

Table S1. The list of spring durum wheat material included in the study.

Study Entry #	KASIB Entry #	Variety/Line	KASIB years	Pedigree
Aktobe Agricultural Experimental Station (KZ)				
28	2-18	Kargala_18	2001-02	
30	2-20	383-MC	2001-02	
31	2-21	452-MC	2001-02	
40	5-1	Kargala 24	2005-06	
41	5-2	Kargala 447	2005-06	
42	5-3	Kargala 303	2005-06	
50	6-1	Kargala 1514-06	2007-08	
61	7-1	Kargala 69	2009-10	16256//Orenburgskaya 10/Aktubinskaya 78/3/Kargala 9
62	7-2	Kargala 1538	2009-10	Orenburgskaya-10/Kargala-471
63	7-3	Kargala 1540	2009-10	Aktubinskaya 75 /Kargala 9 // Kargala 34
73	8-2	Kargala 1539	2011-12	Hordeiforme-91-144-4/Kargala-9
74	8-3	Kargala 1671	2011-12	K-45675/Omskii-rubin//Kargala-1
89	9-1	Kargala 1408	2013-14	Orenburgskaya 10/Kargala 471
102	10-1	Kargala 66	2015-16	Line 17052 // Orenburgskaya 10 / Rodonit
103	10-3	Kargala 1514	2015-16	Bogarnaya 56 // Celinnaya 26, Nem-0,015% // Lakota /3/ Line 3940
122	11-2	Kargala 228	2017-18	Line 1358 / Kargala 69
123	11-3	Kargala 238	2017-18	Hordeyforme 379 / Zhemchuzhina Sibiri//Kargala 71
143	12-1	Line P-1409	2019-20	Kargala 12/ Kargala 26
144	12-2	Soyana	2019-20	Svetlana/Angara
145	12-3	Yantarnaya 60	2019-20	Timiryazevskaya stepnaya/ Kargala 71
Karabalyk Agricultural Experimental Station (KZ)				
1	1-1	Kostanayskaya_30	2000	G-2684 individual selection
2	1-2	Kostanayskaya_1	2000	Kostanaiskaya
3	1-3	Orenburgskaya_2	2000	Kharkovskaya-46/Bezenchukskaya-105
6	1-9	Line_160.93	2000	G-2897 /Kubanskaya 24
7	1-10	Line_362.91	2000	G-2723 / Kostanayskaya 14
19	2-2	Gordeiforme 430-88	2001-02	G-3686/G-255-76
20	2-4	Gordeiforme 59-92	2001-02	K-37087/SID 88
21	2-5	Gordeiforme 207-92	2001-02	G-471/88// Kharkovskaya 46
22	2-6	Gordeiforme 362-91	2001-02	G-2723/Kostanayskaya 14
23	2-7	Gordeiforme 242-93	2001-02	I-395926/Orenburgskaya 10
24	2-8	Gordeiforme 127-89	2001-02	Kostanayskaya 1 - individual selection
38	4-10	Kostanayskaya 12	2003-04	(S)Kustanaiskaya-1[3012];
39	4-11	Asangali	2003-04	Omskii-rubin//6301/Kustanaiskaya-14
46	5-8	Karabalykskaya chernokolosaya	2005-06	Bashkirskaya 23/Kubanka K-26602
47	5-9	Altyn dala (LC-2)	2005-06	G-2684/Altaisakaya-niva//Kustanaiskaya-1[3012]; Omskii-rubin//6301/Kustanaiskaya-14[3012]; Kharkovskaya-21/Saratovskaya-zolotistaya[3012];

53	6-4	Altyn shygys	2007-08	G-2684/Altayskaya niva//Kostanayskaya 1
54	6-5	Altyn dala	2007-08	G-2684/Altaiskaya-niva//Kustanaiskaya-1[3012]; Omskii-rubin//6301/Kustanaiskaya-14[3012]; Kharkovskaya-21/Saratovskaya-zolotistaya[3012];
64	7-4	Kostanayskaya 10	2009-10	Kharkovskaya 46/Leucurum 21-50-63//Line 182-3078
65	7-5	Bolashak	2009-10	Saratovskaya zolotistaya / Leucurum 86-89//Line 3045
