

**Project #:** GR00010236. AWD004480

**Progress Report Year:**   2   of   3   (*maximum of 3 year funding cycle*)

**Title:** Evaluation and Selection for Cold Tolerance in Wheat and Barley

**Researcher(s):** Kimberly Garland Campbell, Karen Sanguinet

**Cooperators:** Bob Bruggeman, Arron Carter, Clark Neely, Mike Pumphrey.

**Executive summary:**

The freezers were serviced and re-calibrated in late 2022 which greatly improved the reliability and reproducibility of the screening. We screened 400 winter wheat breeding lines from the WSU Winter Wheat Program. We also screened 128 Soft and Hard Winter wheat lines and 58 hard and soft spring wheat lines from the Washington Variety Trials. Data was returned to the breeding program and included in the Small Grain Variety Selection tool. We conducted several trials to determine the correct temperature to screen winter barley breeding lines and are in the process of evaluating those lines now.

*Introduction:* Winterkill continues to be a major cereal production risk in the Pacific Northwest and globally. Winter injury affects winter cereals throughout their growing area in the PNW, especially under variable snow cover. Increased winter rain and decreased snow cover leaves crops more vulnerable to sudden temperature drops. The crop is especially vulnerable to winter injury in early and in late winter. In 2013 and 2021 we experienced winter kill in late November, before the crop was adequately acclimated. Sudden temperature swings in February and March damaged the crop in Washington in 2014, 2015 and 2017, 2019 and 2020 and are a problem in parts of the wheat growing region every year.

*Approach:* Screening for winter hardiness in the field is difficult because winterkill varies across a field. Therefore, we have developed artificial freezing trials at the WSU Plant Growth Facility that are correlated with winter injury in the field. Seedlings are germinated and exposed to 4°C for 5 weeks for acclimation, then placed in a programmable freezer cabinet. The temperature is dropped to -3 °C, held for 16 hours, then dropped to the target temperature (-12 to -14 °C), held for 1 hour, and gradually increased back to 22°C. Check cultivars ‘Eltan’ (resistant), ‘Norstar’ (resistant) and ‘Stephens’ (susceptible) are included in each run of the test as controls. Seedlings are moved to a growth room and survival is rated after three weeks. Spring wheat and Barley are tested the same way with higher target temperatures (-7 to -9 °C).

*Results:* Over 200 wheat lines were evaluated at -13 °C in 4 replications in 2023. Spring wheat lines were evaluated at -9 °C but most lines did not survive. We will evaluate spring wheat lines at -7 and -8 °C next year to obtain more information about their relative survival. Winter barley checks were evaluated at -12, -9, -8 and -7 °C. Based on these results we decided to evaluate the winter barley breeding lines at -7 and -8 C and are doing that now.

**Impact:**

- The data from these cold tolerance trials is available in the small grains variety selection

