting from addition of biosolids to satisfy plant N needs. Concerns about environmental contamination from the introduction of P into waterways may change biosolids land application limitations to be based on plant P needs. Another issue associated with P accumulation is the form of P found in soils. A method developed by Kuo (1996) allows the separation of total P into various forms that could be affected by biosolids application rates. Following determination of the concentration of P in various soil forms, statistical analysis is typically utilized to detect differences between various biosolids application rates.

While selected statistical calculations do indicate statistical significance, a statistical technique known as meta-analyses can determine the direction and magnitude of an effect across locations, sampling dates, and biosolids application rates (Borenstein et al., 2009). Meta-analysis is commonly used in medical trials, plant and animal breeding programs, and environmental studies (Borenstein et al., 2009). This statistical approach allows us to answer simple questions regarding the effects of biosolids additions relative to an untreated control.

Our goal in this report is to illustrate the effects of plot location, dates of sampling (every 2 months over 1 year), and biosolids rates on the soluble P, inorganic P, organic P, and total soil P concentrations. The effect of biosolids and the positive or negative magnitude of the effects on these various P forms will be determined by meta-analysis.

MATERIALS AND METHODS

We established two study sites (labelled as East and West) on Weld loam soils (fine, smectitic, mesic, Aridic Agriustoll) (NRCS, 2016) near Bennett, CO (39.9563° N, 104.462° W) in 1992 and 1993. Littleton/Englewood (L/E), CO biosolids were dried for 60 days and then were surface applied biennially at rates of 0, 1, 2, 3, 4, and 5 dry tons/acre in late July or early August before September winter-wheat (*Triticum aestivum* L.) planting.

The biosolids applications were part of a biosolids-N fertilizer comparison study where the other half of the treatments consisted of biennial N-fertilizer rates of 0, 20, 40, 60, 80, and 100 pounds/acre. We used four replications of each treatment (24 biosolids, 24 N-fertilizer plots) as a randomized complete block design at both sites. This study focuses on the biosolids-treated plots.

Soil samples were collected from the top 2 inches of the biosolids treatment using a Giddings soil probe and zero contamination sampling tubes in July, September, and November 2013 and in January, March, May, and July 2014. The extraction procedures of Kuo (1996) were used to determine the soluble, organic, inorganic, and total P concentrations in each sample.

Response ratios (biosolids versus the control) and confidence intervals for the various forms of P are illustrated in “forest plots”. If the 95% confidence interval spans above and below a response ratio of 1.0, then the response ratio is not significant. All response ratios represent the biosolids effect (numerator) compared to the control (0 tons biosolids/acre; the denominator).

RESULTS AND DISCUSSION

Biosolids increased the soluble P (the most plant-available form) over all sampling dates and biosolids rates at the East site but had no effect at the West site (Figure 1) compared to the control. The January and March 2014 samplings and the 3 and 4 tons/acre biosolids rates showed that biosolids increased soluble P (Figure 1).

In contrast to soluble P, biosolids increased the organic P at the West site and had no effect at the East site (Figure 2) compared to the control. The November 2013, and January, May, and July 2014 samplings and all biosolids rates except for 1 ton/acre showed that biosolids increased organic P (Figure 2).

Biosolids addition increased inorganic P concentrations at both sites (Figure 3) compared to the control. The January and March 2014 samplings showed that all biosolids rates increased inorganic P (Figure 3).

The total P content was significantly influenced by biosolids application (Figure 4). Compared to the control, both sites, at the November 2013 and January, March, and May 2014 samplings and all biosolids rates affected the total P (Figure 4).

The differences found between the two locations were most influenced by whether a crop has been planted in the plots or if the plots were in fallow. During the sampling

period, the west plots had an active wheat crop while the east plots were in fallow. During the fallow phase of the rotation, the soluble P concentration increased, since an active crop was not present to absorb the soluble P.

The soil P changes with date of sampling should be influenced by microorganism and plant activity which are most affected by soil temperature and moisture. We did not, however, notice definitive patterns with regard to sampling date effect.

All biosolids rates increased all P forms. This was expected since the biosolids are a significant source of P, and contain both organic and inorganic P forms.

After 20 years of biosolids applications to 2 locations, we found that biosolids increased soluble, organic, inorganic and total P over 7 sampling dates (1-year period) and 5 biosolids rates. This was also evident the recommended agronomic rate of biosolids application (2-3 dry tons per acre; Barbarick and Ippolito, 2000). These changes indicate that close monitoring of soil P will be needed to prevent excessive soil accumulation, especially if biosolids regulations require application at the agronomic rate for P rather than N.

