Backcrossing Linkage Blocks of Stem Rust Resistance Genes for United States Spring Wheat

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Background

- United States spring wheat has historically been vulnerable to widespread epidemics of wheat stem rust causing over 50% yield loss over Minnesota, North Dakota, and South Dakota during epidemic years.
- Though conventional US spring wheat varieties are resistant to races of the wheat stem rust pathogen, *P. graminis* f. sp. *triciti*, present in the US, nearly all US spring wheat lines are susceptible to foreign virulent races such as Ug99.
- The number of Ug99-effective wheat stem rust resistance genes has increased from 22 to 45 in the past 13 years. Despite this research progress, most United States spring wheat cultivars and advanced breeding lines remain susceptible to foreign virulent races of the stem rust pathogen.
- Multiple stem rust resistance genes need to be utilized in gene combinations to avoid rapid loss of effectiveness of resistance genes
- Linkage blocks of multiple Ug99-effective stem rust resistance genes can be utilized in backcrossing to introgress multiple stem rust resistance genes into US spring wheat..

Objective

Protect US spring wheat from foreign virulent isolates of the stem rust pathogen by deriving elite resistant germplasm through backcrossing linkage blocks of multiple stem rust resistance genes into modern varieties.

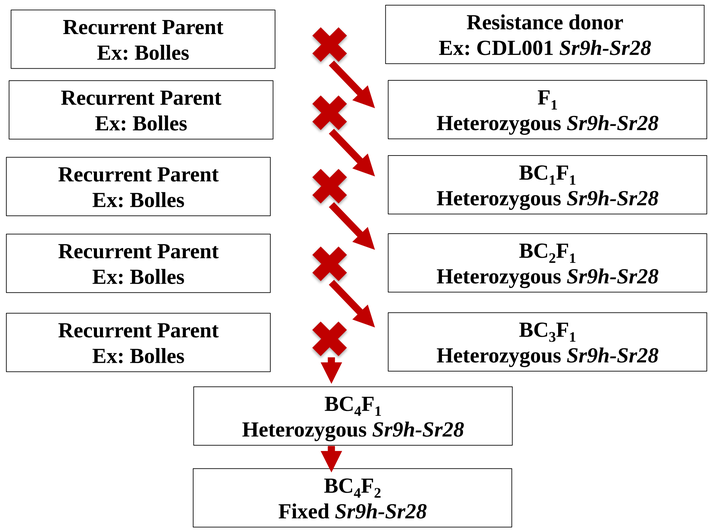

Figure 1. Backcrossing scheme utilized to introgress two linkage blocks of pairs of Ug99-effective stem rust resistance genes *(Sr9h-Sr28* and *Sr15-Sr22)* into US spring wheat cultivars.

Materials and Methods

- Wheat lines CDL001 and CDL002 were used as donor parents in a backcrossing scheme (Figure 1). CDL001 possesses Ug99-effective stem rust resistance genes *Sr9h* and *Sr28* combined in coupling on chromosome arm 2BL. CDL002 possesses Ug99-effective *Sr15* and *Sr22* combined in coupling on chromosome arm 7AL.
- Wheat varieties ‘Linkert’, ‘Lang-MN’, and ‘Bolles’ were obtained from the University of Minnesota whereas ‘Advance’, ‘Forefront’, and ‘Prevail’ were obtained from South Dakota State University.
- The *Sr9h-Sr28* linkage block was backcrossed to the BC_4 generation for backgrounds Linkert, Bolles, Advance, and Forefront whereas the *Sr15-Sr22* linkage block was backcrosssed to the BC_4 generation in backgrounds Linkert, Lang-MN, and Prevail.
- KASP markers (Figure 2) linked to *Sr9h*, *Sr15*, and *Sr28* and STS markers linked to *Sr22* were used to select for the genes in marker-assisted backcrossing. Markers were employed beginning at the BC_1F_1 generation, though the BC_4F_2 generation.
- Four lines with and without (eight total) the desired linkage blocks were derived for each background and evaluated for stem rust resistance at the seedling stage and in the field in Africa.
- BC_4F_5 seed increases of the *Sr9h-Sr28* derived lines were planted in replicated yield trials in two locations in South Dakota (Figure 3) and two locations in Minnesota in 2020. Traits measured will include yield, protein, and test weight.

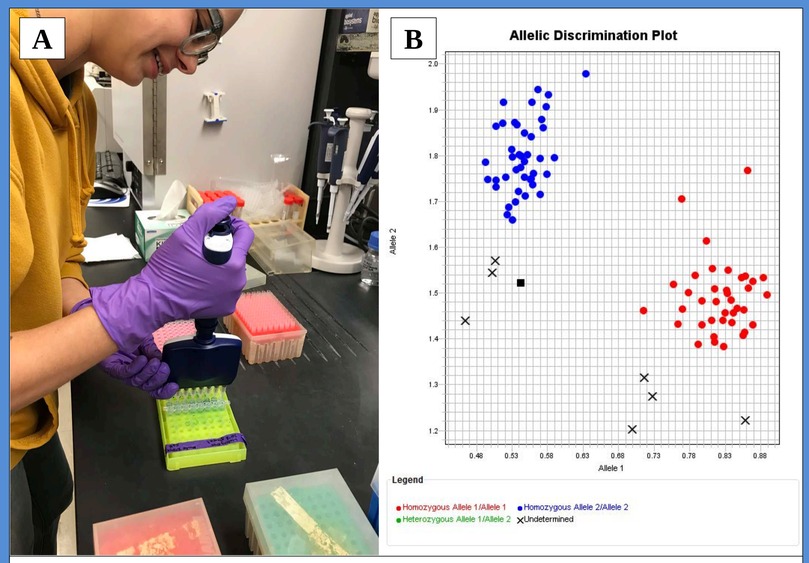

Figure 2. (A) Marker-assisted backcrossing necessitated extraction of DNA from plants of each generation and (B) assessment of KASP markers using a real time PCR machine.

Figure 3. (A) Five generations of crosses were maintained in a greenhouse and **(B)** subsequent seed increases of fixed lines with and without the linkage blocks were evaluated in replicated yield trials at four locations in two states (Brookings, SD pictured).

Results

- A total of sixteen lines with *Sr9h-Sr28* were derived in four spring wheat backgrounds (Linkert, Bolles, Advance, Forefront).
- A total of twelve lines with *Sr15-Sr22* were derived in three spring wheat backgrounds (Linkert, Lang-MN, Prevail).
- Lines screened at the seedling stage with Ug99 (race TTKSK) of the stem rust pathogen were resistant if they possessed the linkage blocks, but susceptible if they did not possess the linkage blocks.

Conclusions

- The fixed lines with linkage blocks of Ug99-effective stem rust resistance genes have been used as parents in crossing blocks of spring wheat breeding programs.
- Deployment of Ug99-effective stem rust resistance genes in U.S. spring wheat could protect U.S. wheat production from a stem rust epidemic if a member of the Ug99 race group were to arrive in the United States.

Acknowledgements

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