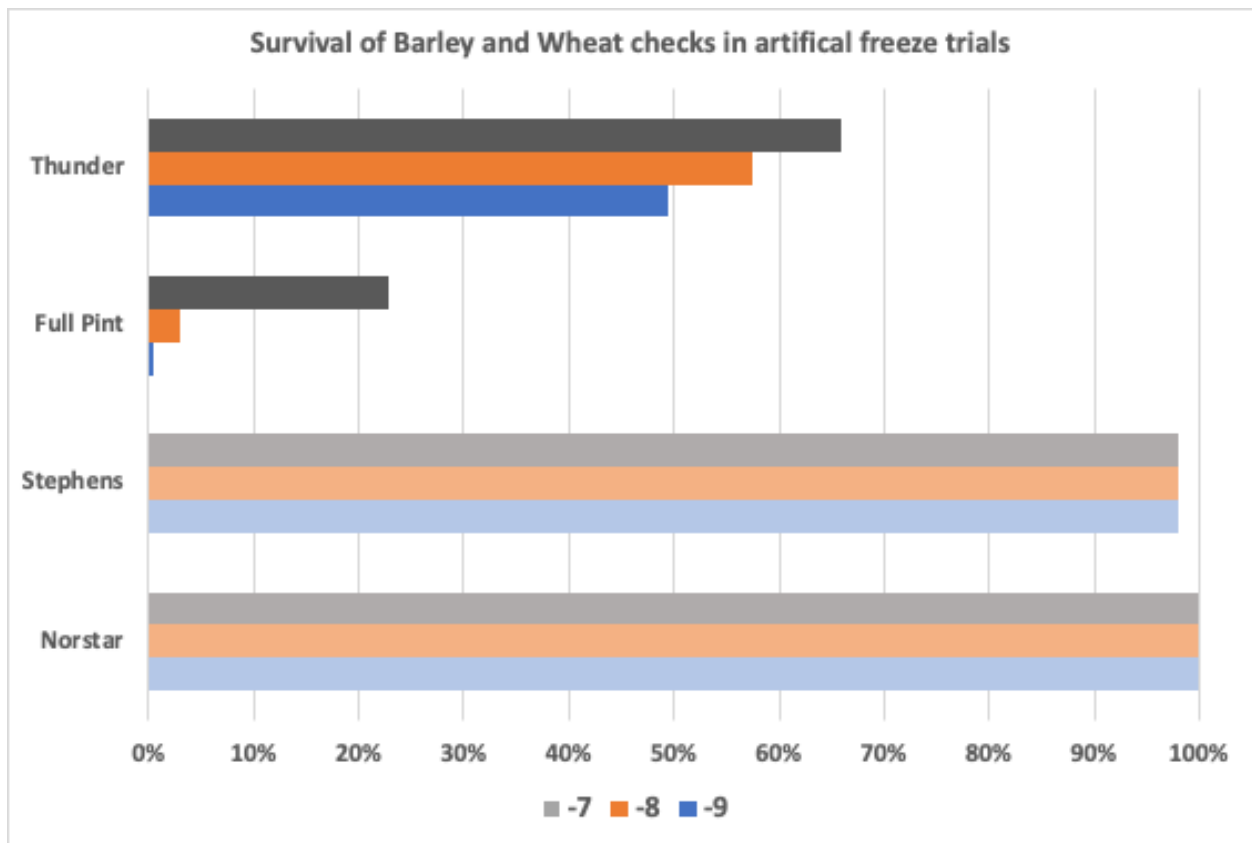
tool and by request.

- Varieties released from the WSU winter wheat breeding program have consistently excellent cold tolerance and this tolerance has been maintained because of testing using the procedures developed by this project.
- Methods developed for this project are being used to evaluate cold tolerance of pulses, pennycress, and brassicas.
- Publications:

Garland Campbell, K. 2003. What's up with winter wheat? How plants survive, thrive during cold. *Wheatlife* Vol. 66(02) pp 51-53.

Oates, D. 2003. Identification of key cold-response determinants in *Triticum aestivum*: Elucidating the interaction between vernalization and photoperiod for cold temperature acclimation. Annual Meeting North American Plant Breeders, July 16-20. Greenville SC. Poster P-006.

### Figures and Tables:



**Percent Survival of Major Wheat Cultivars from the WA Cereal Variety Trials in Artificial Freezing Trials, over 4 Replications at the WSU Plant Growth Facility, 2023.**