REFERENCES

- Barbarick, K.A., and J.A. Ippolito. 2000. Nitrogen equivalency of sewage biosolids applied to dryland winter wheat. *J. Environ. Qual.* 29:1345-1351. 1696–1702.
- Barbarick, K.A., J.A. Ippolito, and J.M. McDaniel. 2017. Meta-analyses of biosolids effect in dryland wheat agroecosystems. *J. Environ. Qual.* 46:452-460.
- Borenstein, M., L.V. Hedges, J.P.T. Higgins, and H.R. Rothstein. 2009. Introduction to meta-analysis. John Wiley & Sons, Chichester, UK. doi:10.1002/9780470743386
- Kuo, S. 1996. Phosphorus. *Methods of Soil Analysis Part 3—Chemical Methods sssabookseries:* 869-919. doi:10.2136/sssabookser5.3.c32.
- USDA-NRCS.2016. Web soil survey. USDA-NRCS.
<http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>(accessed 4 Dec. 2016).

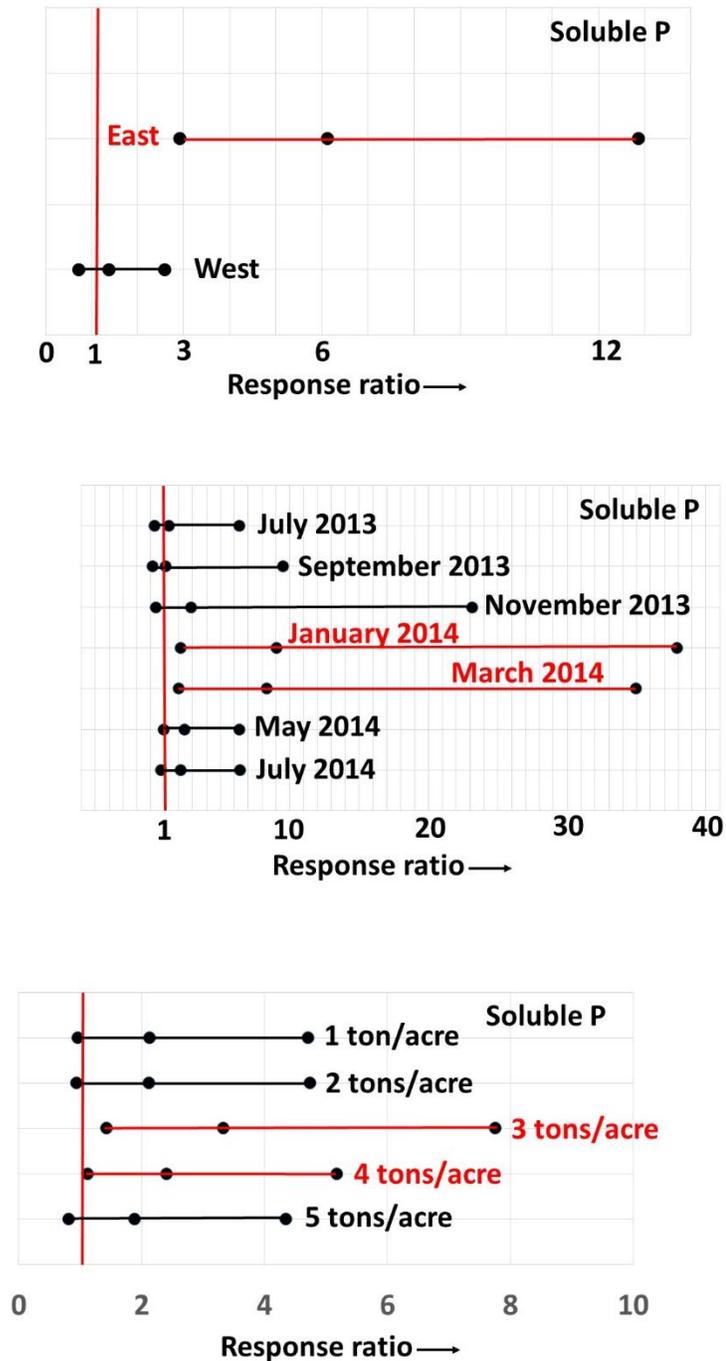


Figure 1. Response ratios (middle dot) and 95% confidence intervals (end dots) comparing L/E biosolids application to the control for soluble P at two locations, over 7 sampling dates, and 5 biosolids rates. **Red horizontal lines indicate statistically significant differences.**

