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Nutrient Digest

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REDUCED TILLAGE IN A THREE YEAR POTATO ROTATION

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Working to Improve Conservation Tillage (CT) in Irrigated Vegetable Farming. In vegetable crops, the difficulty of controlling weeds and the need for custom-built equipment continues to slow the acceptance of reduced tillage practices. Reduced tillage can save production costs and soil resources. The objectives of our research were to develop a reduced tillage system in potato based rotations using existing field equipment with minor modifications. The study started in 2001 to evaluate reduced tillage practices in a three-year crop rotation of sweet corn/ sweet corn/ potato and continued through 2010 under sprinkler irrigation. Trials were located at the USDA-ARS research field site located near Paterson, WA. The primary pieces of equipment used in these studies include: Flail chopper, Sunflower™- chisel-chopper-packer, Supercoulter™, 13-shank bed splitter mark-out rig, six-row pick or Airecup potato planters, and a twelve-row reduced till corn planter. We evaluated pre-plant N application rates of 50 and 100 lbs N ac^{-1} with remaining N (total N at 300 lb N ac^{-1}) applied in-season by center pivot, beginning 3 weeks after emergence.

Reduced tillage in potato. Most soil disturbance resulted from the 13-shank bed splitter used in hill formation, the six-row planter, and the unavoidable disturbance from the potato digger. The

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MANAGEMENT PRACTICES TO INCREASE WHEAT GRAIN PROTEIN

By Clain Jones and Kathrin Olson-Rutz – Dept. of Land Resources and Environmental Sciences, Montana State University

Crop and fertilizer management practices can increase wheat grain protein without sacrificing yield. Growing wheat with high grain protein begins with selecting the appropriate variety and providing enough fertilizer to meet the wheat's requirements for growth and grain yield. If nutrient levels are sufficient to meet yield goals, then providing adequate available nitrogen (N) may be the most important management factor to produce high grain protein.

Timing N Application to Avoid Losses. Using cultural practices or adding other nutrients to increase yield without adding additional N can reduce, rather than increase, protein through a dilution effect. Applying the entire N required for high yield and grain protein before or at seeding is risky. In low rainfall years, excess N applied early will not get used and may end up in the air or well water rather than in the wheat. Residual soil nitrate can become fertilizer dollars lost to leaching if followed by a wet winter and spring. In irrigated production, applying the entire necessary N early in the season can produce excess vegetation rather than grain yield or protein.

Try the Nitrogen Economic Calculator. Base pre-plant N rates on realistic yield potential and residual soil nitrate. The Montana State University Small Grains Nitrogen

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Head Editor—Amber Moore, University of Idaho; Guest Editor—Robert Flynn, New Mexico State University

Management Practices to Increase Wheat Grain Protein, continued from pg 1

Economic Calculator (http://www.montana.edu/softwaredownloads/software/SWFertilizerEconomics.swf) helps calculate economically optimal N rates based on yield potential, soil nitrate-N, soil organic matter, wheat prices, protein discounts/premiums and N fertilizer cost. The calculator also shows the effect of N rate on expected grain protein content. In a high-yielding year, follow pre-plant applications with in-season N fertilization. A flag-leaf (uppermost leaf of the stem sampled at heading) N concentration less than about 4% indicates grain protein is likely to increase with late-season N.

The Best Time for Improved Protein. Protein may get the highest boost with N applied at flowering. However, the ability to incorporate fertilizer applied anytime between boot and shortly after flowering, with rainfall or irrigation, is more important than timing the application exactly at flowering. In dryland production, N applied late-season is money potentially lost if there is insufficient rainfall after application to move the fertilizer into the root zone. Relatively little foliar N is taken up directly by the leaf.

