Distributions of Cold Tolerance in F_3 Wheat Populations

Daniel Z. Skinner and Kimberly Garland-Campbell

USDA-ARS Wheat Genetics, Quality, Physiology and Disease Research Unit
209 Johnson Hall, Washington State University
Pullman, WA 99164-6420
dzs@wsu.edu

Abstract The temperatures at which 50% of fully acclimated plants are killed (LT_{50}) were determined as -13.6C, -13.5C, and -9.5C, for cultivars 'El Tan,' 'Tiber,' and 'Oregon Feed Wheat #5' (ORFW), respectively. Thirty-one $F_{2:3}$ populations from the cross of El Tan X ORFW (E X O) and 31 from Tiber X ORFW (T X O) were acclimated and tested for ability to survive exposure to -12C soil temperature for one hour. The mean percentage survival for the two crosses were virtually identical. However, the mean survival of the T X O F_3 populations was less than the midparent while the mean survival of the E X O F_3 populations was greater than the midparent. Density plots of the F_3 survival percentages showed a bimodal distribution in both crosses with modes at about 10% survival and at 60-80% survival. The density plot of the composite data showed a trimodal distribution, reflecting differences in the two populations. These density plot results suggest polygenic inheritance of response to freezing with the majority of gene combinations conferring very little (ca. 10%) survival, but a slight propensity in favor of 60-80% survival as opposed to 40-50% survival. These results suggest different sets of genes are responsible for cold tolerance in 'Tiber' compared to 'El Tan,' even though the standard LT_{50} test results in virtually identical scores.

Materials and Methods
Cultivars 'El Tan' and 'Tiber' were crossed to 'Oregon Feed Wheat #5' including reciprocals. $F_{2:3}$ seed was planted to 30 X 50 cm flats, germination and seedling growth for 2 wk was at 23C, all flats were vernalized for 5 wk at 4C. Plants were then counted, shoots were removed, soil was watered and allowed to drain, and temperature probes were inserted into each flat. Soil temperature was then lowered to -12C over 36 h, held at -12C for 1h, then warmed to 4C over 9h. Flats were transferred to a greenhouse, survival was evaluated after 5wk recovery. Thirty-one F_3 populations from each cross were evaluated. The entire experiment was repeated twice. A total of 105,701 F_3 plants comprised the experimental material. The three parents (four flats each) were included.

Results
Table 1. ANOVA:

Source	DF	SS	MS	F	Pr > F
Crosses	6	1.08	0.18	3.04	0.0083
Reps	1	0.02	0.02	0.37	0.54
Error	126	7.46	0.06		
Total	133	8.54			

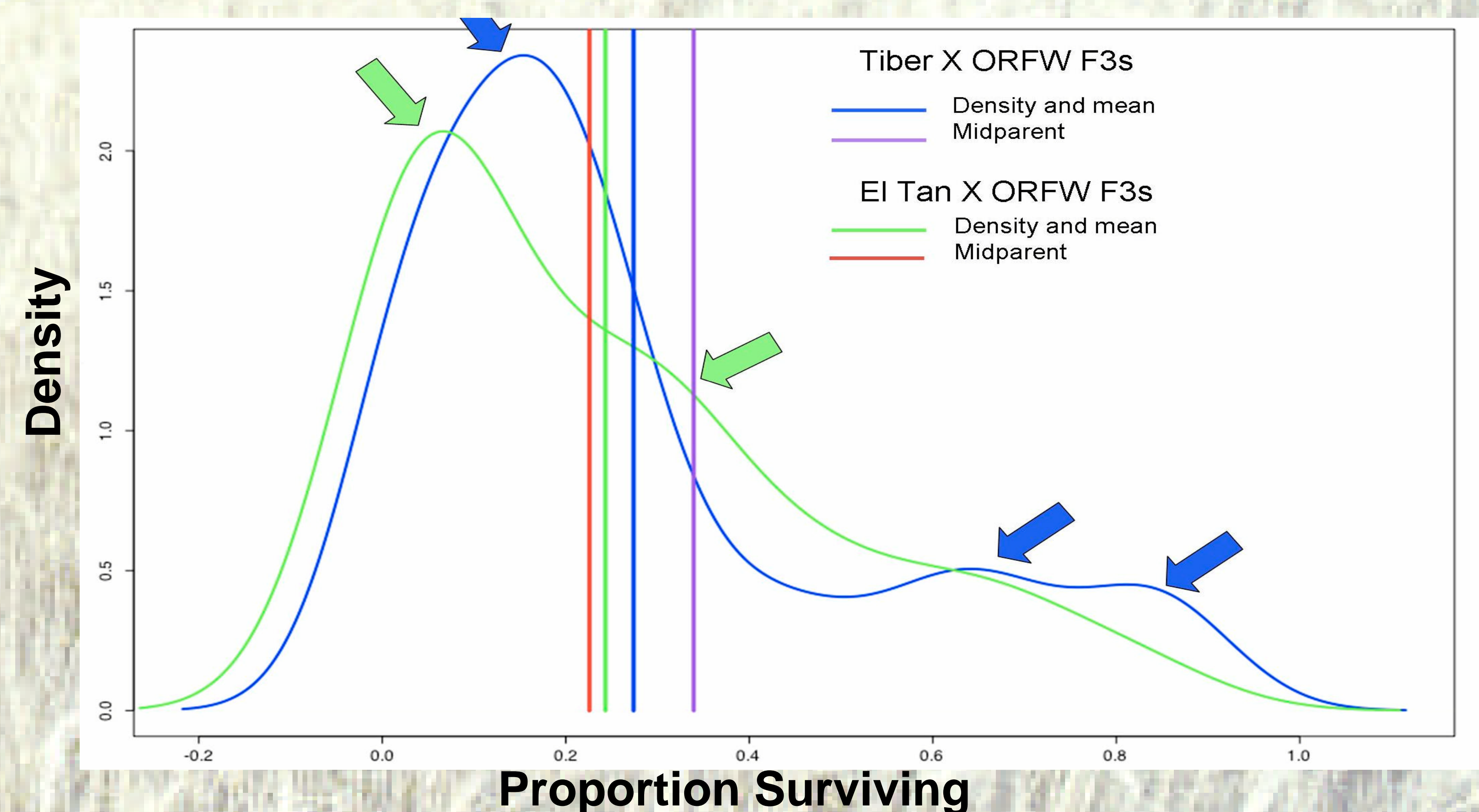| Duncan Grouping (P=0.05)		Mean Proportion Surviving	N	Cross or Cultivar
	A	0.6590	4	Tiber
B	A	0.4315	4	Eltan
B		0.2975	30	Tiber X ORFW
B	C	0.2643	31	Eltan X ORFW
B	C	0.2511	31	ORFW X Tiber
B	C	0.2216	30	ORFW X Eltan
	C	0.0199	4	ORFW

Figure 2. Density distributions, means, and midparents of proportions of acclimated F_3 populations that survived freezing to −12C. Arrows indicate local maxima in the density distributions of the same color.

Figure 1. Flats of acclimated F_3 populations prepared for freezing survival test. Shoots have been removed and temperature probes have been placed in the soil. Soil temperature was monitored and air temperature was adjusted to reach target soil temperature within the described time frame.

Discussion
Although 'Tiber' and 'El Tan' were indistinguishable in standard LT_{50} tests, local maxima in survival density distributions of F_3 populations differed, and the mean of the T X O F_3 was less than the midparent while the E X O mean was slightly greater than the midparent (Fig. 2). These results suggested different genes conditioned cold tolerance in these parent lines.