ITEMS FROM PAKISTAN

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Evaluation of synthetic wheat lines under normal irrigated conditions.

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Wheat is the most widely grown cereal in Pakistan. Abiotic and biotic stresses, especially rust diseases, are the main reasons for a low average national yield. Therefore, a dire need exists to develop genotypes with improved resistance to these diseases along with high yield potential. Synthetic hexaploid wheat (man-made wheat) is a novel source of wheat germplasm that may be used as a resource to break the yield barrier in the wheat crop. These synthetics (2n = 6x = 42; AABBDD) are a globally recognized, potent genetic stock and are used by several wheat-breeding programs (Mujeeb-Kazi et al. 2008, Trethowan and Mujeeb-Kazi 2008; Ogbonnaya et al. 2013).

The Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan, is working on wheat improvement and has developed high-yielding recombinants; some promising ones contributing in multilocation microtrials. In addition, a large number of recombinants and synthetics were evaluated in different trials/generations. In the current studies, synthetic lines were evaluated in two different field experiments. The first experiment consisted of a set of 13 wheat-breeding introductions, advanced synthetic-derived lines, and two check cultivars (Punjab-2011 and Galaxy-2013) sown in six 6-m rows with a row-to-row distance of 30 cm and plot size of 10.8 m^2. In the second experiment, 35 synthetic-derived lines were tested in the field along with the two check cultivars sown in a 4.95 m^2 plot. The material was sown in November 2013. Data were recorded on days-to-heading, plant height (cm), tiller number, spike length (cm), number of grains/spike, 1,000-kernel weight (g), grain yield (kg/ha), harvest index (%), and reaction to leaf rust, yellow rust, and stem rust.

Experiment I. The data of 13 synthetics, along with two checks, are presented (Table 1, p. 37). All synthetic lines were early heading compared to the checks, except four lines that were similar. Maximum plant height and tiller number were noticed in Nepal-AL/249, whereas Ehydral/13 and Kazi-09 were better for spike length and number of grains/spike, respectively. The 1,000-kernel weight ranged from 31.0 g to 51.8 g among the synthetic lines. Six lines (Kazi-09, EM, IBT-S/1069, Ehydral/13, ITMI/71, and Nepal-AL/186) all had a 1,000-kernel weight above 40.0 g and acceptable grain yield, and were selected for further evaluation in replicated yield trails next year.

Experiment II. A wealth of variability was observed in the synthetic-derived lines, represented by the range of various morpho-agronomic traits (Table 2, p. 37-38). Entry 140 had the earliest number of days-to-heading. Taller (plant height ≥110 cm) entries with good seed size and higher grain yield, such as entries 30, 42, 44, 47, 52, 64, 123, 129, 147, and

Table 1. Morpho-agronomic traits of the advanced, synthetic-derived wheat lines (DH, days-to-heading; PH, plant height; TIL, tiller number; SL, spike length; NGPS, number of grains/spike; TKW, 1,000-kernel weight; and GY, grain yield).

Entry	DH	PH (cm)	TIL	SL (cm)	NGPS	TKW (g)	GY (kg/ha)
Kazi-09 (5-101)	103	101.4	235	12.3	67	41.4	4,155
EM	101	91.8	216	11.9	74	47.6	3,484
IBT-S/1069 (5-133)	102	100.2	210	13.3	60	43.0	3,399
Nepal-AL/249	108	113.8	265	11.2	48	39.0	3,502
9X1/36	107	100.6	213	10.8	55	38.2	3,324
T/FCT/18	127	99.4	211	10.8	59	38.4	2,754
Ehydral/13 (5-151)	124	101.0	232	13.7	64	47.6	3,336
Nepal-AL/247	108	111.6	224	11.8	60	37.6	3,334
Nepal-AL/268	128	99.0	212	12.2	60	43.8	2,451
ITMI/71	126	104.6	240	12.3	46	51.8	3,265
Nepal-AL/186	105	102.6	235	12.6	48	44.6	3,694
9X1/26	107	99.0	238	10.6	48	39.8	2,841
T/FCT/73	109	100.4	215	11.4	63	31.0	2,737
Galaxy-2013 (check)	127	103.0	208	13.6	51	49.0	3,650
Punjab-2011 (check)	127	97.8	197	12.4	68	44.2	3,422