Reduce N Loss. Use application methods that maximize N use efficiency, especially by minimizing ammonia loss to the atmosphere. A Montana study found an average 20% loss of applied N from urea broadcast between October and April. Higher volatilization loss tended to produce wheat with lower protein (Figure 1). Mechanical incorporation or incorporation by at least a ½-inch single rainfall or irrigation event within 2 days of broadcast application can reduce urea volatilization. Volatilization can also be minimized by using Agrotain® (Figure 1) or a slow release fertilizer. Controlled and slow release fertilizers applied in fall should have the best chance of boosting winter wheat grain protein. However, their N release may be too delayed for winter wheat if top-dressed in late winter or early spring or for spring wheat in cool growing conditions. Mineralized N from manure, legume crop residue, or legume green manure can also provide N late in the season to boost protein. Legumes rather than fallow or continuous small grain in rotation may increase protein similar to about 25 lb N/ac from fertilizer.

Mid- to Late- Season N Decision. The decision to apply mid- to late-season N to increase protein should be based on the ability to apply N without severely damaging the crop, the potential protein response to late-season N, and whether protein discounts are sufficiently high to justify the cost. Supplying sufficient pre-plant N and top-dressing at flowering are the two most consistent strategies to boost grain protein. Minimizing N losses and growing wheat after annual legumes should both, in general, increase protein.

For more information see *Practices to Increase Wheat Grain Protein*, available online at http://landresources.montana.edu/soilfertility/publications.html. For printed copies contact Montana State University Extension Publications (www.msuextension.org/store). You can contact Clain at 406-994-6076, or at clainj@montana.edu with questions.

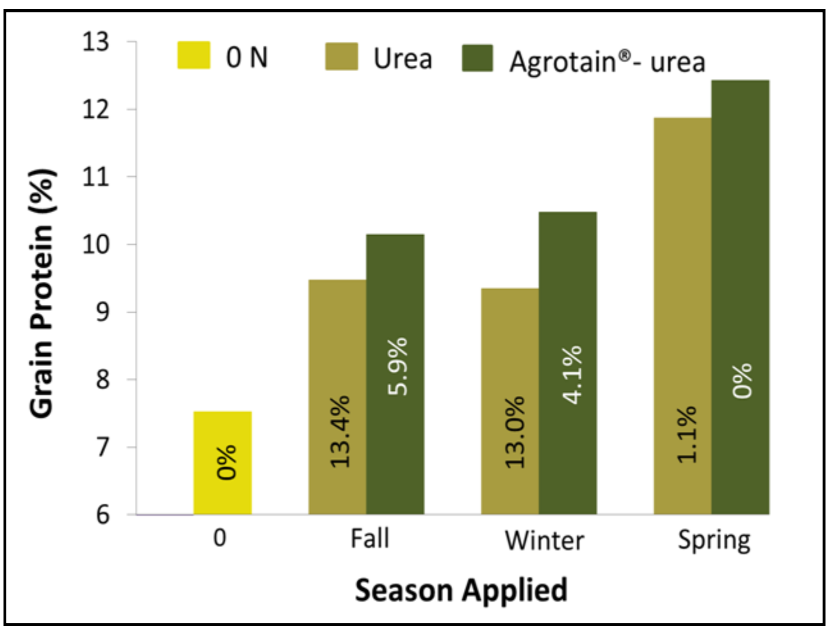

Figure 1. Application timing and N source effect on winter wheat grain protein and N volatilization loss. The numbers on the bars are percent of applied N lost to volatilization (90 lb N/acre broadcast urea; Rick Engel, Montana State University, unpubl. data).

Reduced Tillage in a Three Year Potato Rotation, continued from pg 1

potato tillage strategy reduced the total number of passes to three; mark out, planting and dammer diker which maximized residue retention (Figure 1). Sweet corn residues needed to be chopped so the bed splitter or the planter would not drag residues that would flatten the hills. For sweet corn, field operations under reduced tillage consisted of no disturbance except for the operation of direct seeding using a Orthman One-Tripper/JD MaxEmerge planter.