75	8-4	Gordeiforme 113-01	2011-12	Saratovskaya-zolotistaya//Kharkovskaya-46/Omskii-rubin[4146];
90	9-4	Line G1549	2013-14	618-89/205-15254
91	9-5	Line G1612	2013-14	Kustanayskaya 1/Hordeiforme 53
104	10-4	Sharifa	2015-16	Hordeyforme 218 / Kostanayskaya 1
128	11-8	Gordeiforme 2264	2017-18	Gordeyforme 1730 / KazRIAPG sample
150	12-8	Kostanayskaya 15	2019-20	Sid-88/Ametist
151	12-9	Gordeiforme 1790	2019-20	G-132-53874 /G-182-3078
Kazakh Grain Research Institute (KZ)				
37	4-8	Damsinskaya yantarnaya	2003-04	Damsinskaya-90(TR.DR)/(TR.AE)Saratovskaya-210[2969][4163];
77	8-6	Korona	2011-12	Kharkovskaya-17/Altaika[3012][4146][4163];
78	8-7	Durum 2	2011-12	Yavaros-79/M-3128[4146];
79	8-8	Durum 49	2011-12	CMH-73-A(CIMMYT)/(93-90-1)Orenburgskaya-2/Maliani-76[4146];
92	9-6	Line e 145-z	2013-14	Kubanka/Hordeiforme 177
93	9-7	Line 54-02-2l	2013-14	Leucurum 6953/L.103
94	9-8	Line e147-z	2013-14	Hordeiforme 315-5/Akmolinka 5
105	10-6	Lavina	2015-16	118-86-1, κ-48235 / Angara // Celinogradskaya 85
106	10-7	Damsinskaya yubileynaya	2015-16	Cocorit 71 / Saratovskaya 29
107	10-8	Shortandinskaya 256	2015-16	κ-59091, Atherapitico / celinogradskaya 85
126	11-6	Gordeiforme 69-08-2	2017-18	Corona /144-00-2 local line
127	11-7	Gordeiforme 178-05-2	2017-18	Saratovskaya 57 / Zhemchuzhina sibiri
148	12-6	Line 69-08-2	2019-20	Corona/ 144-00-2
149	12-7	Line 250-06-14	2019-20	Altayskaya niva/ Kostanayskaya 1477
Kazakh Scientific Research Institute of Agriculture and Plant Growing (KZ)				
8	1-12	Line 6801-34-6	2000	-
9	1-13	Line 654-1-2-3-4	2000	
10	1-14	Line 17950	2000	
11	1-15	Line 17590	2000	
12	1-17	Line 18053	2000	
13	1-18	Line 18022-1	2000	
43	5-5	Nauryz 8	2005-06	
44	5-6	Toma	2005-06	
45	5-7	Seymur	2005-06	Altayskaya niva/ Hordeyforme 254
172	6-6	Nauryz 6 (LC-1)	2007-08	Orenburgskaya-10/Kharkovskaya-46[3012][3931]; (S)18018-KIZ[3645];
56	6-7	Lan	2007-08	Orenburgskaya-10/Saratovskaya-40//Omskii-

				rubin[3931];
68	7-7	Ertol	2009-10	Line 49270 / Line 44422
87	8-20	Line 18485-2	2011-12	
88	8-21	Line 18404	2011-12	58741/Orenburgskaya-10[4146];
100	9-9	Line 18987	2013-14	58266/Orenburgskaya 10
95	9-10	Line 18472-3-2	2013-14	Opushennaya steblevaya/Aktyub. 74
108	10-9	Gordeiforme 18567-6	2015-16	58266 / Orenburgskaya 10
109	10-10	Gordeiforme 18585-2	2015-16	Melyanopus 26 / SID 88
124	11-4	Line 19003	2017-18	58266 / Orenburgskaya 10
125	11-5	Line 19029	2017-18	39781 / 15090
146	12-4	Seymur 17	2019-20	Altayskaya niva/ Hordeyforme 254
147	12-5	Serke	2019-20	Bashkirsкая 21/Odesskaya 116
167	CVT-1	19055/Gordeiforme	2019-20	
166	CVT-2	Line_18093-7-2	2019-20	