Table 2. Morpho-agronomic traits and disease performance of bread wheat x synthetic-derived wheat lines. Mean, range, and standard deviation of the synthetic derivatives also are presented at the bottom of the table (DH, days-to-heading; PH, plant height; TIL, tiller number; SL, spike length; NGPS, number of grains/spike; TKW, 1,000-kernel weight; GY, grain yield; HI, harvest index; Lr, reaction to leaf rust; Yr, reaction to yellow rust; and Sr, reaction to stem rust).

Entry	DH (50%)	PH (cm)	TIL	SL (cm)	NGPS	TKW (g)	GY (kg/ha)	HI (%)	Lr	Yr	Sr
25	99	115	164	10.4	53.4	43.6	2,283	20	0	0	0
28	103	99	276	10.7	67.4	36.8	4,212	38	0	0	0
30	98	114	239	12.1	56.6	46.4	3,464	32	0	0	0
37	104	122	230	12.4	58.2	38.8	1,788	21	0	0	0
39	108	110	300	11.1	57.6	42.0	3,626	28	0	0	0
42	105	117	387	8.6	56.2	39.6	4,464	28	0	0	0
43	105	112	286	9.3	53.4	40.4	3,283	31	0	0	0
44	105	111	203	9.4	63.8	39.2	3,434	33	0	0	0
45	102	109	201	11.4	49.6	52.0	3,091	34	20R	0	0
47	102	113	316	12.7	50.2	49.0	3,858	32	10R	0	0
49	106	110	141	9.7	60.4	38.2	3,111	33	0	0	0
52	101	114	195	12.2	49.2	50.8	3,747	36	10R	0	0
64	99	115	259	12.0	54.2	46.0	3,313	31	0	0	0
73	102	83	273	11.2	64.8	36.2	3,343	36	0	0	0
74	107	100	223	11.5	54.0	41.8	3,081	33	0	0	0
76	103	98	265	11.6	55.8	41.8	3,343	36	0	0	0
83	98	104	188	10.9	44.8	47.8	2,374	32	0	0	0
84	99	113	245	11.8	47.4	45.6	3,010	31	0	0	0
90	100	112	201	10.2	61.4	41.4	2,949	26	0	0	0
109	98	107	241	11.5	59.2	38.4	3,515	35	0	0	0
116	102	110	100	11.4	56.8	32.8	1,737	26	0	0	0
117	102	107	166	11.3	67.6	35.2	1,990	29	0	0	0
120	104	108	365	12.1	78.4	33.0	2,475	29	0	0	0
121	105	106	217	13.1	57.8	34.8	3,121	33	0	0	0
123	106	112	235	13.3	61.0	42.6	4,424	32	0	0	0
125	102	106	240	11.1	62.6	39.4	3,919	32	0	0	0
126	101	109	225	11.7	63.2	39.4	3,313	38	0	0	0

Table 2. Morpho-agronomic traits and disease performance of bread wheat x synthetic-derived wheat lines. Mean, range, and standard deviation of the synthetic derivatives also are presented at the bottom of the table (DH, days-to-heading; PH, plant height; TIL, tiller number; SL, spike length; NGPS, number of grains/spike; TKW, 1,000-kernel weight; GY, grain yield; HI, harvest index; Lr, reaction to leaf rust; Yr, reaction to yellow rust; and Sr, reaction to stem rust).