Figure 1. Hills formed under reduced tillage using 13-shank bed splitter.

Soil Characteristics: Compaction is a short-term downside to reduced tillage. Soil density showed a 25% increase from 1.20 g cm^{-3} in potatoes to 1.5 g cm^{-3} in the second year of sweet corn. This higher density was lowered in the subsequent potato crop because the reduced tillage potato treatments include the operation using a 13-shank bed splitter at hilling.

Weeds: When sweet corn follows potato in the rotation, volunteer potatoes are usually a problem since Washington's normally mild winter temperatures don't freeze all of the potato tubers left in the ground. If fluroxypyr is used to suppress volunteer potatoes, better control is achieved if the sweet corn is cultivated 7 to10 days after the herbicide application. If mesotrione herbicide is used to suppress volunteer potatoes, cultivation is not necessary, so this herbicide has performed better in reduced till sweet corn for volunteer potato control.

Yields: Potato yields averaged 34.8 and 33.9 t ac^{-1} for the conventional and reduced tillage plots, respectively (Table 1). An infestation of leafhoppers was attributed to the yield decline in potato in 2004. We observed a trend of 2-3 t ac^{-1} increase in the >8 ounce size classes for the reduced tilled potato plots. Sweet corn yields average 10.0 t ac^{-1} for the conventional and reduced tillage plots in the first year following potatoes. Second year sweet corn yields declined 20% under reduced tillage. There were no significant effects from fertilizer rate or timing.

The dramatic differences Continued on page 4

Table 1. Potato and sweet corn yields from conventional and reduced tillage treatments at the USDA-ARS Paterson, WA field site.

	Potato		Sweet Corn yr1		Sweet Corn yr2	
Year	CT	RT	CT	RT	CT	RT
			T/acre			
2001	33.5	32.1	†10.2	8.8	9.9	8.8
2002	32.6	32.5	7.5	7.4	7.5	6.7
2003	33.1	31.2	‡4.5	4.1	4.7	4.4
2004	27.8	27.0	9.9	10.4	9.3	9.4
2005	37.7	38.6	12.5	10.2	10.0	7.0
2006	36.3	36.1	9.5	10.4	11.0	9.2
2007	30.9	29.8	11.9	10.6	11.1	9.4
2008	40.9	39.7	13.3	12.6	12.7	9.0
2009	40.1	37.9	10.4	12.7	10.3	8.6
Average	**34.8**	**33.9**	**10.7**	**10.4**	**10.2**	**8.5**
STD	**4.3**	**4.4**	**1.9**	**1.8**	**1.5**	**1.1**

CT- conventional tillage, RT- reduced tillage, STD – Standard deviation. †Fresh weight sweet corn yield. ‡Dried field corn grain in 2003, excluded from eight year sweet corn average.

EARLY DETECTION OF NITROGEN IN CORN IS KEY TO PRACTICING 4R NUTRIENT STEWARDSHIP

By Dr. L. Longchamps and Dr. R. Khosla – Colorado State University

4R nutrient stewardship is applying the right source (fertilizer), at the right rate, in the right time, and at the right place. In order for farmers to practice "4R" nutrient stewardship, they must have a mechanism to detect differences in crop nutritional needs spatially and temporally. Since the majority of nutrient application to row crops occurs either prior to planting or soon thereafter as side-dress or top-dress, it is important that farmers be able to estimate the crop nutritional needs at an early stage of growth. This is easier said than done because most commercially available crop canopy sensor technologies do not provide reliable information before the eight-leaf (V8) growth stage. Farmers generally start side-dressing nitrogen around the four-leaf (V4) growth stage to be able to cover all their fields by or before the peak period of corn nitrogen uptake that begins in earnest at the six-leaf (V6) stage of growth.