168	CVT-3	Line_18924	2019-20	
169	CVT-4	Line_19029	2019-20	39781 / 15090
Altay Agricultural Research Institute (RU)				
34	4-5	Altayskaya Niva	2003-04	Kharkovskaya-51/P-274//P-274/3/Kharkovskaya-46[302][2913];
35	4-6	Gordeiforme 415	2003-04	Orenburgskaya 10/SID 88
36	4-7	Gordeiforme 417 (Salut Altaya)	2003-04	Novodonskaya / Zarnica Altaya
48	5-12	Gordeiforme 426	2005-06	Aya//Line 6 / G291
57	6-13	Gordeiforme 553	2007-08	Hordeyforme 350 / Hordeyforme 283
69	7-12	Altayskiy yantar	2009-10	Hordeiforme-728/Altayskaya-niva//Hordeiforme-728/Orenburgskaya-10[2913][2971]; Hordeiforme-828/Altayskaya-niva//Hordeiforme-121/Orenburgskaya-10[1359];
70	7-14	Gordeiforme 561	2009-10	Hordeyforme 369 / Altayskiy yantar
80	8-12	Gordeiforme 573	2011-12	Angel/Hordeiforme-328[4146];
81	8-13	Gordeiforme 616	2011-12	Hordeiforme-382/Durabon[4146];
96	9-14	Gordeiforme 587	2013-14	Aleyskaya / Hordeiforme 325
97	9-15	Gordeiforme 627	2013-14	Bezenchukskaya stepnaya / Hordeiforme 1692
98	9-16	Gordeiforme 628	2013-14	Hordeiforme 415 / L.1675
110	10-14	Gordeiforme 719	2015-16	Hordeyforme 423 / Omskiy Korund
111	10-16	Gordeiforme 748	2015-16	Hordeyforme 415 / Bezenchukskaya stepnaya
131	11-15	Gordeiforme 829	2017-18	Pamyati Yanchenko / Pamyati Chekhovicha
132	11-16	Gordeiforme 864	2017-18	Hordeyforme 474 / G1692
133	11-17	Gordeiforme 881	2017-18	Pamyati Yanchenko / Pamyati Chekhovicha
153	12-15	Gordeiforme 895	2019-20	G440 / Omskiy Korund
154	12-16	Gordeiforme 910	2019-20	Omskaya stepnaya / 1TD-1
155	12-17	Gordeiforme 924	2019-20	Daonskaya elegiya/ Oazis
Omsk Agricultural Research Center (RU)				
14	1-19	Angel	2000	Atlant/Atlant-14[1359][1369];

15	1-20	Ametist	2000	Hordeiforme-6673/Omskii-rubin//Hordeiforme-7008/Hordeiforme-440-79[1929];
16	1-21	Omskaya_Yantarnaya	2000	Svetlana/Kharkovskaya-46//Hordeiforme-10/K-5173[3012]; Hordeiforme-ek-27-1-1/Hordeiforme-zl-35-2[1359][1929];
17	1-22	Omskiy_Rubin	2000	Almaz/Kharkovskaya-46//Kharkovskaya-46/Hordeiforme-10/3/wells[302][1001][2913]; Almaz/Kharkovskaya-46/3/Kharkovskaya-46/Hordeiforme-10//wells[1155];
18	1-23	Omskiy_korund	2000	Angel/(k-47117)Tehuacan-67[1359];
25	2-9	Gordeiforme 94-71	2001-02	Hordeyforme ZL 41-4/ Hordeyforme ZL 4-13
26	2-10	Gordeiforme 91-102-6	2001-02	Hordeyforme ZK 35-2/ Hordeyforme ZL 35-2
27	2-11	Gordeiforme 91-22-2	2001-02	Hordeyforme VJ 45-5/ Hordeyforme ZL 35-2
32	4-3	Zhemchuzhina Sibiri	2003-04	Antei/Leucurum-6953//Almaz/Omskii-rubin/3/Svetlana[1359];
33	4-4	Gordeiforme 91-144-4	2003-04	Hordeyforme VJ 45-5/Hordeyforme ZL 35-2 / 3/ Hordeyforme VJ 45-5/2/K 47117)
49	5-16	Gordeiforme 94-94-13	2005-06	Hordeyforme IL 54-1/ HordeyformeZL 35-2