Entry	DH (50%)	PH (cm)	TIL	SL (cm)	NGPS	TKW (g)	GY (kg/ha)	HI (%)	Lr	Yr	Sr
129	102	110	243	11.2	64.4	40.2	3,818	32	0	0	0
130	104	107	280	13.0	57.6	41.4	3,010	32	0	0	0
136	100	105	237	11.4	58.8	38.4	3,212	36	0	0	0
140	95	107	275	11.8	60.0	43.6	3,141	26	0	0	0
142	104	105	215	13.6	67.6	39.0	2,818	34	0	0	0
147	105	113	224	12.0	64.8	36.0	3,757	34	0	0	0
150	100	116	237	14.2	49.2	45.4	2,727	26	0	0	0
158	101	113	246	13.5	61.4	46.0	3,909	33	0	0	0
Punjab-2011	103	104	225	13.6	70.4	37.4	3,000	33	0	0	0
Galaxy-2013	102	108	226	13.3	56.3	46.5	3,882	38	0	0	0
Mean (synthetics)	102	109	238	11.6	58.5	41.2	3,264	32	0	0	0
Range (synthetics)	95–108	83–122	100–387	8.6–14.2	44.8–78.4	32.8–52.0	1,737–4,464	20–38	0	0	0
Standard deviation (synthetics)	±2.9	±6.8	±56.0	±1.2	±6.9	±4.8	±702	±4.4	0	0	**0**

158, are worth testing under drought conditions. Maximum tiller numbers were recorded in entries 42 (387) and 47 (316) when compared to checks Punjab-2011 (225) and Galaxy-2013 (226). Entry 42 also was the highest yielder, whereas the yeild of entry 47 was equal to that of the better check Galaxy-2013. Almost all the synthetic derivatives had comparatively shorter and more compact spikes than those observed in the checks. The selected synthetics were either equal to or higher in number of grains/spike or bold seed size, which contributed to thier higher grain yield. Entry 158 produced a higher number of grains/spike, a similar seed size, and was higher in yield compared to the Galaxy-2013 check. The maximum seed weight was observed in entry 52, which was coupled with a higher grain yield than both check cultivars. The highest grain yield was produced by entry 42 (4,464 kg/ha), followed by entries 123 (4,424 kg/ha) and 28 (4,212 kg/ha). Among the synthetic derivatives, entry 28 also had the maximum harvest index (38%), which is similar to the commercial check Galaxy-2013. No severe rust attack was observed in the synthetic derivatives and checks. Fifteen superior synthetics, entries 28, 30, 42, 44, 45, 47, 52, 64, 73, 76, 123, 125, 129, 147, and 158, with acceptable seed size/color and a yield higher than that of Punjab-2011, were finally selected. These selected synthetics are planted in replicated yield trials at NIAB, Faisalabad, for evaluation during the 2014–15 crop cycle.

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Field evaluation of synthetic and durum wheat lines in replicated yield trial.

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To broaden the genetic base of bread wheat, D-genome synthetic (2n=6x=42;AABBDD) derivatives and durum wheat advanced breeding lines were included in the wheat improvement program of the Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, during 2013–14. In this study, 65 wheat genotypes, including synthetic-derived wheat

lines, durum, and five check cultivars (Punjab-2011, Millat-2011, Galaxy-2013, Fakhr-e-Sarhad, and Lasani-2008), were evaluated in a preliminary yield trial under irrigated conditions. The trial was laid out in an alpha-lattice design with two replications keeping a row distance of 30 cm and plot size of 4.95 m^2. The material was planted on 18 November, 2013, at NIAB, Faisalabad. Irrigation was applied as and when required by the crop. Data were recorded on days-to-heading, plant height (cm), 1,000-kernel weight (g), grain yield (kg/ha), leaf rust, yellow rust, and stem rust. Five random plants/replication were used for the measurements of PH, whereas all other traits were recorded on plot basis.