A New Sensor Technology. A new crop canopy sensor called Multiplex®3 was recently released in the US market that uses induced fluorescence to estimate crop nutrient needs. This sensor measures an indicator of nitrogen status in the leaves called the nitrogen balance index (NBI). No previous studies have tested the suitability of Multiplex®3 or assessed its potential to detect nitrogen deficiency at early corn growth stages.

How the Technology was Evaluated. The Multiplex®3 fluorescence sensor's potential for future use in early growth stage detection of leaf nitrogen status was evaluated at the Plant Growth Facility (greenhouse) of Colorado State University. The accuracy of the sensor to discern differences in leaf nitrogen content was evaluated using corn plants at early growth stages that had received an equivalent of no nitrogen, 70, 130, or 200 lbs N/acre. Corn was grown in 2 gallon pots with 20 pots used per treatment. All other essential plant nutrients were applied based on soil sample analysis. The soil used for the experiment was collected from a field at the Agricultural Research, Development and

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between reduced and conventional tillage illustrated in Figure 2 should have a much greater impact than the relatively small changes in costs and returns ($57/A) between these systems. Soil protection by residues was observed in RT plots after a wind storm following plant emergence. Note the shifting of hills in CT vs. the effect of residues on hill integrity in RT. Potato plants were damaged by the blowing sand in the conventional tilled but recovered, with minimal damage observed in reduced tillage plots.

We encourage growers to modify this approach and incorporate reduced tillage strategies that fit their unique situations and soils.

Figure 2. Potato emergence from conventional tilled and reduced tilled plots.

Early Detection of Nitrogen in Corn, continued from page 4

Education Center of Colorado State University from a location where a soil analysis report indicated very low nitrogen (1.7 ppm). Fluorescence readings were acquired weekly from V4 to V8 corn growth stages (Figure 1). At the end of the experiment, plants were dried and weighed. Analysis consisted of comparing the NBI of corn plants that received different nitrogen rates.

The different nitrogen treatments had a significant effect on dry weight (Figure 2). Dry weight resulting from 130 lbs/ac N rate and 200 lbs/ac N rate were not significantly different from each other. All other treatments resulted in significantly different dry weights.

Figure 1. Operator holding the Multiplex®3 sensor for corn fluorescence readings.

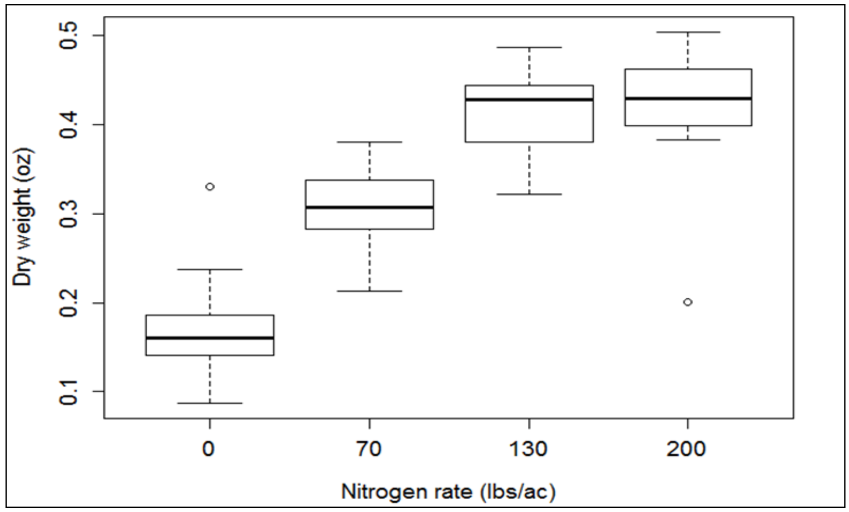

Figure 2. Boxplots of the difference in dry weights per plant for the four N rate treatments.

The NBI presented good potential in detecting N-content from V5 growth stage of corn (Figure 3). All four N-rate treatments were significantly different from each other at V7 and V8 crop growth stage. The NBI also enabled the distinction between the lowest N rate (0 lbs/ac) and the highest N rate (200 lbs/ac) at V4 growth stage of corn.

