Mineral Nutrition of Leafy Lettuce and the Impact on Verticillium Severity

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Lettuce production in the US is worth more than one billion dollars annually. California and Arizona grow 90 percent of all lettuce produced in the United States. Until the mid-1990s lettuce was thought to be resistant to Verticillium wilt, but in 1995 it was first identified in the central coast of California. Some field infections have been so severe the entire field was lost. The disease causes early collapse and death or lettuce heads with symptoms are not marketable, which threatens the lettuce industry because of complete crop lose through plant death or unmarketable produce.

Adjustments in mineral nutrition could reduce Verticillium wilt severity. Mineral nutrients have marked effects on plant health by providing building blocks for plant growth, as well as for mitigating abiotic and biotic stress factors such as disease development. Despite these known interactions, studies with N, P, and K are typically traditional rate response fertility trials for agronomic analyses rather than finely tuned nutrient studies for biotic stress suppression or enhancement. Even if mineral field studies are conducted to study disease management, they are at the mercy of complex soil, water, and climatic conditions not amenable to strict experimental control. The lack of uniform conditions in the root environment in soils or spatially through the landscape potentially skews results or makes interpretation difficult. Uncontaminated root tissue for disease assessment is also difficult to obtain in field studies. Although implicated in disease suppression or enhancement, N, P, and K nutrition/disease studies are often frustrated because differences among treatments are confounded by variability induced by complex rhizosphere relationships. Control of specific, relevant variables is vital for more meaningful data- the use of a hydroponic solution offers control of the root and shoot environments to allow detection of subtle differences in disease severity that are lost in field studies.

Three minerals N, P, and K were evaluated hydroponically to determine the optimum level of dry matter production for the lettuce cultivar Salinas—a common cultivar in California production systems. Increasing levels of N, P, and K produced significantly more shoot tissue growth in all three minerals. Nitrogen shoot levels peaked at 80 mg N L^{-1}, P maximum shoot growth was at 4 mg P L^{-1}, and K was 160 mg K L^{-1} (Figures 1, 6 and 7). Potassium dry weight growth did level out at 10 mg K L^{-1}.

Expectedly, as N increased in shoot tissues, percent C declined as plants became more succulent (Figure 5). Making the shoots a more likely target for disease development because of the N that could be acquired. However, as N increased in roots, C increased slightly suggesting that the roots would not increase in succulence due to increased
N concentrations (Figures 3 and 4). Yet, the overall C to N ratio decreased (plants becoming more succulent) for both shoots and roots as the available N increased (Figure 4).

Phosphorus deficiency limits lettuce yield and will decrease overall plant health because the element is used for energy transfer and protein metabolism. Reports indicate that P does not have a great influence on Verticillium wilt and may even increase wilt rates. For our hydroponic study, we needed to know the optimum P rate at which lettuce would grow so we could identify the influence of N and K on *Verticillium* infection in lettuce.

Potassium is important as a regulator of lettuce growth and increased availability of K to plants corresponds to a decrease in Verticillium wilt rates. Potassium levels in a hydroponic system were identified for Salinas lettuce growth. Studies can now be conducted to determine the influence of K on the infection levels of Verticillium in a hydroponic growth system.

Mitigation of Verticillium wilt in lettuce through mineral nutrition is a promising avenue, and through fertigation growers could deliver precise amounts of nutrients at optimal stages of development. Hopefully, lowering the severity of disease by increasing resistance to *Verticillium* by preventing infection through better plant health. The ability of N and K to act through multiple pathways to prevent infection implies a possible role for these elements to limit or prevent *Verticillium*. Studies with Verticillium added to the hydroponic growth system will begin in 2015.