Enormous genetic variability for days-to-heading (98–113), plant height (82.7–119.7), 1,000-kernel weight (30.9–51.8), and grain yield (2,293–4,062) were observed among the tested material (Table 3, pp. 39-40). Seven genotypes showed were greater than 108 days-to-heading compared to 104 days for the bread wheat check Galaxy-2013. Three genotypes were taller than 110 cm, which also are worth evaluating under drought. Forty-five of the test genotypes produced 1,000-kernel weights in the range of 40–51.8 g, compared to 36.7 g for the check Lasani-2008. Genotype 69 (Fakhr-e-Sarhad), a T1BL·1RS cultivar of the Khyber Pakhtunkhwa Province, produced the highest grain yield (4,062 kg/ha) followed by genotypes 59 (durum, 3,754 kg/ha) and 68 (Galaxy-2013, 3,744 kg/ha). Forty-four test genotypes produced higher yields than those of three local checks (Punjab-2011, Millat-2011, and Lasani-2008). All genotypes were found to be nearly free from disease. Of the 65 test genotypes, 25 were selected based on their bold seed size and/or higher grain yield. Among these, 17 were synthetic derivatives (1, 5, 7, 29, 31, 32, 35, 37, 43, 45, 46, 48, 49, 50, 52, 53, and 55) and eight were durum wheats (3, 56, 57, 59, 60, 61, 62, and 63). Among the durum genotypes, entry 3 was prominent because it had the highest 1,000-kernel weight (51.8 g), although it had a medium yield. Entry 3 could be crossed with high yielding genotypes, such as Fakhr-e-Sarhad, Galaxy-2013, and selected synthetic derivatives, to recover recombinants with improved seed size and grain yield.

Table 3. Agronomic traits and disease reaction of synthetic derivatives, durum wheat genotypes, and checks (DH, days-to-heading; PH, plant height; TKW, 1,000-kernel weight; GY, grain yield; Lr, reaction to leaf rust; Yr, reaction to yellow rust; and Sr, reaction to stem rust; TR, trace).

Entry	DH	PH (cm)	TKW (g)	GY (kg/ha)	Lr	Yr	Sr
1. Bioremediation Plot. 7th EBWYT	99	95.9	48.8	3,596	10MR–MS	0	0
2. Bioremediation Plot. 7th EBWYT	105	103.1	40.0	2,627	TR	0	0
3. ITLY D-	113	82.7	51.8	2,643	TR	0	0
4. N-Lines	104	95.6	37.6	2,912	0	0	0
5. ICARDA	105	95.8	37.9	3,551	0	0	0
6. ICARDA	105	104.9	39.9	2,695	0	0	0
7. ICARDA	103	93.1	40.4	3,374	0	0	0
8. ICARDA	101	93.1	37.9	3,207	0	0	0
9. ICARDA	103	90.1	43.4	2,387	0	0	0
10. ICARDA	103	94.7	34.2	2,874	TR	0	0
11. KAGHAN selection	109	96.0	34.3	2,427	0	0	0
12. KAGHAN selection	107	103.7	36.6	2,609	0	0	0
13. KAGHAN selection	104	119.7	38.7	2,713	0	0	0
14. KAGHAN selection	107	109.9	37.7	2,530	0	0	0
15. KAGHAN selection	105	105.5	38.9	2,677	0	0	0
16. KAGHAN selection	105	104.5	38.0	2,916	0	0	0
17. KAGHAN selection	103	103.1	37.2	2,944	0	0	0
18. KAGHAN selection	106	97.8	33.2	2,338	0	0	0
19. KAGHAN selection	106	104.8	33.8	2,797	0	0	0
20. KAGHAN selection	106	105.3	33.1	3,367	0	0	0
21. KAGHAN selection	107	95.8	33.0	2,586	0	0	0
22. KAGHAN selection	107	99.3	33.2	2,952	0	0	0
23. KAGHAN selection	106	105.8	34.0	3,037	0	0	0
24. KAGHAN selection	102	97.7	37.5	3,055	0	0	0
25. KAGHAN selection	107	101.5	32.9	2,798	0	0	0
26. KAGHAN selection	105	96.8	33.7	2,394	0	0	0
27. KAGHAN selection	106	101.9	33.0	3,396	0	0	0

Table 3. Agronomic traits and disease reaction of synthetic derivatives, durum wheat genotypes, and checks (DH, days-to-heading; PH, plant height; TKW, 1,000-kernel weight; GY, grain yield; Lr, reaction to leaf rust; Yr, reaction to yellow rust; and Sr, reaction to stem rust; TR, trace).

