RECOMMENDING SOIL COPPER THRESHOLDS FOR POTATO PRODUCTION IN IDAHO

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Where does the copper come from? A rising concern with the application of dairy wastes to agricultural fields is the accumulation of copper (Cu) in the soil. Copper sulfate (CuSO4) from cattle footbaths is washed out of dairy barns and into wastewater lagoons. The Cu-enriched dairy waste is then applied to agricultural crops. Repeated applications of lagoon water could potentially raise Cu concentrations to toxic levels for agricultural crops. Potato growers are concerned that fields currently suitable for potato production may no longer be productive after excessive lagoon water applications with high concentrations of copper have been applied. The objective of this project was to evaluate potato growth and copper plant uptake for potatoes grown under low, moderate, and excessively high soil copper concentrations.

How much is too much soil copper? This study was conducted in a greenhouse setting at the USDA ARS Kimberly Research Station. To establish an effective copper response curve, 6 rates of copper sulfate (0, 50, 100, 250, 500, and 1000 mg Cu/ kg soil) were applied to either Portneuf silt loam or Quincy sand. Treatments were replicated four times in a complete randomized block design. After 130 days of growth, plants were harvested, separated into shoots, roots, and tubers, and were analyzed for copper concentration. Soils were also analyzed for soil test copper concentration using the commonly used DTPA extractant.

Potato Response Varied by Soil Texture. Potato plants grown on sandy soil textures absorbed copper more readily than silt loam textured soils, as indicated by increased concentrations of copper in plant roots and shoots (Figure1). This finding illustrates that silty textured soils likely bind more Cu than sandy soils, leaving more copper available for plant uptake on sandy soils. Comparing shoots to roots, we also found between 10 and 17 times greater Cu accumulation in roots than shoots for both soil types at varying soil copper levels (Figure 1). This finding validated what is currently known about copper movement in plants, with copper accumulating in roots rather than shoots.

As Cu concentration increased in roots and shoots, dry weight biomass decreased (Figure 2). This finding suggests reduced potato productivity and yield with increasing soil copper levels from 7 to 350 ppm. For the Portneuf silt loam, Cu concentrations greater than 90 ppm appeared to significantly *Continued on page 7*

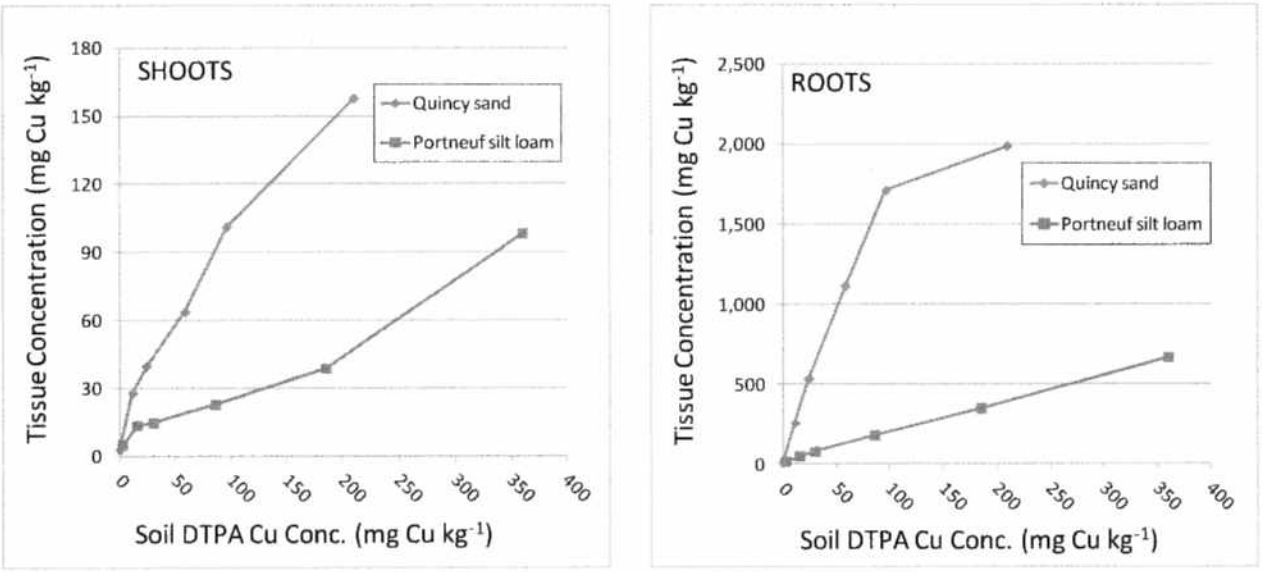

Figure1. Increasing copper concentrations in Russet Burbank potato shoots and roots with increasing soil DTPA copper concentrations, as influenced by soil texture.

decrease both root and shoot biomass. In the Quincy sand, soil Cu levels above 25 ppm decreased shoot biomass (Figure 2). (Rootballs were relatively small for all Quincy sand treatments, which limited the potential for restricted root growth related to high copper levels Figure 3). Based on our findings, we would recommend setting limits for potato production at 25 ppm for sandy soils and 90 ppm for silt loam soils.