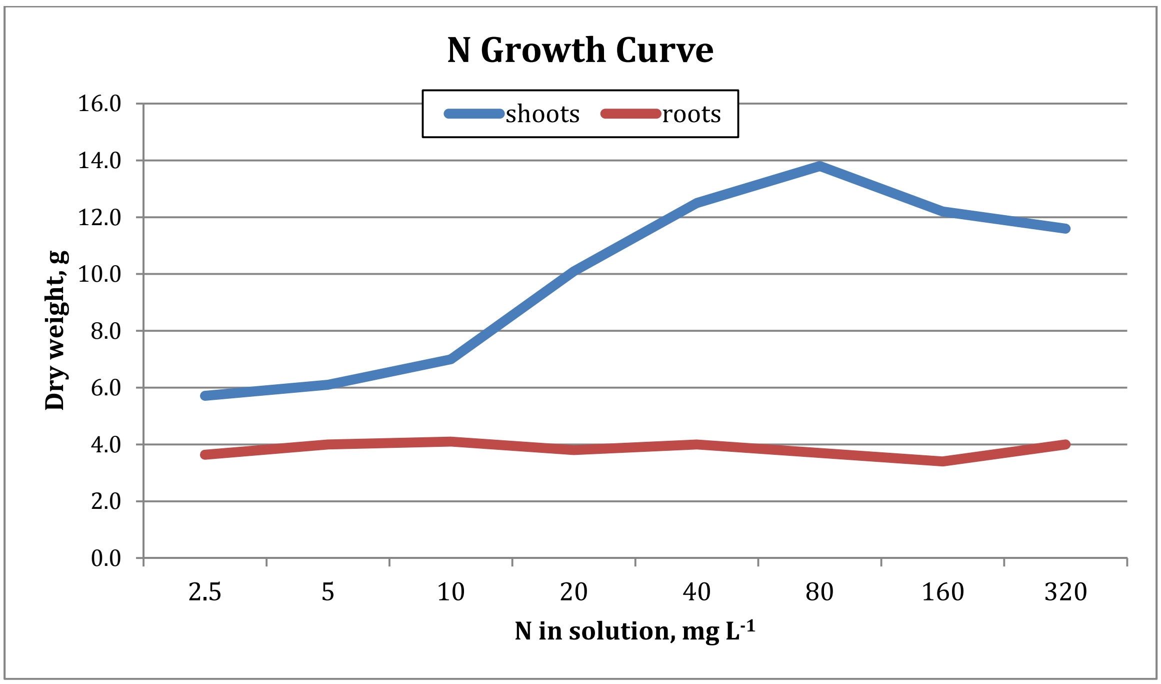


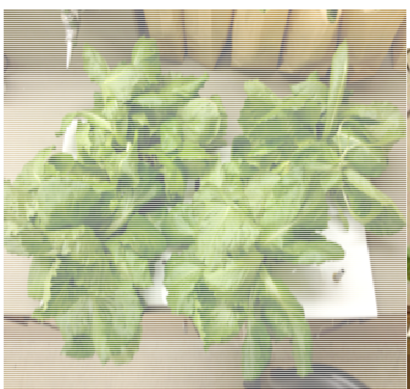
Figure 1. Oven dry weight of root and shoot tissue of Salinas lettuce grown in 2.5, 5.0, 10, 20, 40, 80, 160, and 320 mg N L^{-1} solution.

Lettuce grown in 2.5 mg N L^{-1}

Lettuce grown in 5.0 mg N L^{-1}

Lettuce grown in 10 mg N L^{-1}

Lettuce grown in 20 mg N L^{-1}



Lettuce grown in 40 mg N L^{-1}

Lettuce grown in 80 mg N L^{-1}

Lettuce grown in 160 mg N L^{-1}

Lettuce grown in 320 mg N L^{-1}

Figure 2. Demonstration of how Salinas lettuce grew in 2.5, 5.0, 10, 20, 40, 80, 160, and 320 mg N L^{-1} solution.