Entry	DH	PH (cm)	TKW (g)	GY (kg/ha)	Lr	Yr	Sr
28. KAGHAN selection	110	104.1	39.0	2,787	0	0	0
29. KAGHAN selection	106	112.6	39.0	3,739	0	0	0
30. KAGHAN selection	98	98.4	39.0	2,493	0	0	0
31. KAGHAN selection	100	99.4	43.7	3,243	0	0	0
32. KAGHAN selection	99	94.9	42.1	3,345	0	0	0
33. KAGHAN selection	101	102.6	38.2	3,177	0	0	0
34. KAGHAN selection	99	95.0	35.0	2,593	0	0	0
35. KAGHAN selection	99	104.2	39.3	3,226	0	0	0
36. KAGHAN selection	103	98.7	39.4	2,737	0	0	0
37. KAGHAN selection	103	100.3	39.5	3,372	0	0	0
38. KAGHAN selection	103	99.8	36.4	2,922	TR	0	0
39. T/FCT	106	94.0	38.5	3,491	0	0	0
40. 12X2	103	97.0	37.2	3,170	0	0	0
41. Mayoor/FCT	105	100.5	34.3	2,562	TR	0	0
42. Mayoor/FCT	104	95.4	34.4	2,580	0	0	0
43. *Th. curvifolium* derivative	103	112.7	37.9	3,671	0	0	0
44. M/OPATA	107	91.0	30.9	2,850	0	0	0
45. SAWSN selection (2012–13)	101	107.6	44.3	3,090	0	0	0
46. SAWSN selection (2012–13)	103	104.7	39.9	3,724	0	0	0
47. SAWSN selection (2012–13)	104	103.7	41.7	2,675	0	0	0
48. SAWSN selection (2012–13)	103	107.8	44.3	3,526	0	0	0
49. SAWSN selection (2012–13)	103	104.6	42.4	3,644	TR	0	0
50. SAWSN selection (2012–13)	106	106.6	40.9	3,050	TR	0	0
51. SR selection	107	101.0	41.3	2,753	TR	0	0
52. SR selection	100	107.1	39.1	3,127	TR	0	0
53. SR selection	101	106.6	44.0	2,935	0	0	0
54. SR selection	106	92.1	43.4	2,370	0	0	0
55. SR selection	105	106.0	41.5	3,584	0	0	0
56. Durum selection (2012–13)	108	89.0	35.9	3,418	0	0	0
57. Durum selection (2012–13)	109	91.7	41.8	3,074	0	0	0
58. Durum selection (2012–13)	109	88.0	38.2	2,293	0	0	0
59. Durum selection (2012–13)	106	91.6	35.6	3,754	0	0	0
60. Durum selection (2012–13)	112	95.8	42.0	3,434	0	0	0
61. Durum selection (2012–13)	106	87.9	41.1	2,533	0	0	0
62. Durum selection (2012–13)	106	93.9	41.7	3,586	0	0	0
63. Durum selection (2012–13)	105	91.1	34.7	3,,084	0	0	0
64. Durum selection (2012–13)	107	91.0	41.3	2413	0	0	0
65. Durum selection (2012–13)	109	98.2	42.0	2,636	0	0	0
66. Punjab-2011	102	96.0	41.3	2,568	0	0	0
67. Millat-2011	99	101.8	42.0	2,746	0	0	0
68. Galaxy-2013	104	107.9	43.8	3,744	5R	0	0
69. Fakhr-e-Sarhad	104	104.0	42.7	4,062	0	0	0
70. Lasani-2008	102	92.9	36.7	2,749	0	0	0
Mean	104	100.0	39.0	2,999	—	—	—
Range	98–113	82.7–119.7	30.9–51.8	2,293–4,062	—	—	—
Standard deviation	±3.1	±6.8	±4.1	±435.5	—	—	—

The selected synthetic and durum genotypes have been planted in separate replicated yield trials at NIAB for evaluation during the 2014–15 cropping season. In the durum trial, Durum-97 was added as a local check. Crosses will be attempted between these synthetics, the commercial checks, and other promising entries during 2014–15. We also are exploring the direct potential of the best durum wheat entries as a cultivar and embarking on a pentaploid-based, durum improvement program to improve durums and bread wheat germplasm using synthetic derivatives.