| <b>Winter Wheat</b>                   |                         |                        |                         | <b>Spring Wheat</b>                  |                         |
|---------------------------------------|-------------------------|------------------------|-------------------------|--------------------------------------|-------------------------|
| <b>Winter Wheat Test Temp: -13 °C</b> |                         |                        |                         | <b>Spring Wheat Test Temp: -9 °C</b> |                         |
| <b>Name</b>                           | <b>Percent Survival</b> | <b>Name</b>            | <b>Percent Survival</b> | <b>Name</b>                          | <b>Percent Survival</b> |
| <b>Soft White</b>                     |                         | <b>Winter Club</b>     |                         | <b>Hard Red</b>                      |                         |
| Piranha Cl+                           | 95                      | Pritchett              | 65                      | WB9668                               | 0                       |
| Norwest Tandem                        | 61                      | Castella               | 54                      | AP Venom                             | 63                      |
| VI Voodoo Cl+                         | 1                       | ARS Crescent           | 93                      | WB9662                               | 43                      |
| LCS Shine                             | 35                      |                        |                         | Kelse                                | 3                       |
| TMC M-Press                           | 29                      | <b>Hard Red Winter</b> |                         | Alum                                 | 0                       |
| Stingray CL+                          | 40                      | LCS Jet                | 38                      |                                      |                         |
| LCS Blackjack                         | 20                      | Keldin                 | 67                      | <b>Soft White</b>                    |                         |
| Sockeye CL+                           | 74                      | LCS Helix<br>AX        | 71                      | Ryan                                 | 2                       |
| LCS Hulk                              | 62                      | LCS Eclipse<br>AX      | 44                      | Tekoe                                | 10                      |
| LCS Dagger AX                         | 47                      | Scorpio                | 30                      | Louise                               | 2                       |
| Norwest Duet                          | 74                      |                        |                         | Seahawk                              | 64                      |
| LCS Artdeco                           | 6                       | <b>Checks</b>          |                         | AP Mondovi Cl2                       | 1                       |
| UI Magic Cl+                          | 3                       | Norstar                | 95                      |                                      |                         |
| SY Assure                             | 27                      | Eltan                  | 90                      | <b>Checks</b>                        |                         |
|                                       |                         | Stephens               | 31                      | Norstar                              | 99                      |
|                                       |                         |                        |                         | Eltan                                | 96                      |
|                                       |                         |                        |                         | Stephens                             | 92                      |
|                                       |                         |                        |                         | SY Gunsight                          | 6                       |

The survival ranking from these tests is highly correlated with field survival, but percent survival is relative to the checks in this test and is not the exact percent survival expected in the field. Field survival is expected to be higher.

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**Project PI(s):** Kim Garland-Campbell, Karen Sanguinet  
**Project initiation date:** July 2022  
**Project year (1 of 3-yr cycle):** 2

| Objective  | Deliverable  | Progress   | Timeline   | Communication  |
|--|--|--|--|--|
| Evaluate Washington Winter Cereal Variety trials, Washington Variety Testing hard spring wheat trials and Wheat regional nurseries for survival after freezing.      | Data collected, analyzed, reported to Cereal Variety Testing and to growers            | Data has been collected, analyzed and reported.  | 2023 reporting completed, 2024 trials are underway                             | Presentation at grower meetings, Wheat commission meetings, Wheat Life and Research Review. Published on WSU wheat variety selection tool Web-site. Paper in |
| Evaluate freezing tolerance of advanced breeding lines contributed by the WSU and USDA-ARS wheat and barley breeding programs.                                       | Data collected, analyzed, reported to Winter wheat breeding program                    | Data was collected, analyzed and returned to winter wheat breeding program. Waiting for submissions from Barley breeding program   | Data returned to breeding programs. 2024 trials are underway.                  | Email to breeding programs.  |
| Evaluate cold tolerance of F <sub>3</sub> -F <sub>5</sub> (early generation) wheat populations that are segregating for cold tolerance and select resistant progeny. | Tests run to determine correct temperatures for selection                              | Populations for screening have been selected   | Based on capacity, this objective may be postponed until summer 2024 and 2025. | Presentation at Research Review. Peer reviewed publications. Direct communication with wheat breeders.   |
| Identify genes controlling cold hardiness in winter wheat.   | Major genes identified and molecular markers. Development of breeder friendly markers. | Major genes for cold tolerance have been identified on chromosomes 1A, 1B, 1D, 2A, 2B, 2D, 3B, 3D, 4A, 4B, 5A, 5B, 6B, 7A, and 7B. | Additional screening of segregating populations is underway. Complete in 2024  | Presentation at Research Review. Peer reviewed publications and presentations  |

|  |   |   |   |  |
|--|---|---|---|--|
| Determine if UAV can be used to assess plant health in research trials in the spring and correlate with our freeze test results. | UAV flights in early spring analyzed for greenness and results correlated with Freeze test results. | UAV flights were conducted but need to be repeated earlier in the season. | Initial correlation results by Dec 2024, and complete in 2025 | Presentation at Research Review. Peer reviewed publications. Direct communication with wheat breeders. |
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