Wheat Research Progress Report

Project #: 3019-3253

Title: Improving Winter Wheat Seedling Emergence from Deep Sowing Depths

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Progress Report Year: 2008

RESULTS / ACCOMPLISHMENTS / IMPACTS:

Hiring Post-Doctoral Scholar

This is the first year of the project. We are in the final stages of hiring a post-doctoral scholar, Dr. Amita Mohan, who will be funded 60% by this project with the remainder by Vogel Endowment funds. In addition to this project, Dr. Mohan will work on understanding the basic biology of seedling emergence and its relationship to dwarfing genes, and hormone signaling in general. We expect that the outcomes from her efforts will not only accomplish the objectives of this project but will also generate enough preliminary data to help us prepare a competitive grant application for USDA-NRI and NSF programs. Because of recent hiring restrictions at WSU, her hiring process is taking longer than usual but we expect to have her onboard in December 2008.

Acquiring Germplasm and Initial Crosses

The first and foremost priority of this project is to identify a good source of longer coleoptiles that we will evaluate by our emergence test and then use as a donor source to transfer "good emergence" trait into the variety Xerpha. Dwarfing genes were the basis for Orville Vogel's and Norman Borlaug's "green revolution" that increased the harvest index (i.e., more grain and less straw). The dwarfing gene mutants dramatically increased wheat grain yield potential in the intermediate and high rainfall areas of the PNW and indeed in many regions around the world. However, most semi-dwarf cultivars in the PNW contain Rht_1 or Rht_2 dwarfing genes that impede seedling emergence. There are now 15 other dwarfing gene mutants that are available and out of these Rht_8, Rht_{12}, Rht_5, and Rht_{18} do not reduce the length of the coleoptile or first leaf, the two traits that control about 65% of the variation in winter wheat emergence from deep planting. We have obtained seeds for two of these mutants and are in the process of obtaining the remaining two. Using one of these mutants, Dr. Rebetzke and colleagues from Australia have developed wheat lines with coleoptiles up to six inches long and we expect to receive seed of those lines in January 2009. Furthermore, we have made a collection of about 700 wheat lines from all over the world. We have started to measure coleoptile lengths of these lines to identify about 20 lines with the longest coleoptile and first leaf lengths.

We also started an experiment to remove the Rht_1 dwarfing gene from Xerpha to see if we can develop a standard-height Xerpha (i.e., no dwarfing gene) that will have better emergence. It is yet to be determined if replacing the Rht_1 mutant with its normal allele will have any adverse effect on the yield and quality. We believe that this experiment will address the long-standing question about how dwarfing genes increased wheat yields worldwide. For this experiment, we have already made crosses of Xerpha with both Moro and Buchanan cultivars. Both Moro (soft white club) and Buchanan (hard red common) are standard height varieties noted for their excellent emergence traits (see Field Emergence Study in 2008 section).

Soils Laboratory at Lind

A section of the greenhouse at the WSU Dryland Research Station at Lind was converted into a soils laboratory in 2008 with all labor provided by WSU personnel. This temperature-controlled facility will allow us to conduct emergence pot experiments year round. Existing equipment (e.g., drying oven, digital scales, rainfall simulator, etc.) have been moved to the new lab. In addition, we have fabricated a hydraulically controlled press devise to achieve uniform soil bulk density in our pot studies.

Emergence Studies in Pots

Through much trial and error over several years, we have developed a reliable and realistic method of simulating deep-sowing conditions for winter wheat in pots in the laboratory that closely correlates to what we find in actual field conditions. In brief, we use soil from the Lind Station (Shano silt loam) collected from the surface 6 inches of tilled summer fallow in August. We determine water content of air-dried soil and then add prescribed quantities of soil and water in a small cement mixer to achieve the desired soil water content. This "wet" soil is placed in 10-inch-tall plastic pots with 24-inch diameter and tamped with the previously-describe hydraulic press to create a 3-inch-deep soil layer with a bulk density of 1.35 Mg m^{-3}. Twenty-five seeds from each winter wheat entry are placed on top of the wet soil and another one inch of wet soil added on top. Immediately thereafter, 4 inches of dry soil is added to the pot and the hydraulic press used to create a dry soil layer with 1.00 Mg m^{-3} bulk density above the moist soil. Thus, there is 5 inches of soil (1 inch moist + 4 inches dry) covering seed that accurately simulates deep planting conditions. Emergence is measured by counting individual seedlings at 24-hour intervals beginning 6 days after planting and continues until no further emergence occurs.

