

Report to California Wheat Commission: GH 2010-2011 Experiments.

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Title: Determination of optimum root and shoot size in bread wheat for increased water and nutrient –use efficiency and grain yield.

Goal during the first year: To characterize the root and shoot characters of 118 recombinant inbred lines and parents.

Growing conditions: 80 cm tubes, sand cultures, with plants harvested at 45 days after germination, 2 growing replications in fall 2010 and winter 2011.

Of the 165 original recombinant inbred lines (RILs) between ‘Iran 49’ and ‘Yecora Rojo’ we chose, at random, 118 and the two parents as we can only handle 120 individual tubes in racks in the center of the glasshouse, which reduces the cv. If we plant tubes at the sides of the glasshouse the cv. of the experiment increases. Therefore each of the 118 RILs was represented by one plant in a tube. The experiment was repeated.

Materials and Methods: 118 RILs derived from the cross of “Iran 49” x “Yecora Rojo” plus the two parents (a total of 120 lines) for root traits and shoot traits at 45 days after germination grown under well-watered irrigation, using a randomized complete block with two replicates. Values from the two replicates were averaged. Shoot traits included plant height, number of tillers, and shoot biomass. Root traits included longest root length, number of roots > 30 cm, total root length > 30 cm, shallow root weight (roots developed between 0-30 cm) deep root weight (roots developed below 30 cm), root biomass (sum of shallow and deep roots). Also, plant biomass (sum of shoot and root biomass) was measured. Two ratios were calculated; ratio of root to shoot biomass and ratio of root biomass to plant biomass expressed as percentage.

Results: Differences among the lines were highly significant for all the characters examined. There was transgressive segregation (mean values of RILs greater or less than mean values of both parents, or one of the parents) for number of roots > 30 cm, maximum root length, shallow root weight, deep root weight, and root biomass indicating epistatic gene action for these root traits. Yecora Rojo produced 55% more shallow roots per plant than Iran 49 (0.76 vs. 0.49 g/plant), but Iran 49 produced more than 200% difference in deep roots than Yecora Rojo (0.38 vs. 0.17 g/plant). However, difference between the two parents for total root biomass was not significant (see comment below**). Only two RILs produced shallow root weight similar to that of Yecora Rojo. Only one RIL produced deep root weight greater than Iran 49, but five had

similar deep root weight to that of Iran 49. Five RILs had greater root biomass than the best parent. Broad-sense heritability was relatively low for shallow root weight (0.41), deep root weight (0.22), and root biomass (0.35); indicating that many genes, each with small effect, are involved in expression of root traits.

Discussion: Therefore, root characters in hexaploid bread wheat are quantitatively inherited and the genes involved are probably on several different chromosomes. We suspected this from earlier research on roots of wheat plants with chromosome-arm deletions in ‘Chinese Spring’ telosomics. These RILs derived from crosses between Iran 49 and Yecora Rojo, developed by single seed descent, allow for selection of lines with desirable root and shoot traits from this population. They were measured at 45 days after germination. A more useful observation will be to measure roots at maturity, which we plan to carry out in the 2011-2012 season with the same 118 RILs and parents, when we can also determine grain yield per plant. This will indicate whether it is useful to measure root characters at 45 days, rather than at maturity. In other words, can there be early selection for root characters in the life cycle of the plant?

From a breeding point of view, low heritability for root characters may make selection in early generations after a cross difficult, but with increased homozygosity in F3 or F4 generations, early generation selection may be possible. Moreover, the proposed Diversity Arrays Technology (DArT) analysis of these 120 lines may allow early molecular marker-assisted selection in this and similar populations for root and shoot traits.

**We did not expect there to be no significant difference between the values for total root biomass of the two parents Iran 49 and Yecora Rojo in these two experiments, started in fall and winter, but this may mean that temperature during the growing season may affect this root trait differently. Also the values were an average of only two plants, one from each experiment. However, there were significant differences between shallow root weight and deep root weight between the two parents, which confirmed results from previous experiments. All our previous experiments in large pots and 80 cm tubes indicated there are up to 3-fold differences in total root biomass between the two parents.

In a separate small pilot experiment with 150 cm (long) tubes with the two parents and 9 selected RILs for root biomass from the fall experiment and California cvs. ‘Joaquin’ and ‘Blanca Fuerte’, with 4 replications, we did observe significant differences between the two

parents for total root biomass. There was also a positive association between root size and grain yield, which we shall investigate further in 2012 season.

Experiments to be conducted in 2011-2012 season: Evaluation of the same lines for root traits and shoot traits at maturity starting in early December 2011. This coming year the 118 RILs and two parents (120 tubes) will be grown in two adjacent sections of the glasshouse and planted at the same time in late fall, then grown to maturity, so that we can measure root characters and grain yield of each line. The 2 replications will be started at the same time. We shall also grow plants to extract DNA for DArT analysis for molecular markers to associate these with root characters. The experiment in long tubes (150 cm) with 9 selected RILs, 2 parents and 2 California cvs. with 4 replications, will also be repeated and grown to maturity.