

# Winter Wheat Breeding and Variety Development

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**Report type:** Annual progress report

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## Research Summary:

The objective of the winter wheat breeding program at South Dakota State University is to develop high-yielding winter wheat varieties with excellent disease resistance and suitable end-use quality for the domestic and export markets. Two newly released wheat varieties, Oahe (released in 2016) and Thompson (released in 2017) from SDSU performed well in 2018 CPT trials along with Ideal (2011). Oahe has excellent disease resistance package being moderately resistant to stripe rust, leaf rust and Wheat Streak Mosaic Virus (WSMV) and is moderately resistant to moderately susceptible to FHB but better than Wesley and Ideal. On the other hand, Thompson has a good yield potential with good straw strength and moderate resistance to leaf and stem rust. Oahe and Thompson are expected to offer the producers a higher yielding and more disease resistant alternative to popular varieties grown in South Dakota. Several advanced breeding lines with high yield potential and excellent disease resistance were also evaluated across South Dakota and in the Northern Great Plains. The two most promising of these lines are being increased for potential release in summer of 2019.

## Introduction:

Winter wheat is one of the most important cereal food crops of economic significance for South Dakota with 830,000 acres planted and yield of 48 bu/ac in 2018. To increase the profitability of South Dakota wheat producers, and to increase South Dakota wheat production from its current level, it is essential to develop and release stable high-yielding varieties adapted to South Dakota's environment, resistant to prevalent diseases and pests, and with excellent end-use quality. The objective of the breeding program at South Dakota State University (SDSU) is to develop winter wheat varieties adapted to South Dakota that exhibit:

- high and stable yield,
- resistance to the prevalent fungal, bacterial, and viral disease pathogens,
- and excellent quality for bread, wheat flour tortillas, and other emerging end-use markets.

## Description of Accomplishments:

During this reporting period, 710 unique wheat hybridizations ( $F_1$ 's), including several novel crosses were made to improve winter hardiness, stripe rust, and FHB resistance and end-use quality of winter wheat. The breeding operation is cyclic, with nearly 643 new  $F_2$  populations developed from crosses made in 2016 and 2017, were evaluated at Brookings, SD. In 2018, selections were performed in segregating generations from 274  $F_3$  populations at three locations (Brookings, SD; Dakota Lakes, SD; and Castroville, TX) and nearly 50-100 individual ears were selected from each population. Further selections were performed on 15,220 head rows at Brookings location. Reselections were performed on 1,998 short 4-row plots for advancing lines for first yield trial. Early yield trials (EYT) were conducted on 760 new breeding lines along with checks (980 plots) at Dakota Lakes and Brookings in single replication. Preliminary (PYT) and Advanced Yield Trials (AYT) were conducted at seven locations where more than 156 elite lines were evaluated for yield potential and stability, levels of disease and abiotic stress resistance, as well as increased end-use quality parameter values in several local or

regional nurseries. The top 10 performing experimental lines from 2017 AYT were evaluated across 16 locations (under CPT) in South Dakota. Breeding lines from the PYT, AYT and CPT nurseries are tested for grain yield potential, test weight, protein content, and end-use quality characteristics. Depending on the stage of the breeding program, we recorded phenotypic data for agronomic performance, disease resistance (stripe rust, leaf rust, stem rust, FHB, tan spot, WSMV), and end-use quality to ensure that lines with the highest potential are advanced to the next generation.

The yield trials performed in 2018:

- **Early Yield Trial (EYT):** 980 entries evaluated at 2 South Dakota locations.
- **Preliminary Yield Trial (PYT):** 120 entries evaluated at 7 South Dakota locations.
- **Advanced Yield Trial (AYT):** 36 entries evaluated at 7 South Dakota locations.
- **Crop Performance Trial (CPT):** 38 entries including 10 SDSU advanced breeding lines were planted at 16 South Dakota locations.

Comparisons over years and locations are made with respect to the check cultivars and top 10 best entries are moved to CPT and regional nurseries where they are evaluated for agronomic performance for 2-3 years at 15-17 locations across South Dakota and 15 Northern Regional Performance Nursery (NRPN) locations across 6 northern states. Lines with superior performance for 2-3 years are considered for potential release after seed increase through SD Foundation Seed Stocks Division.