The four mutant lines, material from Dr. Rebetzke in Australia, and the selected 20 lines from the world collection will be tested under four different water potentials in the pot experiments. This experiment will identify the best two wheat lines for seedling emergence from deep planting under variable seed-zone soil water content. Those two lines will be used as donor parents to make crosses with Xerpha.

Field Emergence Study in 2008

Eighteen winter wheat varieties and numbered lines were evaluated for emergence from deep planting depths at Lind in 2008. Most of the entries were provided by Dr. Steve Jones, who has made several crosses of semidwarf varieties with existing standard height varieties. Other entries were obtained from Dr. Bob Allan who also has made similar semidwarf x standard height crosses. For each entry, 100 seeds were sown using a four-opener deep-furrow drill in 15-ft-long rows with 16-inch spacing between rows. The drill delivered seed of individual entries to separate openers. The design was a randomized complete block with 4 replicates per entry. Six inches of soil covered the seed. Volumetric water content in the seed zone was only 10.3%, this being considered very marginal for winter wheat seedling emergence from such deep depths.

Results from the 2008 field emergence study are shown in Figure 1. Seedlings did not start to emerge until 9 days after planting (DAP) whereas seedling emergence usually begins at 7 DAP with wetter conditions. Buchanan and the two entries by Dr. Allan (BA64 and BA65) showed the most promising early (i.e., 9 to 13 DAP) as well as final (21 DAP) emergence. However, because of variability among replicates, these were not significantly different statistically from many of the other entries. Xerpha had relatively low seedling emergence (Figure 1). Note the emergence of Buchanan compared to Moro (Figure 1). It has been our observation throughout the years that Buchanan will emerge better than Moro under dry seeding conditions but the reverse is true under wetter seeding conditions. Now that we are perfecting our pot experiment techniques, we hope to answer the question of whether certain winter wheat varieties can germinate and emerge from lower soil water potentials than other varieties. This information would be valuable to Washington wheat growers and also make an important contribution to the science of wheat physiology.

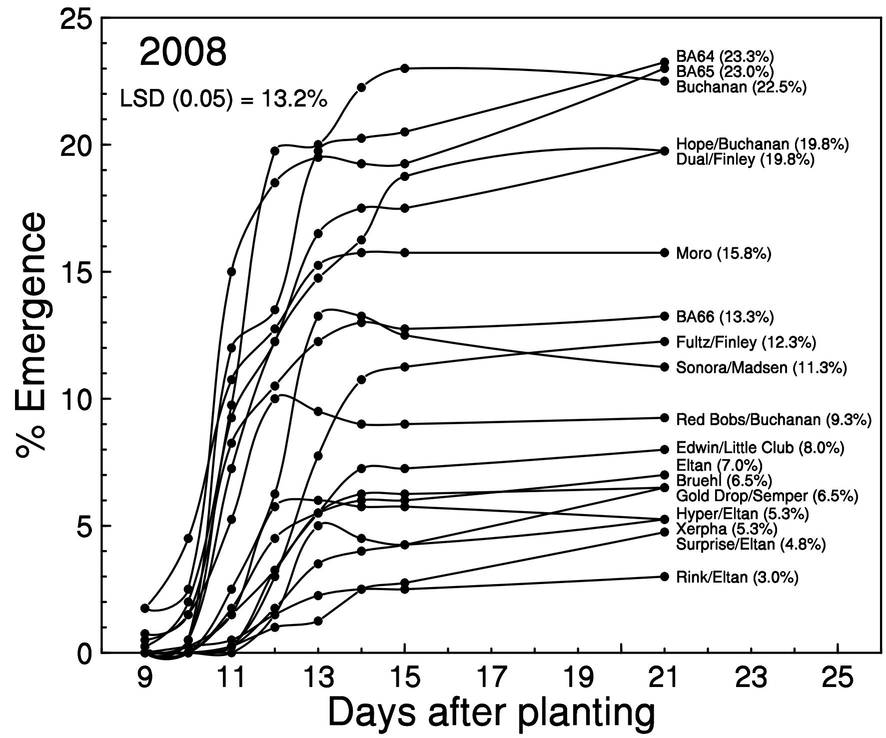

Figure 1. Seedling emergence of 18 winter wheat varieties and numbered lines planted with six inches of soil cover into summer fallow at Lind on September 4, 2008. Volumetric soil water content in the seed zone was only 10.3%, this being considered very dry for successful establishment of winter wheat.

Publications

This is a new project and there are no publications to date.

Presentations and Reports

An overview of this project was given by W.F. Schillinger at the Washington Grain Alliance annual meeting in Spokane on November 13, 2008. The meeting was attended by approximately 100 wheat growers and WSU / ARS scientists.