Is Early Detection of N Deficiency Possible? The main outcome of this study is the potential that induced fluorescence, as measured by Multiplex®3, enabled the early detection of N content prior to V8 growth stage of corn (Figure 3). It also enabled the detection of strong deficiencies (0 lbs/ac) at V4 growth stage, which means that farmers could use fluorescence to detect the most drastic changes in plant nutrition as reflected in crop canopy very early in the growing season. The readings for this study were acquired in a static mode, but the sensor already offers the capability to acquire fluorescence in mobile mode and incorporate location coordinates with the fluorescence data.

Bottom Line. Our results indicate that induced fluorescence is a promising approach to detect N content in corn at early growth stages, opening new possibilities for the practical implementation of site-specific N management and "4R" nutrient stewardship.

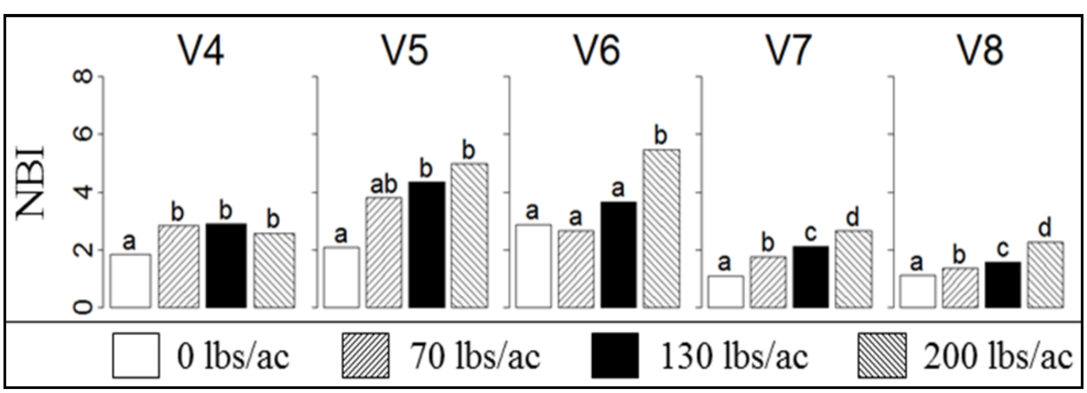

Figure 3. Bar graphs of the average values of NBI, for each growth stages from V4 to V8 and for each nitrogen rate. Different letters indicate significant difference (α=0.05) within the same growth stage.

RECOMMENDING SOIL COPPER THRESHOLDS FOR POTATO PRODUCTION IN IDAHO

By Amber Moore[1], Megan Satterwhite[1], and Jim Ippolito[2]— [1]University of Idaho, Twin Falls, Idaho, [2]USDA ARS, Kimberly, Idaho

