Improving Water and Nitrogen Use Efficiency in Lettuce by Selecting for Root Characteristics

Connor Soderstrom[1]*, Samuel Morales[1]*, Justin Medina[2]*, Caden Nihart[3]*, Aldo Romero[1]*, Sophia Ramirez[2]*, Chris Kinyon[4]*, Jenesis Perez[2]*, Trevor Blakey[5]*, Kali Hamed[6]*, Youngsook You[7], and David W Still[7]

[1]Department of Plant Science, [2]Department of Biological Sciences, [3]Department of Electrical and Computer Engineering, [4]Department of Aerospace Engineering, Cal Poly Pomona; [5]Department of Biology, Mt. San Antonio College; [6]Department of Computer Science, Cal Poly Pomona; and [7]California State University Agricultural Research Institute

<u>Impact on California Agriculture</u>: California supplies 76% of the nation's lettuce, and annual farm receipts (i.e., cash to growers) over the last three years ranged from about $2 to $3 billion with the crop ranking between the fifth- and eighth-most economically important commodity produced in the state. In addition to its importance to growers, many support industries are involved with the production, harvest, handling, packaging, and marketing of the crop. The commercial cultivars of lettuce used today were developed when water was plentiful and the environmental effects of nitrogen (N) fertilizers were not known. Global warming, recurring droughts, and competing demands limit the amount of water available for agriculture. Legitimate environmental concerns over N fertilizers also threaten the sustainability of lettuce production in California. The long-term goal of our lab is to identify traits that contribute to improved water and nitrogen use efficiency (WUE, NUE, respectively), identify genetic loci controlling these traits, and develop tools (genetic maps, molecular markers, and improved germplasm) that will be used by private and public breeders to improve WUE and NUE in their breeding programs.

<u>Rationale/Introduction</u>: To identify the genetic and physiological basis of WUE and NUE in lettuce, diverse germplasm, including wild (non-domesticated) *Lactuca* species was screened. Plants were grown in the field under non-limiting and limited N and water. Leaf N concentration was used as a proxy to identify genotypes that had the greatest capacity for water and N uptake. Previous results indicated a strong positive relationship between leaf N concentration, photosynthetic assimilation, and biomass production per unit of carbon fixed. Water and N uptake by roots is partly due to a passive process that depends on physical interception of the water and N fertilizers. Greater root biomass results in a larger volume of soil being available for uptake of water and dissolved N, and we sought to identify and breed genotypes that have both greater root biomass and high leaf N concentration.

<u>Experimental Approach</u>: Based on the results of the germplasm screening, four genetic lines were used to create three RIL populations of lettuce. Parental lines D221 (*Lactuca sativa*), W28 (a primitive accession of *L. sativa*), cultivar Cibola, and W34 (a *L. serriola* accession) are high leaf N accumulators segregating for root architecture and biomass and plasticity of root growth under limited N. Plants were grown in 20 L grow bags under limited N (N50 = 140 kg N/ha) or non-limited N (280 kg N/ha). At market maturity each plant was harvested and evaluated for root length, root biomass and head weight. In addition, $\Delta^{13}C$, $\delta^{15}N$, C and N concentration were obtained, and along with head weight, were used to derive parameters of WUE and NUE. Each of these traits are being used to identify quantitative trait loci on a genetic map that will facilitate marker development and breeding, as well as develop hypotheses for the genetic basis of WUE and NUE.

<u>Major Conclusion</u>: Root biomass and architecture is a plastic response to environmental conditions. Most genotypes, but not all, responded to limited N by increasing their root biomass. When grown under limited N, head weight was maintained or improved in two populations. Taken together, these observations suggest that lettuce can be bred to be grown under both limited water and N and still maintain yield. These newly developed cultivars will help sustain the lettuce industry in California while using less water and N fertilizers, thus lowering the environmental impact of growing the crop.

*Student researcher