In 2018 CPT trials, South Dakota material performed well and four of the top five entries were from SDSU. SD141115-5 ranked 4<sup>th</sup> in both eastern and central SD but did not do well in western South Dakota, whereas, SD141113-3 ranked 11<sup>th</sup> based on average yield over all locations but ranked 9<sup>th</sup> in central SD and 11<sup>th</sup> in western SD. Combined analysis over two years of CPT trials (2017 and 2018) showed SD141115-5 ranked 3<sup>rd</sup> overall and SD141113-3 ranked 4<sup>th</sup> overall across 31 location-years. SD141113-3 and SD141115-5 are moderately resistant to stripe and stem rust, but likely carry APR (adult plant resistance) to leaf rust (*Lr46*).

In 2018 Northern Regional Performance Nursery (NRPN), four SDSU entries SD13W064-7, SD13062-2, SD141115-5, and SD141113-3 ranked 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 5<sup>th</sup>, respectively based on overall mean yield out of 45 entries tested across 10 locations (whose data is available). Additionally in 2017 NRPN, SD141115-5 ranked 2<sup>nd</sup> overall among 45 entries in the NRPN (Table 1). Two of the top five entries in the NRPN trial were from SDSU winter wheat breeding program.

### **Projections:**

To increase the scale and pace of variety development we have significantly increased the number of populations developed and early yield trials (EYT) of 500 new advanced lines have been planted in two locations, Brooking and Dakota Lakes. Seven new elite breeding lines have been advanced to South Dakota CPT and NRPN trials. As of fall 2018, two experimental breeding lines (SD141113-3 and SD141115-5) are under final seed increase for potential release in the summer of 2019 and another four breeding lines are under a small 1.5-acre increase.

### **Publications:**

Appels, R., Eversole, K., Feuillet, C., Keller, B., Rogers, J., Stein, N., Pozniak, C.J., Choulet, F., Distelfeld, A., Poland, J., Ronen, G., Sharpe, A.G., Pozniak, C., Barad, O., Baruch, K., Keeble-Gagnère, G., Mascher, M., Ben-Zvi, G., Josselin, A.-A., Himmelbach, A., Balfourier, F., Gutierrez-Gonzalez, J., Hayden, M., Koh, C., Muehlbauer, G., Pasam, R.K., Paux, E., Rigault, P., Tibbits, J., Tiwari, V., Spannagl, M., Lang, D., Gundlach, H., Haberer, G., Mayer, K.F.X., Ormanbekova, D.,