58	6-14	Gordeiforme 94-24-12	2007-08	Hordeyforme VJ 45-5/ Hordeyforme ZL 41-13
59	6-15	Gordeiforme 95-139-4	2007-08	Hordeyforme1131/Svetlana
60	6-16	Omskaya Stepnaya	2007-08	Orenburgskaya-10/Omskaya-yantarnaya[1359];
71	7-15	Gordeiforme 97-49-1	2009-10	Hordeyforme IP 54-1 // Orenburgskaya 10
72	7-16	Gordeiforme 98-42-1	2009-10	Hordeiforme-90-37-4/Hordeiforme-3-L-35-2[4146];
84	8-17	Omskiy izumrud	2011-12	Hordeiforme-94-8-5/Omskaya-yantarnaya[1359][4146];
86	8-19	Gordeiforme 00-96-8	2011-12	Hordeiforme-90-37-7/Nik[4146];
101	9-21	Omskiy Korall	2013-14	Omskaya yantarnaya// pod11/yazi1 cdss93b00069s-9m-oy-ob-1y-ob
113	10-18	Gordeiforme 01-115-5	2015-16	Hordeyforme 95-170-5 / Hordeyforme 95-126-1
134	11-18	Gordeiforme 04-76-5	2017-18	G.98-130-6 // pod11/yazi1
136	11-20	Gordeiforme 05-42-12	2017-18	G.97-49-1/ Bezenchukskaya stepnaya
156	12-18	Gordeiforme 08-25-2	2019-20	G.01-107-5/Zhemchuzhina sibiri
157	12-19	Gordeiforme 08-67-1	2019-20	G.99-224-1/G.455
85	13-18	Omskiy_Cirkon	2012-13	Hordeiforme 90-37-4/Hordeiforme ZL -35-2
121	17-26	Zhemchuzhina_Sibiri (LC-3)	2016-17	Antei/Leucurum-6953//Almaz/Omskii-rubin/3/Svetlana[1359];
Samara Agricultural Research Institute (RU)				
82	8-15	Line 688 d-4 – (Bezenchukskaya 210)	2011-12	Pamyati-Chekhovicha/4/Saratovskaya-zolotistaya/Hordeiforme-740//Apulicum-341/3/Kharkovskaya-9/Saratovskaya-zolotistaya//Saratovskaya-zolotistaya[4146];
83	8-16	Line 653 d-44 – (Bezenchukskaya zolotistaya)	2011-12	Pamyati Chekhovicha/ 356D-14
99	9-17	Leucurum 1307D-51 (Bezenchukskaya krepost)	2013-14	L.1751/Pamyati Chekhova
117	10-22	Leucurum 1307D-54	2015-16	L.1751/Pamyati Chekhova
118	10-23	Leucurum 1469D-21	2015-16	Line 495d-6 /Leucurum 1714
119	10-24	Leucurum1594D-3	2015-16	Leucurum 1752 / Marina

120	10-25	Bezenchukskaya 139	2015-16	Kharkovskaya 46/ Bezenchukskaya 121
137	11-21	Leucurum 1429-10	2017-18	Icaro / B202
138	11-22	Leucurum 1506-36 (Bezenchukskaya yubileynaya)	2017-18	Leukurum 1714 / Pamyati Chekhovicha
139	11-23	Gordeiforme 1591-21 (Triada)	2017-18	Hordeyforme 1732 / 646D-37
142	11-26	Leucurum 1469-21	2017-18	Line 495d-6 /Leukurum 1714
159	12-20	Line 1693D-71	2019-20	Leukurum 1687 (Bezenchukskaya zolotistaya)/ Hordeiforme 944// Valentina
160	12-22	Line 1970D-5	2019-20	495D-7/Bezenchukskaya zolotistaya
161	12-23	Line 2021D-1	2019-20	L1753/694D-11
South-East Agricultural Research Institute (RU)				
115	10-20	Elizavetinskaya	2015-16	Saratovskaya zolotistaya / Svetlana
116	10-21	Valentina	2015-16	Saratovskaya 59/Leukurum 1897 / D-1973/Saratovskaya zolotistaya
140	11-24	Annushka	2017-18	Saratovskaya 53/Medora//D-1995/3//Leukurum 5594.