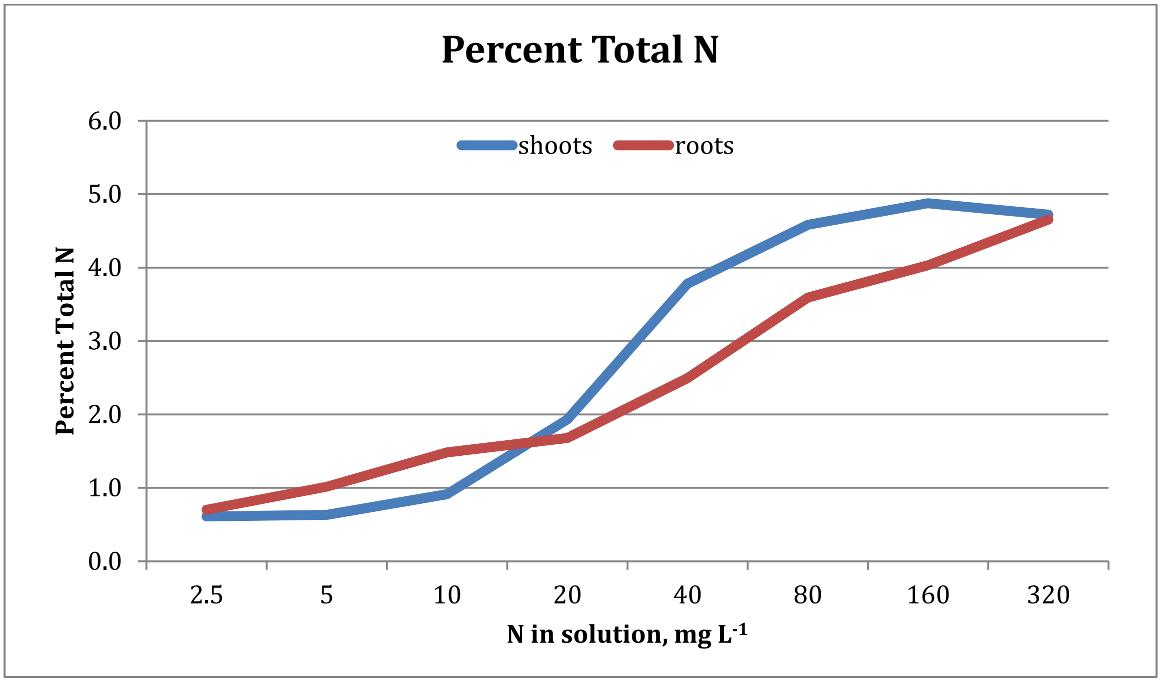


Figure 3. Percent N in shoots and roots of Salinas lettuce grown in 2.5, 5.0, 10, 20, 40, 80, 160, and 320 mg N L^{-1} solution

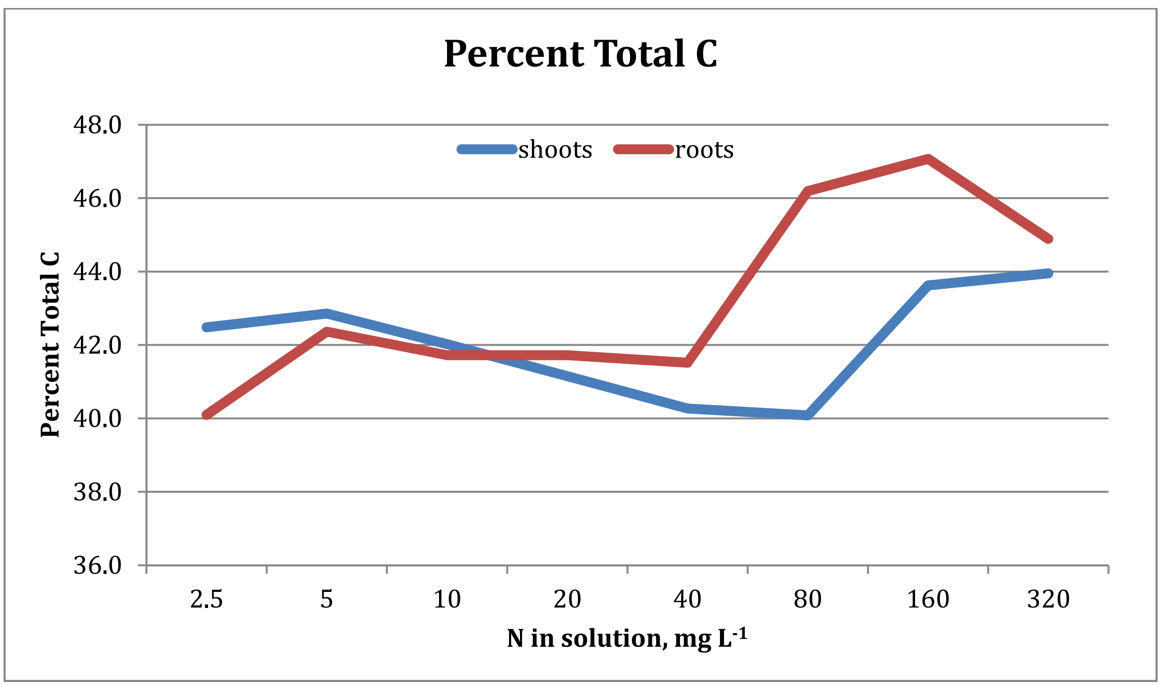


Figure 4. Percent C in the shoots and roots of Russet Burbank potatoes grown in 2.5, 5, 10, 20, 40, 80, 160, and 320 mg N L^{-1} solution.

