Wheat Research Progress Report

Project #: 3019-5344

Title: Evaluation and Selection for Cold Tolerance in Wheat

Researchers: K. Garland Campbell, D.Z. Skinner, B. Bellinger, C Hoagland, R. Rai, L. Reddy

Cooperators: R.E. Allan, J. Burns, D. Dreesman, J. Dubcovsky, S.S. Jones, K.K. Kidwell, T. Murray, C.J. Peterson, C. Steber, R. Zemetra

Progress Report Year: 2008

Accomplishments and Results: (listed by objective)

1. **Evaluate Washington wheat variety trials (Soft Wheat and Hard Wheat Trials)**
2. **Evaluate cold tolerance of new breeding lines in regional nurseries.**
3. **Evaluate cold tolerance of advanced breeding lines.**
4. **Evaluate cold tolerance of F3-F5 (early generation) wheat populations that are segregating for cold tolerance and select resistant progeny.**
5. **Conduct artificial freeze tests after six weeks of hardening at 36^{o} F plus infection by soil borne diseases.**
6. **Identify genes controlling cold hardiness in winter wheat.**
7. **Identify genes controlling cold hardiness in spring wheat.**

The new freezer finally arrived and was installed in the spring of 2008. After making some additional modifications it became fully operational in the summer of 2008. Since then we have evaluated the following nurseries for response to freezing at a single temperature (-10) after a period of cold acclimation:

Washington Variety Trials Hard Winter Wheat
Washington Variety Trials Soft Winter Wheat
Washington Variety Trials Hard Spring Wheat
Washington Variety Trials Soft Spring Wheat
Western Regional Cooperative Soft Winter Wheat Nursery
Western Regional Cooperative Hard Winter Wheat Nursery
Breeding lines from the Washington Winter Wheat Program (112 lines)
Breeding lines from the USDA-ARS Winter Wheat Program (48 lines)

The data for all of these trials is still being analyzed and is not available for this report. It will be published, along with previous testing results from our cold tolerance assays in Wheat Life, and submitted to the Journal of Plant Management.

As of Dec 2008, we have planted the 2009 WA Variety Testing Soft and Hard Winter wheat trials, which will be evaluated beginning in 2009 at a second temperature. The other trials listed above will also be evaluated at the second temperature as well as several trials including the world collection of cold tolerant wheat cutlivars, and the Alpowa/Avocet mapping population.

We conducted long term freezing survival tests of major PNW cultivars and other North American wheat cultivars possessing tolerance to freezing. Fifty seeds of each cultivar were planted into flats in a randomized complete block, vernalized for five weeks at 4^{o}C , then transferred to -5^{o}C. After 15 weeks, one set of cultivars in flats was removed to a greenhouse and rated for survival. A second set of flats was removed after 20 weeks. Survival of cultivars as a function of time frozen, appeared to fit into one of three categories: cultivars whose survival remained relatively high for the first15 wk of freezing, then declined rapidly over the next 5 wk; those whose survival declined at essentially the same rate over the entire 20-wk period; and those whose survival declined rapidly in the first 15 wk, then less rapidly in the next 5 wk (Fig. 1). In the first group after 15 wk of freezing, the most freezing tolerant cultivars, Norstar and Froid, had 100% survival, and these means were not significantly different from the cultivars Kestrel, Tiber, Wanser, Finley, Eltan, Masami, Edwin, and Hatton. The average survival of this group was 89.7% and the average LT50 was -15.18^{o}C. The second group consisted of Madsen, Hiller, Lewjain, Tubbs, Bruehl, Buchanan, Hill 81, Rely, ORCF 101, and Moro with average survival of 46.7% and LT50 of -12.78^{o}C. The third group, with less than 15% survival after 15 wk of freezing included ORFW, Finch, Stephens, Coda, Rod, and Chukar, with average survival of 7.8% and LT50 of -11.08^{o}C. Although the LT50 values were highly correlated with survival at 15 weeks, only two cultivars survived to 20 weeks. Long-term freezing tests are needed, in addition to LT50 tests, to identify genotypes with superior ability to remain viable while frozen for long periods of time.