Genetic variation in exotic durum wheat accessions.

Babar Manzoor Atta, Sajid Shokat, and Kamran Saleem.

Durum is the only commercially cultivated tetraploid wheat species. Durum is a hard wheat, high in protein and strength, and used to prepare various products, such as breads, cakes, biscuits, pastas, noodles, and other bakery products. The Wheat Research Institute (WRI), at AARI, Faisalabad, released the durum wheat cultivars (2n=4x=28; AABB) Wadhanak-85 and Durum-96 during 1985 and 1996, respectively, for cultivation in the province of Punjab. The demand for durum wheat is increasing in Pakistan and augments our breeding efforts to improve yield potential and disease resistance. This will definitely lead to the development of cultivars to feed our local industry and for export to earn foreign exchange.

A set of 13 durum wheat accessions, mostly approved cultivars from Turkey, were planted at the NIAB, Faisalabad, in two 2.8-m rows to test their adaptability and productivity. Data were recorded on days-to-heading, plant height, spike length, number of grains/spike, 1,000-kernel weight, grain yield, and resistance to leaf rust, yellow rust, and stem rust. Five random plants were used for recording the data and means.

One accession, Karsakilcik, did not adapt to Faisalabad conditions; no heading and high susceptibility to rusts, rejected this cultivar in the field. Data for the other 12 accessions is presented (Table 4). Sufficient genetic variability was recorded for all the traits. Ceylan-95 (118) and Divarbakir-81 (117) were comparatively late in heading. Ceylan-95 also was the tallest (104 cm) and had the longest spike (10.2 cm) but had the minimum number of grains/spike (50.4), due to a lower spike density and resulting in a lower yield. Harran was the shortest accession (87.6 cm) with the highest number of grains/spike (75.6) but much lower seed weight (40 g) and the lowest grain yield (240 g). The most desirable accessions had a medium height, compact spike, and good seed weight. Firat-93 was the most promising cultivar, with a bold seed size (51.2) and highest yield (725 g). These accessions were found to be free from all the three rust diseases. Eight entries, with a yield ranging from 620 g to 725 g, were better adapted to the local conditions.

Table 4. Morpho-agronomic traits and disease performance of exotic durum wheat accessions (DH, days-to-heading; PH, plant height; SL, spike length; NGPS, number of grains/spike; TKW, 1,000-kernel weight; GY, grain yield; Lr, reaction to leaf rust; Yr, reaction to yellow rust; and Sr, reaction to stem rust; TR, trace disease).

Entry	DH	PH (cm)	SL (cm)	NGPS	TKW (g)	GY (g)	Lr	Yr	Sr
Altintoprak-98	102	90.2	7.7	60.8	47.2	490	0	0	0
Artuklu	101	102.6	9.1	66.8	50.4	660	0	0	0
Aydin-93	114	102.4	7.6	55.6	37.8	680	TR	0	0
Ceylan-95	118	104.0	10.2	50.4	44.6	565	0	0	0
Divarbakir-81	117	101.8	9.6	54.2	44.8	630	0	0	0
Eyyubi	102	96.4	7.7	66.4	45.2	715	0	0	0
Firat-93	103	91.0	7.9	54.8	51.8	725	0	0	0
Guneyyildizi	107	96.2	8.5	63.6	41.4	725	0	0	0
Harran	103	87.6	9.0	75.6	40.6	240	0	0	0
Saricanak-98	105	93.2	8.3	66.0	45.8	620	TR	0	0
Sahinbey	102	96.2	8.8	56.8	62.2	685	0	0	0
Zuhre	105	91.8	8.3	61.4	43.2	440	0	0	0

Improvement of wheat for drought tolerance.

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Wheat is the main cereal crop of Pakistan. Among the various environmental stresses affecting wheat production, drought is the major limiting factor. The current cultivars do not produce a maximum yield due to the large spatial variation in rainfall under arid and semi-arid conditions. Therefore, developing genotypes that are either tolerant to terminal drought or that mature early to escape this stress is a dire need.