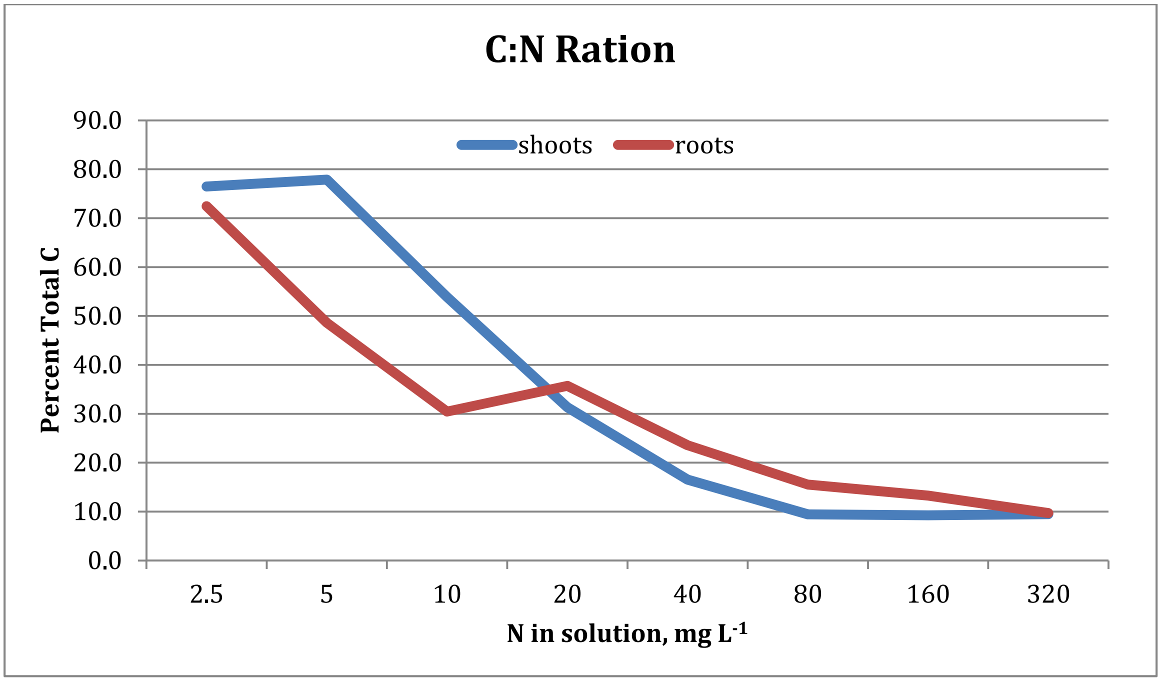


Figure 5. Carbon to N ratio in the shoots and roots of Russet Burbank potatoes grown in 2.5, 5, 10, 20, 40, 80, 160, and 320 mg N L−1 solution