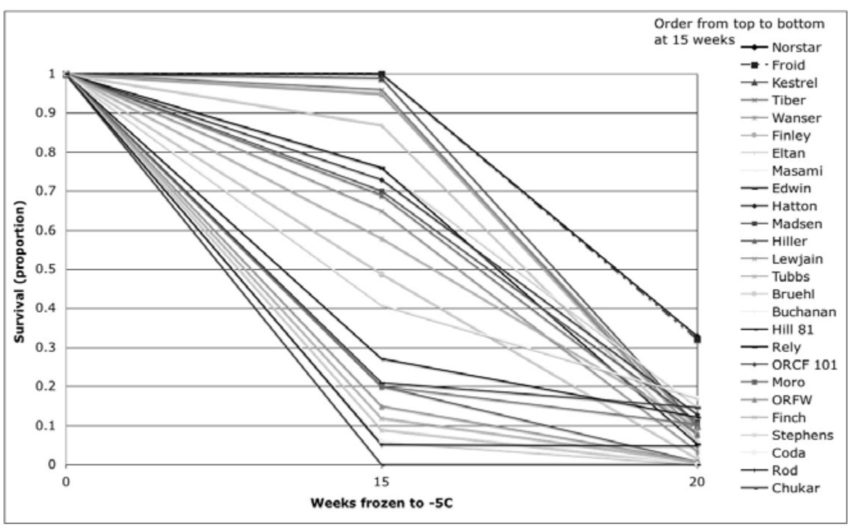

Fig. 1. Survival of 26 winter wheat cultivars frozen to _58C for 0, 15, or 20 wk.

Objective 6: Identify genes controlling cold hardiness in winter wheat.

In previous research funded by the WWC, we used molecular markers to identify three chromosome regions, 5AL, 6B, and 5D, associated with cold tolerance in a population developed from a cross between Norstar and Centurk78 and two chromosomes, 4B, and 5AL, associated with cold tolerance in a population developed from Karl and Z0031. We want to verify that these chromosome regions are associated with heritable cold tolerance so we evaluated both populations in the new freezers this summer and have planted them again to test at a second temperature. We received additional funding from USDA-CSREES in 2009 to further explore the functions of genes at the *Fr-2* locus in wheat and have identified 60 winter wheat cultivars and land races from around the world (world collection of cold tolerant wheats) that have documented resistance to freezing. We are currently crossing all of these lines to cold sensitive winter wheat in order to develop populations segregating for this trait.

Objective 7: Identify genes controlling cold hardiness in spring wheat.

In conjunction with Scot Hulbert, we are developing facultative, spring wheat that can be planted in the fall or in the spring depending on moisture conditions. This material will be more winter tolerant than current spring wheat cultivars. To that end, we evaluated the WA Variety Testing Spring wheat trials for freezing tolerance. In wheat, cold tolerance is associated with the shift of the plants from vegetative to reproductive growth. This developmental change is due to the action of vernalization (Vrn) and photoperiod (Ppd) genes. Work in Kim Kidwell's laboratory, under the direction of D. Santra, identified a unique *Vrn-B1* allele in the spring cultivar Alpowa. Alpowa also has better cold and drought tolerance than other spring wheat cultivars. We are using a recombinant inbred population from a cross between Alpowa and Avocet, developed by X. Chen, to investigate whether the unique *Vrn-B1* allele is responsible for the increased cold and drought tolerance of Alpowa. We completed the assay of the *Vrn* genes and *Ppd* genes present in the Alpowa/Avocet RIL population. We increased seed of this population in the field in 2008. We used Alpowa, Avocet, and Louise to develop methods to assay root growth and other drought resistance parameters in the greenhouse.

Objectives 4 and 5:

We will conduct these experiments in 2009.

Presentations:

K. Garland Campbell, A. Knox, C. Li, L. Reddy, A. Vágújfalvi, Q. Song, G. Galiba, P. Cregan, E.J. Stockinger, J. Dubcovsky, 2008. Identification of Genetic Factors Conferring Cold Tolerance in Winter Wheat. P283. Plant & Animal Genomes XVI Conference, January 12-16, 2008, San Diego, CA.

Garland Campbell, K., 2008. Evaluating wheat for tolerance to cold. Washington Grain Alliance Wheat Review. February 2008. February 2008. Pullman WA.

Publications:

Santra, D., M. Santra, R. Allan, K. Garland Campbell, K. Kidwell. (submitted). Vrn-1 allele composition of spring wheat germplasm from the Pacific Northwest region of the U.S. based on genetic segregation and DNA marker analyses. Submitted to Plant Breeding.

Skinner, D.Z., and K. Garland-Campbell. 2008. Evidence of a major genetic factor conditioning freezing sensitivity in winter wheat. Plant Breeding. 127: 228-234.

Skinner, D.Z., K.G. Campbell. 2008. The relationship of Lt_{50} to prolonged freezing survival in winter wheat. Can. J. Plant Sci. 88: 885-889