We evaluated wheat genotypes for drought tolerance in two field trials and in an experiment under plastic tunnel conditions. The Wheat Station Yield Trial (WSYT (A-I)) was comprised of eight genotypes and a check (Punjab-2011). Similarly seven local and two exotic (Turkey) genotypes were tested in WSYT (A-II) along with two checks (Galaxy-2013 and Punjab-2011). The trials were conducted in a randomized complete block design with three replications keeping row to row distance of 30 cm and plot size of 4.95 m^2. The material was planted on 11 November, 2013. No supplementary irrigation was applied during the entire cropping season.

Thirteen local genotypes, one exotic line (Sitta), and four checks, including Marvi-2000 as a drought-susceptible check, were evaluated under water-limited conditions in a plastic tunnel. The material was planted in single rows per genotype with two replications. The material was saved from rain, although a single, life-saving irrigation was applied at grain development stage insure a seed harvest.

Table 5. Morpho-agronomic traits and disease performance of wheat genotypes in Wheat Station Yield Trial A-I (a) and A-II (b). Overall mean and p values also are presented (DH, days-to-heading; PH, plant height; TIL, tiller number; SL, spike length; NGPS, number of grains/spike; TKW, 1,000-kernel weight; and GY, grain yield).

Entry	DH (50%)	PH (cm)	TIL	SL (cm)	NGPS	TKW (g)	BI (g)	GY (kg/ha)	Lr	Yr	Sr
Wheat Station Yield Trial A-I											
NW-1-20	103	77.8	151.0	10.4	48.9	42.1	530.0	2,646	TR	TR	0
NW-3-2	91	83.6	141.0	14.0	53.1	48.8	536.7	2,244	0	10MS–S	0
NW-7-13	92	72.1	127.7	9.5	51.8	43.1	463.3	2,248	50MS–S	70S	0
NW-7-20	92	75.0	148.7	9.8	50.1	43.4	476.7	2,212	30S	80S	0
NW-7-19	93	76.8	131.3	9.8	52.1	43.6	523.3	2,538	30MR	60S	0
NW-7-24	92	78.1	140.7	10.2	54.9	44.1	550.0	2,318	0	60S	0
NW-10-19	100	85.7	134.0	10.7	57.7	44.1	546.7	2,386	0	20MS	0
NW-31-2	92	80.1	136.7	11.8	56.9	45.9	613.3	3,058	0	20R	0
Punjab-2011	94	79.1	139.7	11.5	49.9	43.6	526.7	2,355	10MR–MS	0	0
Mean	94	78.7	139.0	10.8	52.8	44.3	530.0	2,445	-	-	-
P value	<.001	<.001	0.94	<.001	0.214	0.002	0.722	0.035	-	-	-
Wheat Station Yield Trial A-II											
NW-15-5-37	99	84.9	180.0	11.3	51.7	42.6	673.0	3,165	0	80S	0
NW-1-47-4	101	84.8	163.3	12.6	62.5	40.3	747.0	3,118	0	0	0
NW-7-1-9	105	87.7	185.0	12.2	55.7	41.5	677.0	3,229	60S	70S	0
NW-10-4-20	99	89.0	149.3	11.6	54.5	42.3	643.0	2,508	0	30MS	0
NW-7-28-13	101	79.6	149.3	10.3	54.0	36.3	520.0	2,545	40MS–S	30MS–S	0
NW-10-46-25	105	80.5	156.3	11.6	51.9	41.7	543.0	3,101	0	0	0
NW-1-27-3	99	84.3	130.0	12.7	57.2	48.1	583.0	2,885	TR	20R	0
PUNJAB-2011	95	84.3	174.3	11.5	56.2	43.9	707.0	3,151	TR	0	0
Galaxy-13	103	87.5	142.0	12.3	54.6	50.1	543.0	2,889	40MS–S	0	0
Karacadag-98	103	84.5	199.3	12.8	72.6	37.9	887.0	1,990	40MS–S	40MS–S	0
Nurekent-2008	109	87.0	148.7	13.2	65.9	37.6	700.0	1,656	50S	50S	0
Mean	102	84.9	162.0	12.0	57.9	42.0	657.0	2,749	—	—	—
P value	<.001	0.001	0.029	<.001	<.001	<.001	<.001	0.001	—	—	—