Prade, V., Šimková, H., Wicker, T., Swarbreck, D., Rimbart, H., Felder, M., Guilhot, N., Kaithakottil, G., Keilwagen, J., Leroy, P., Lux, T., Twardziok, S., Venturini, L., Juhász, A., Abrouk, M., Fischer, I., Uauy, C., Borrill, P., Ramirez-Gonzalez, R.H., Arnaud, D., Chalabi, S., Chalhoub, B., Cory, A., Datla, R., Davey, M.W., Jacobs, J., Robinson, S.J., Steuernagel, B., van Ex, F., Wulff, B.B.H., Benhamed, M., Bendahmane, A., Concia, L., Latrasse, D., Alaux, M., Bartoš, J., Bellec, A., Berges, H., Doležel, J., Frenkel, Z., Gill, B., Korol, A., Letellier, T., Olsen, O.-A., Singh, K., Valárik, M., van der Vossen, E., Vautrin, S., Weining, S., Fahima, T., Glikson, V., Raats, D., Číhalíková, J., Toegelová, H., Vrána, J., Sourdille, P., Darrier, B., Barabaschi, D., Cattivelli, L., Hernandez, P., Galvez, S., Budak, H., Jones, J.D.G., Witek, K., Yu, G., Small, I., Melonek, J., Zhou, R., Belova, T., Kanyuka, K., King, R., Nilsen, K., Walkowiak, S., Cuthbert, R., Knox, R., Wiebe, K., Xiang, D., Rohde, A., Golds, T., Čížková, J., Akpinar, B.A., Biyiklioglu, S., Gao, L., N'Daiye, A., Kubaláková, M., Šafář, J., Alfama, F., Adam-Blondon, A.-F., Flores, R., Guerche, C., Loaec, M., Quesneville, H., Condie, J., Ens, J., Maclachlan, R., Tan, Y., Alberti, A., Aury, J.-M., Barbe, V., Couloux, A., Cruaud, C., Labadie, K., Mangenot, S., Wincker, P., Kaur, G., Luo, M., Sehgal, S., Chhuneja, P., Gupta, O.P., Jindal, S., Kaur, P., Malik, P., Sharma, P., Yadav, B., Singh, N.K., Khurana, J., Chaudhary, C., Khurana, P., Kumar, V., Mahato, A., Mathur, S., Sevanthi, A., Sharma, N., Tomar, R.S., Holušová, K., Plíhal, O., Clark, M.D., Heavens, D., Kettleborough, G., Wright, J., Balcárková, B., Hu, Y., Salina, E., Ravin, N., Skryabin, K., Beletsky, A., Kadnikov, V., Mardanov, A., Nesterov, M., Rakitin, A., Sergeeva, E., Handa, H., Kanamori, H., Katagiri, S., Kobayashi, F., Nasuda, S., Tanaka, T., Wu, J., Cattonaro, F., Jiumeng, M., Kugler, K., Pfeifer, M., Sandve, S., Xun, X., Zhan, B., Batley, J., Bayer, P.E., Edwards, D., Hayashi, S., Tulpová, Z., Visendi, P., Cui, L., Du, X., Feng, K., Nie, X., Tong, W. and Wang, L. (2018) Shifting the limits in wheat research and breeding using a fully annotated reference genome. *Science*, 361.

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Table 1. Northern Regional Performance Nursery results for 2017

Entry	Line	Grain Yield		Grain Volume Weight	
		Mean (kg/ha)	Rank	Mean (kg/hl)	Rank
1	Kharkof	2756	43	75.5	26
2	Overland	4170	14	75.9	32
3	Wesley	3346	39	73.2	7
4	Jagalene	3817	33	77.2	43
5	Jerry	3242	40	72.9	5
6	N13MD2589W	2757	42	76.2	35
7	Overland FHB-10	3939	29	76.5	38
8	NE13434	4168	16	75.5	28
9	NE13604	4227	10	75.1	20
10	NE14448	3908	31	74.9	18
11	NE14434	4303	6	75.4	25
12	NE14538	4178	13	75.9	33
13	NE14606	4282	8	74.6	15
14	NE14663	4112	19	75.5	27
15	NHH144913-3	4296	7	72.0	2
16	PSB13NEDH-7-140	4326	3	76.4	36
17	PSB13NEDH-7-45	4233	9	74.8	17
18	LCH14-052	4036	24	76.7	41
19	LCH14-055	3848	32	73.7	9
20	LCH14-077	4191	12	75.3	24
21	LCH14-089	4002	26	77.1	42
22	AP-16CP010080	4082	20	76.6	40
23	AP-16CP010076	4319	5	75.1	21
24	AP-16CP010077	4322	4	75.3	23
25	AP-16CP010074	3940	28	76.4	37
26	14Nord-01	3366	38	76.6	39
27	15Nord-08	3451	36	74.6	16
28	15Nord-25	3137	41	74.4	13
29	15Nord-32	2704	44	70.1	1
30	SD110060-7	4059	22	75.1	19
31	SD10W153	3719	34	74.3	11
32	SD12008-2	4125	18	77.5	44
33	SD13052-1	4169	15	74.6	14
34	SD13062-2	4220	11	76.0	34
35	SD13090-7	3948	27	75.6	29
36	SD13117-1	4144	17	75.6	30
37	SD13W064-7	4372	1	74.3	12
38	SD14113-3	4022	25	75.2	22
39	SD14115-5	4351	2	75.9	31
40	MT1444	4038	23	73.8	10
41	MT1465	3599	35	72.0	3
42	MT1471	4065	21	73.4	8
43	MT1488	3423	37	73.2	6
44	MTW1491	3918	30	72.5	4
	Mean	3896		75.0	