Are tubers from high copper fields likely to cause human health concerns? Greenhouse conditions limited tuber formation on both the sand and silty soil textures, although small tubers did form in two pots containing 50 mg Cu/kg treatments, and one pot containing the 1,000 mg Cu/kg treatment. Tuber Cu concentrations among the three treatments ranged from 11 to 20 ppm, which equates to 0.1 to 0.3 mg Cu/100 g fresh tuber weight. National Academy of Sciences (2011) recommendation for tolerable upper intake levels of Cu for children ages 1-3 is 1 mg Cu/100 g fresh weight. At these levels, copper toxicity does not appear to be an issue toward humans ingesting potatoes grown on soils containing up to 300 ppm Cu, although further study is needed to confirm this conclusion.

Our Recommendation: In summary, growers are strongly urged to soil test agriculture land that has received lagoon water applications for DTPA soil test Cu to avoid crop losses related to Cu toxicities. We recommend threshold levels for potato production to be 25 ppm Cu for sandy soils and 90 ppm Cu for silt loams. At soil test Cu levels up to 375 ppm, tubers do not appear to pose any copper toxicity health risks to humans, although this needs to be verified.

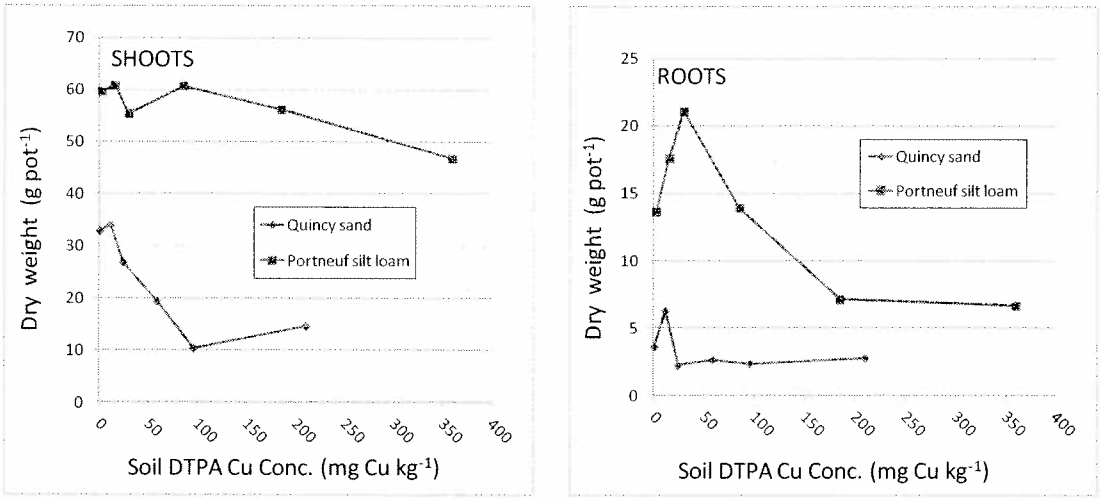

Figure 2. Changes in dry matter weight for Russet Burbank potato shoots and roots with increasing soil DTPA copper concentrations, as influenced by soil texture.

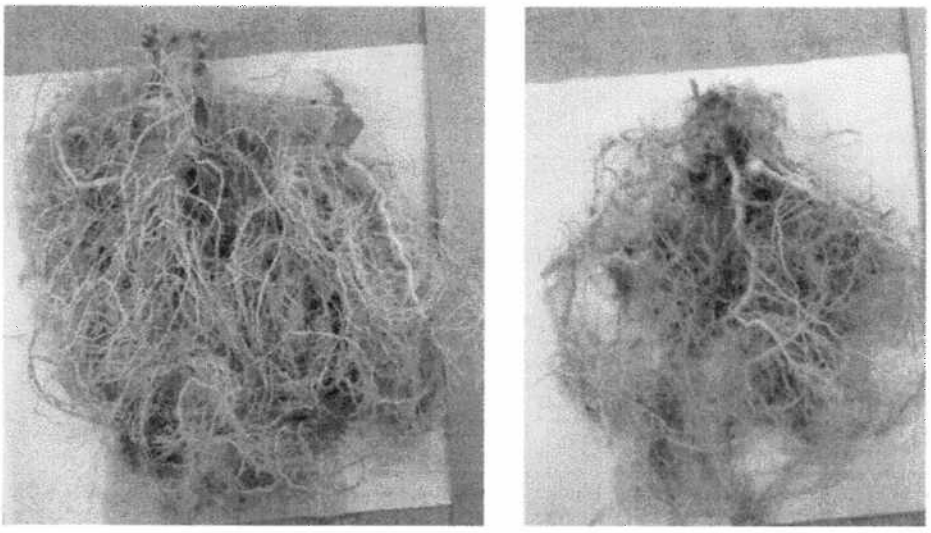

Figure 3. Root mass is smaller and darker for the 1000 mg Cu/kg treatment (right) compared to the 0 mg Cu/kg (left) (Photos from Portneuf silt loam soils).