Combining Ability for Tolerance to Pre-Harvest Sprouting in Wheat

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INTRODUCTION

- Pre-harvest sprouting (PHS) of wheat (*Triticum spp*.), the premature germination of wheat spikes, takes place under condition of high humidity during senescence.
- PHS can have large negative economic effects on both farmers and end-users.
- Wheat breeders have tried to diversify the wheat production system in the Great Plains by introducing hard white winter wheat cultivars.
- Hard white winter wheats typically are less tolerant of pre-harvest sprouting than hard red wheats.
- The adapted hard red winter wheat gene-pool, however, might serve as a reservoir of genes for tolerance to PHS, independent of genes conditioning seed coat color.

OBJECTIVE

- Evaluate red wheats for their potential to donate genes for tolerance to PHS, independent of those conditioning red grain colors.

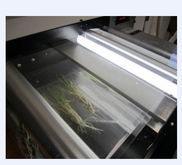
MATERIALS AND METHODS

- A factorial (M×N) mating scheme (Simmonds, 1979) was employed in which the hard white wheats (Nuplains, NW99L7068, RioBlanco, Cayuga, NW97S218, and Peck) were mated in all combinations to the hard red wheats (Niobrara, Wesley, Arapahoe, NE98466, CO960293-2, Jagalene, NI01812, and Plainsman V).
- The hard red winter wheat cultivars Alliance, Arapahoe, Jagalene, Overland, Pronghorn and Wesley; and the hard white cultivars Antelope, Nuplains, Anton, RioBlanco, Platte and Trego were included as checks.
- Seed of progeny was sorted using an automated seed sorting device to obtain pure hard white populations. Tolerance to PHS was assessed in samples obtained from four Nebraska environments, using both a misting chamber assay.

Misting chamber assay

- Tolerance to preharvest sprouting was assessed from F_5 and F_6 populations grown at Mead, NE in 2010 and 2011, as per Graybosch et al. (2011).
- At physiological maturity, which was identified by the loss of chlorophyll from the peduncle, 20 spikes were snapped per plot, dried at 32C, and stored -20 C until they were placed in a misting chamber for 7 days.

- Spikes at PM



- Li-cor 3100 Leaf Area Meter, used to measure "before" treatment area of 10 spikes

- Misting Chamber room, 7 days

- Measure " after" spike area. Δ = area after – area before

- Δ values were calculated as the change in spike area after 7 days in misting chambers, due to seedling growth.
- Lower Δ values were indicative of greater tolerance to preharvest sprouting. Calculated GCA values were multiplied by -1 so that positive GCA indicates more favorable combining ability for PHS tolerance.
- Statistics: SAS version 9.2, 3 way ANOVA; calculation of general combining ability (GCA) and heritabillty as per Simmonds (1979).

Table 1 Factorial analysis of variance for Δ values in two environments (2010 and 2011)

Type III Tests of Fixed Effects			
Effect	**Num DF**	**F Value**	**Pr > F**
ENV*	1	36.61	0.004
RPAR	7	3.5	0.002
WPAR	5	5.29	<0.001
RPAR*WPAR	35	1.78	0.008
ENV*RPAR	7	0.88	0.527
ENV*WPAR	5	0.55	0.738
ENV*RPAR*WPAR	35	0.91	0.612

* RPAR= red parent, WPAR = white parent, ENV =environment error mean squares *(EMS)* = 141

Table 2 Heritability of Δ values (2010 and 2011)

Heritability*	
Check Cultivars	0.86
Populations	0.60

* Entry means basis

RESULTS 1

- The main effects, red parents, white parents, red × white interaction, and environments, were highly significant.
- No significant interactions of environment with genotype were observed. Therefore, subsequent analyses were combined over environments (Table 1). Δ values heritability were high (Table 2).

Table 3 Population means and general combining ability for Δ values (2010 and 2011)

Δ values (cm^2) of a 10-spike sample									
WPAR \ RPAR	**Arapahoe**	**CO960293-2**	**Jagalene**	**NE98466**	**NI01812**	**Wesley**	**Niobrara**	**Plainsman V**	**GCA(-1)****
Cayuga	61.9*	46.4	39.1	51.6	50.9	48.0	51.5	39.0	**-3.2**
Nuplains	39.9	62.1	38.2	29.6	35.8	47.4	39.1	38.0	**4.1**
NW97S218	42.8	53.7	38.1	47.2	41.7	46.6	42.7	38.7	**1.4**
NW99L7068	47.5	56.7	46.2	46.3	50.4	49.6	40.1	55.2	**-3.6**
Peck	63.3	39.3	54.1	48.5	52.5	51.3	40.4	41.4	**-3.4**
RioBlanco	48.1	41.7	37.3	38.4	47.3	38.5	41.8	32.7	**4.7**
GCA(-1)**	**-5.2**	**-4.6**	**3.2**	**1.8**	**-1.0**	**-1.5**	**2.8**	**4.6**	

* Std Error = 5.0

** Calculated GCA values were multiplied by -1 so that positive GCA indicates more genes for PHS tolerance

RESULTS 2

- Four hard red winter wheats, Plainsman V, Jagalene NW98499 and Niobrara, showed favorable GCA.
- Among white winter wheats, RioBlanco and Nuplains showed the most favorable GCA. NW99L7068, Peck and Cayuga white winter wheat did not have favorable GCA values.
- Cayuga and Peck, previously described as tolerant, did not display favorable GCA. This could be due to poor adaptation to Great Plains environments (Table 3).

CONCLUSIONS

- Among red wheats, Plainsman V, Jagalene, Niobrara and NE98466 donated PHS tolerance to hard white wheats, independent of genes conferring red seed coat.
- Among white wheats, RioBlanco, and Nuplains, had favorable GCA for PHS tolerance. Both carry the PHS gene(s) on chromosome 3As (Graybosch et al., 2013).

REFERENCES

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