Data were recorded on days-to-heading, plant height (cm), tiller number, spike length (cm), number of grains/spike, 1,000-kernel weight (g), biomass (g), grain yield (kg/ha or g), and resistance to leaf rust (Lr), yellow rust (Yr), and stem rust (Sr). Five random plants per replication were used for the measurements.

Morpho-agronomic data and disease response of the wheat genotypes tested in WSYT A-I and A-II are given (Table 5, p. 42). In trial A-I, significant differences between the genotypes were observed for days-to-heading, plant height, spike length, 1,000-kernel weight, and grain yield, whereas tiller number, grains/spike, and biomass were not significant, as showed by the p-values. Genotype NW-1-20 had a significantly higher days-to-heading (9 days) and grain yield (12.4 higher) than the check; NW-3-2 was comparatively taller, had the longest spike length, and the highest 1,000-kernel weight and grain yield, equal to that of the check cultivar. NW-10-19 was late (6 days), taller, and with a comparatively higher yield than that of the check. The plant height and spike length of genotype NW-31-2 was not significantly different than those of the check, but had a highter 1,000-kernel weight and the highest grain yield (29.9 higher than that of the check). These four genotypes were also disease resistant and were selected for further evaluation during 2014–15 crop season. The remaining four genotypes were found to be susceptible to either to leaf rust or stem rust or both.

In trial A-II, the genotypes showed significant differences for all traits. Among the seven local and two exotic genotypes, all were susceptible to the rusts with the exception of NW-1-47-4, NW-10-46-25, and NW-1-27-3. Genotype NW-10-46-25 did not qualify for visual selection. The remaining two genotypes (NW-1-47-4 and NW-1-27-3) were 2–4 days earlier in heading, equal to the check for spike length, had higher number of grains/spike and biomass. Their yiels was either equal to or higher than that of the Galaxy-2013 check. These genotypes were selected for further testing during next year.

In the tunnel experiment, all test genotypes were at equal to or earlier than Galaxy-2013 in days-to-heading; Sehar-06 was the earliest (Table 6). NW-3-3341-7 and Marvi-2000 were the tallest. NW-10-1111-3, NW-10-46-25, and Inqulab-91 had the highest biomass and grain yield at maturity. This trail confirmed the findings of the field trials and the same genotypes also were selected in this experiment, with the addition of new genotypes tested in this experiment. In total, eight genotypes that showed higher yield than the susceptible and latest checks Marvi-2000 and Galaxy-2013, respectively, were selected for subsequent evaluation, with the exception of three disease-susceptible genotypes.

Table 6. Agronomic traits of wheat genotypes in drought experiment under plastic tunnel conditions.

Entry	Days-to-heading (50%)	Plant height (cm)	Biomass (g)	Grain yield (g)
NW-1-9-47	81	44.2	65	20.0
NW-1-27-3	78	49.8	105	33.7
NW-1-47-4	80	53.0	135	44.5
NW-1-8183-8	78	56.3	105	34.5
NW-3-3341-7	80	62.3	120	33.4
NW-5-1212-1	78	52.1	75	16.6
NW-7-9-30-1	80	57.2	120	37.6
NW-7-28-13	77	52.2	90	26.4
NW-10-4-20	78	55.9	105	31.1
NW-10-46-25	79	56.1	170	62.0
NW-10-1111-3	77	51.3	170	63.2
Sehar-2006	73	52.1	95	32.5
Inqulab-91	76	59.3	155	51.1
Sitta	74	55.4	145	42.7
Marvi-2000	73	60.2	100	29.7
NW-3-2	75	54.2	115	30.8
NW-31-2	75	53.9	100	30.3
Galaxy-2013 (check)	80	51.4	60	23.8
Mean	77	54.3	112.8	35.8