W**here 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*

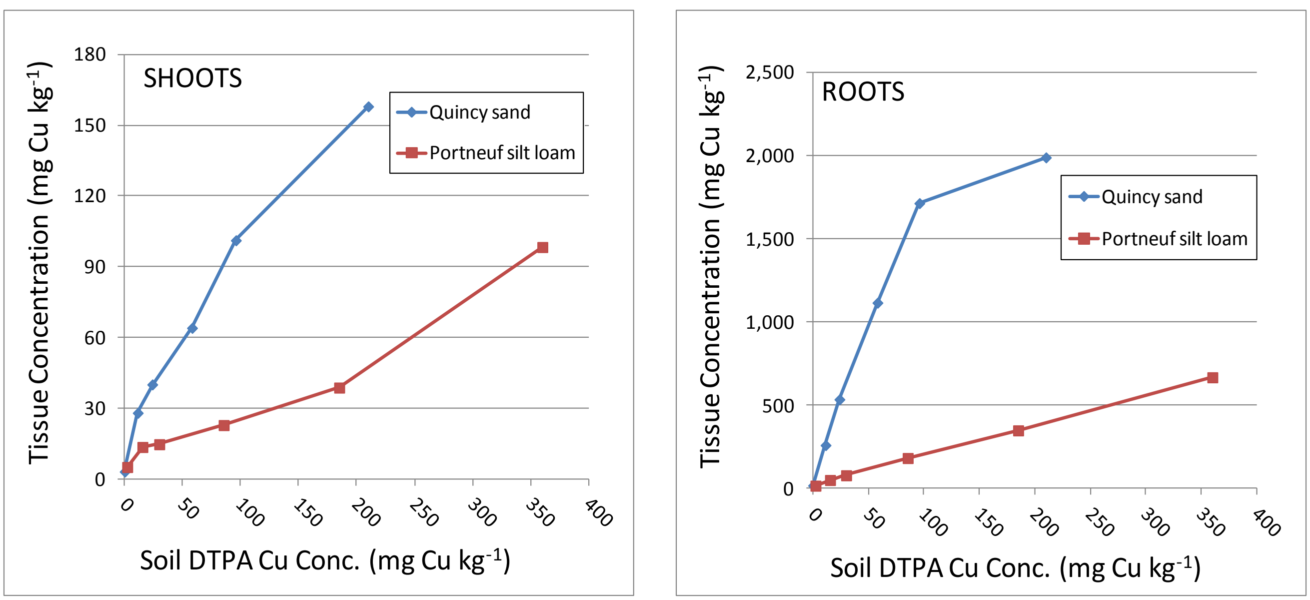

Figure1. Increasing copper concentrations in Russet Burbank potato shoots and roots with increasing soil DTPA copper concentrations, as influenced by soil texture.

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.

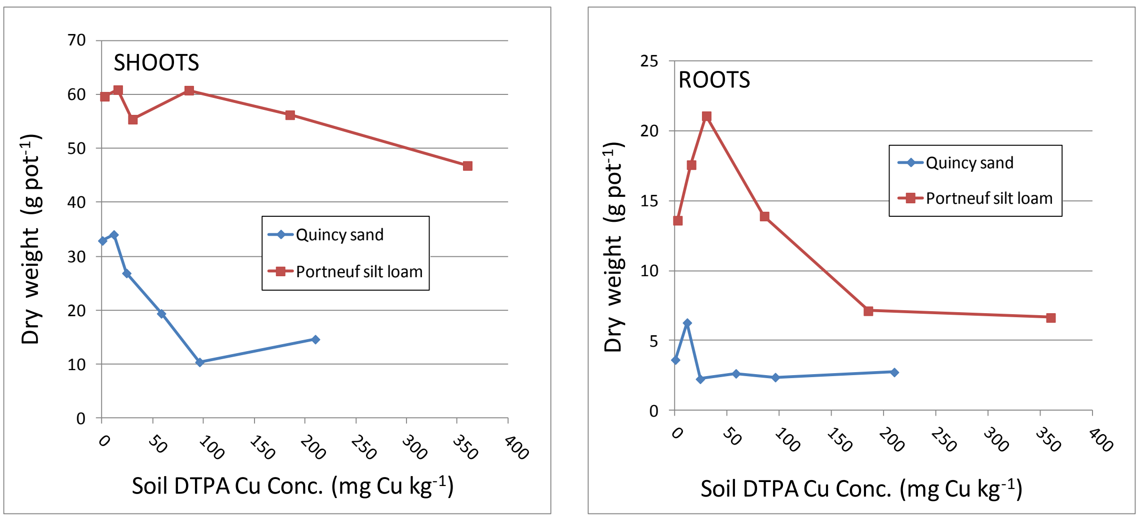

Figure 2. Changes in dry matter weight for Russet Burbank potato shoots and roots with increasing soil DTPA copper concentrations, as influenced by soil texture.

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).