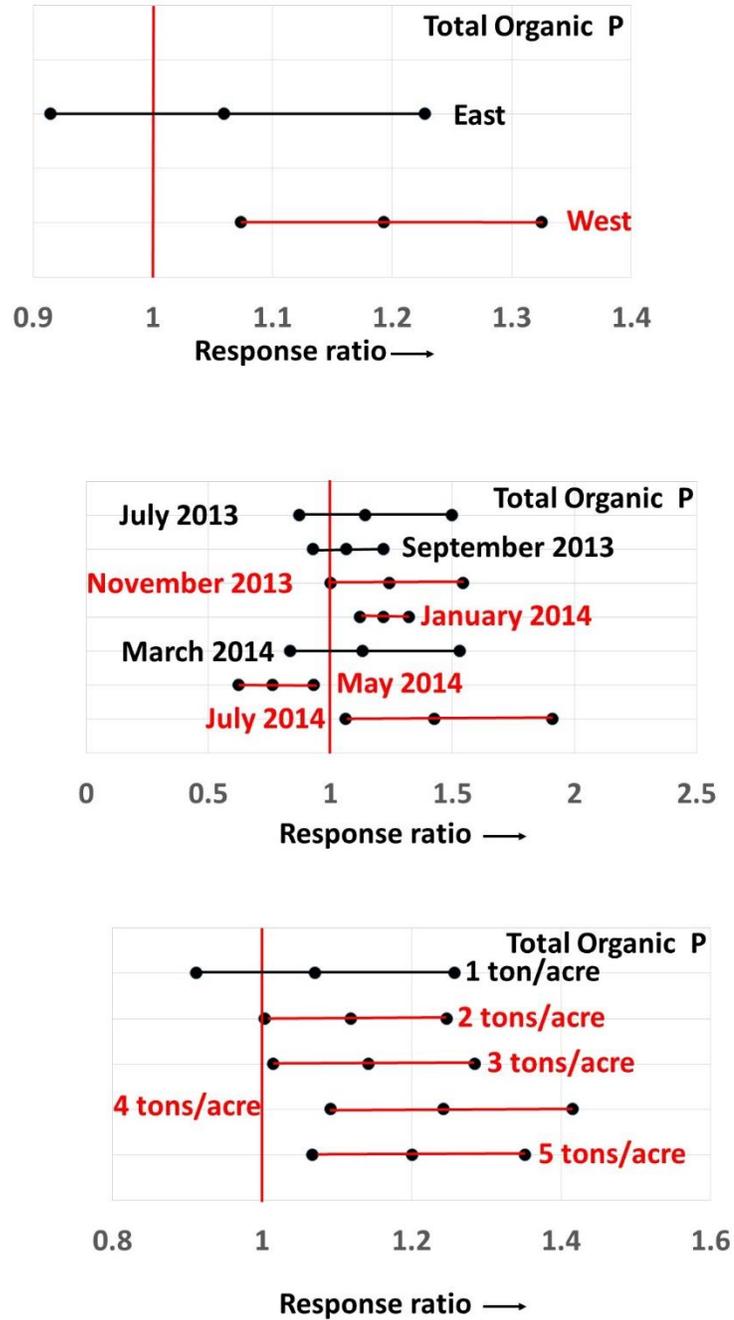


Figure 2. Response ratios (middle dot) and 95% confidence intervals (end dots) comparing L/E biosolids application to the control for total organic P at two locations, over 7 sampling dates, and 5 biosolids rates. **Red horizontal lines indicate statistically significant differences.**