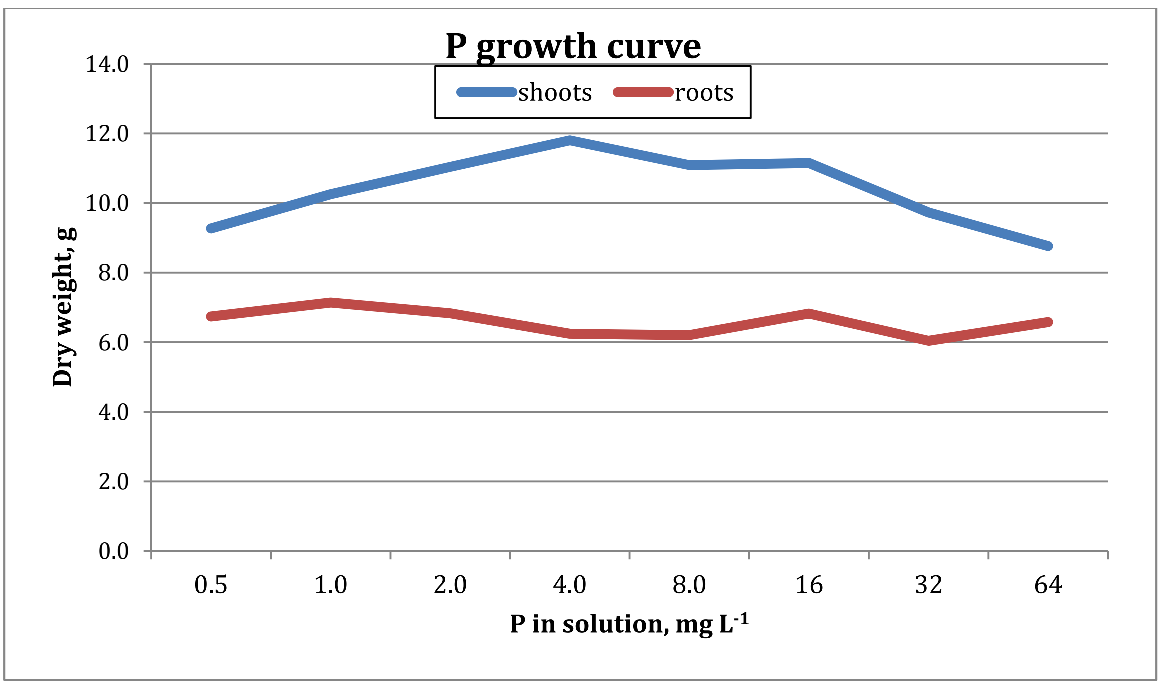


Figure 6. Oven dry weight of root and shoot tissue of Salinas lettuce grown in 2.5, 5.0, 10, 20, 40, 80, 160, and 320 mg P L^{-1} solution.

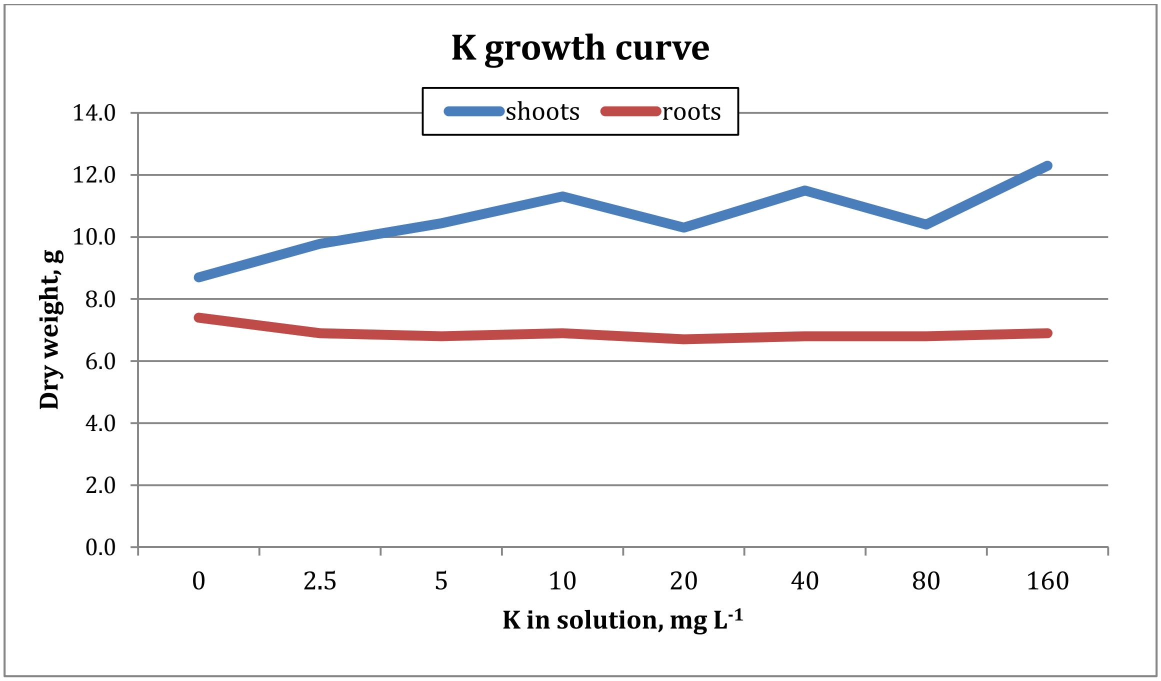


Figure 7. Oven dry weight of root and shoot tissue of Salinas lettuce grown in 0, 2.5, 5.0, 10, 20, 40, 80, and 160 mg K L^{-1} solution.