141	11-25	Luch 25	2017-18	PD45 / Saratovskaya Zolotistaya /5/ Leukurum 1947 / Kharkovskaya 46 /2/ Saratovskaya 59 / Kharkovskaya 46/3/Saratovskaya zolotistaya/4/D- 2034 /6/ D-2005.
162	12-24	Line D-2165	2019-20	

Table S2. Agronomic performance of spring durum wheat material originating from different breeding programs and tested at Almaty (2020 and 2022) and Shortandy (2021-2022).

Originator	Site	Almaty	Shortandy	Aktobe	Karabalyk	Barnaul	Sam-Sar	Omsk	Average
Days to heading	Almaty	59.3	63.4	59.8	62.3	61.8	58.3	60.7	60.7
	Shortandy	41.8	46.2	41.1	44.0	43.7	40.7	42.7	42.7
Plant height, cm	Almaty	102	103	102	107	105	98	103	103.2
	Shortandy	69	74	71	76	74	68	71	71.9
Spikes/plant	Almaty	1.17	1.17	1.07	1.13	1.18	1.50	1.05	1.17
	Shortandy	1.52	1.56	1.44	1.51	1.51	1.43	1.53	1.50
Spike length, cm	Shortandy	6.3	6.1	6.1	6.1	6.2	6.0	6.4	6.2
	Almaty	8.5	9.3	8.6	8.8	8.8	8.6	9.3	8.8
Awn length, cm	Almaty	11.3	10.8	11.9	11.2	11.2	13.1	11.3	11.5
	Shortandy	8.6	9.2	8.7	8.7	8.8	9.5	8.9	8.9
Spikelets/spike	Almaty	18.1	20.5	18.0	19.6	18.5	18.5	19.2	18.8
	Shortandy	12.1	12.5	11.8	12.6	11.8	11.2	12.4	12.1
Grains/spike	Almaty	50.1	53.1	49.3	50.2	48.4	49.2	50.3	49.9
	Shortandy	25.0	23.6	24.6	25.5	23.7	22.7	25.5	24.6
Grains/spikelet	Almaty	2.76	2.59	2.75	2.57	2.63	2.67	2.64	2.66
	Shortandy	2.07	1.89	2.09	2.03	2.00	2.01	2.06	2.03
1000 kernel weight, g	Almaty	38.6	37.0	42.0	37.6	41.2	42.4	38.7	39.8
	Shortandy	43.1	43.3	45.1	42.5	45.1	46.9	42.8	44.1
Grain weight per spike, g	Almaty	2.01	2.06	2.16	1.98	2.10	2.19	2.05	2.07
	Shortandy	1.13	1.16	1.17	1.12	1.15	1.15	1.15	1.15
Yield, g/m ²	Almaty	241	253	244	229	237	223	267	243
	Shortandy	158	161	176	178	168	156	182	170