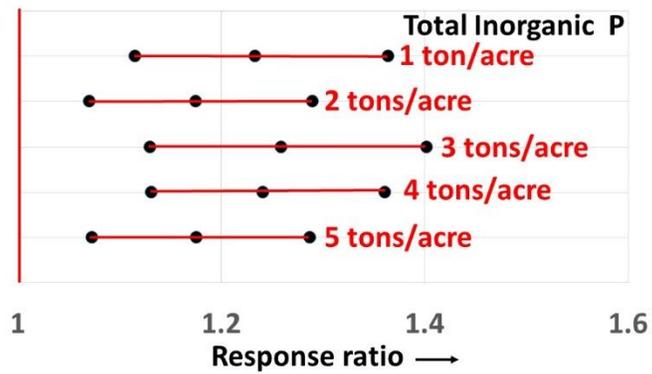
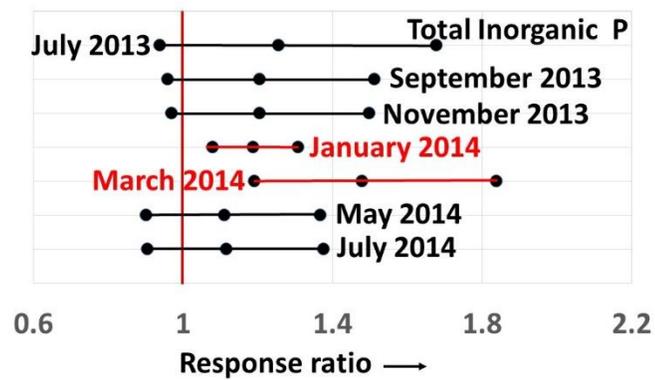
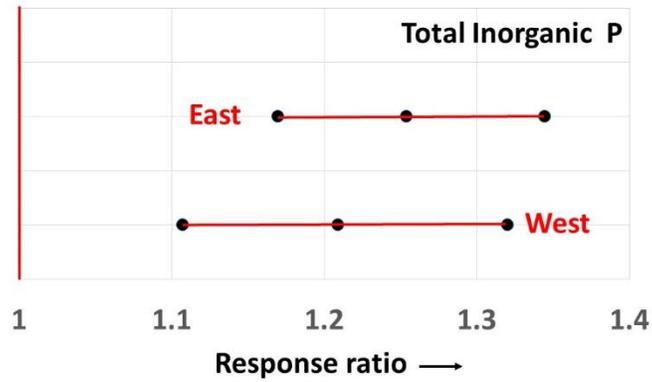


Figure 3. Response ratios (middle dot) and 95% confidence intervals (end dots) comparing L/E biosolids application to the control for total inorganic P at two locations, over 7 sampling dates, and 5 biosolids rates. **Red horizontal lines indicate statistically significant differences.**

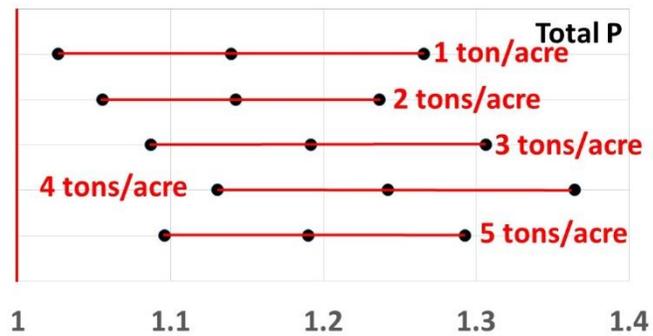
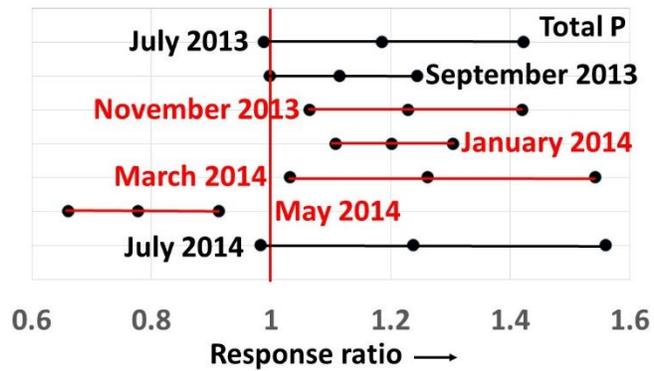
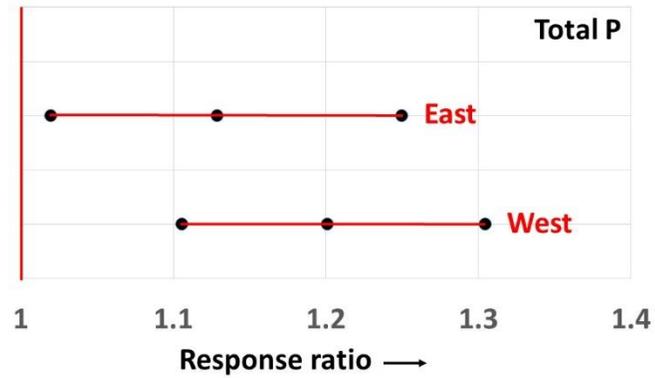


Figure 4. Response ratios (middle dot) and 95% confidence intervals (end dots) comparing L/E biosolids application to the control for total P at two locations, over 7 sampling dates, and 5 biosolids rates. **Red horizontal lines indicate statistically significant differences.**