

Table S1. Names and pedigree of the 20 bread wheat genotypes (6 cultivars and 14 doubled haploid lines (DHLs)) used in this study.

Name	Pedigree
Gemmeiza-9	Ald"s"/Huac//CMH74 .630/SxCGM 4583 -5GM- 1GM- OGM
Gemmeiza-12	OTUS/3/SARA/THB//VEEMSS97Y00227S-5y-010M-010Y-010M-2Y-1M-0Y-OGM
Sakha-93	Sakha 92/TR810328 S8871-IS-2S-IS-0S
Misr1	OASSIS / SKAUZ//4*BCN/3/2*PATOR CMSS00Y01881T-050M-030Y-030M-030WGY-33M-0Y-0S
Pavone-76	Vcm//Cno/7C/3/Kal/Bb
KSU106	Barouk/R1474-75-3-53-3-3
DHLs (23,25)	Derived from the cross (Line-115 × Gemmeiza-7) (El-Hennawy et al. 2011)
DHLs (5,7,8,11)	Derived from the cross (Line-115 × Giza-164) (El-Hennawy et al. 2011)
DHLs (12,14,15,26,29)	Derived from the cross (Gemmeiza-7× Giza-164) (El-Hennawy et al. 2011)
DHLs (1,2, 6)	Derived from the cross (Giza-164× Giza-168) (El-Hennawy et al. 2011)

Table S2. Details of genotype codes and names of 20 bread wheat genotypes (6 cultivars and 14 doubled haploid lines (DHLs)) used in this study

Genotypes	Genotype code	Genotypes	Genotype code
DHL12	G1	DHL14	G11
DHL02	G2	DHL29	G12
DHL25	G3	DHL15	G13
DHL07	G4	DHL06	G14
DHL26	G5	Misr1	G15
Gemmeiza-9	G6	DHL05	G16
DHL11	G7	DHL23	G17
KSU106	G8	Sakha-93	G18
Gemmeiza-12	G9	Pavone-76	G19
DHL01	G10	DHL08	G20

Table S3. Monthly agro-climatological data at the experimental location during the growing seasons.

Parameters Months	Precipitation (mm)			Temperature (°C)									Relative Humidity (%)		
				Maximum			Minimum			Average					
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
November	0.31	0.27	0.17	35.37	34.82	28.07	5.05	5.84	16.37	20.21	20.33	22.03	41.69	41.21	41.34
December	0.02	0.10	0.05	27.40	27.46	21.84	4.01	4.95	10.58	15.71	16.21	16.10	45.31	44.36	55.45
January	0.10	0.05	0.10	29.34	28.65	19.87	1.23	2.01	8.32	15.29	15.33	14.06	40.19	40.68	47.37
February	0.00	0.00	0.00	33.79	32.43	24.66	1.21	2.08	11.62	17.50	17.26	18.19	28.44	29.26	32.89
March	0.00	0.00	0.00	35.80	36.19	28.65	6.98	7.01	15.77	21.39	21.60	22.41	25.69	26.02	28.79
April	0.98	1.02	0.98	39.91	38.63	33.70	14.13	15.11	21.53	27.02	26.87	27.73	31.50	30.24	31.38
May	0.01	0.00	0.01	42.91	41.77	38.97	19.21	19.94	24.87	31.06	30.86	32.37	17.69	17.05	19.69

S1, Season 2018/2019; S2, Season 2019/2020, S3, Season 2020/2021.

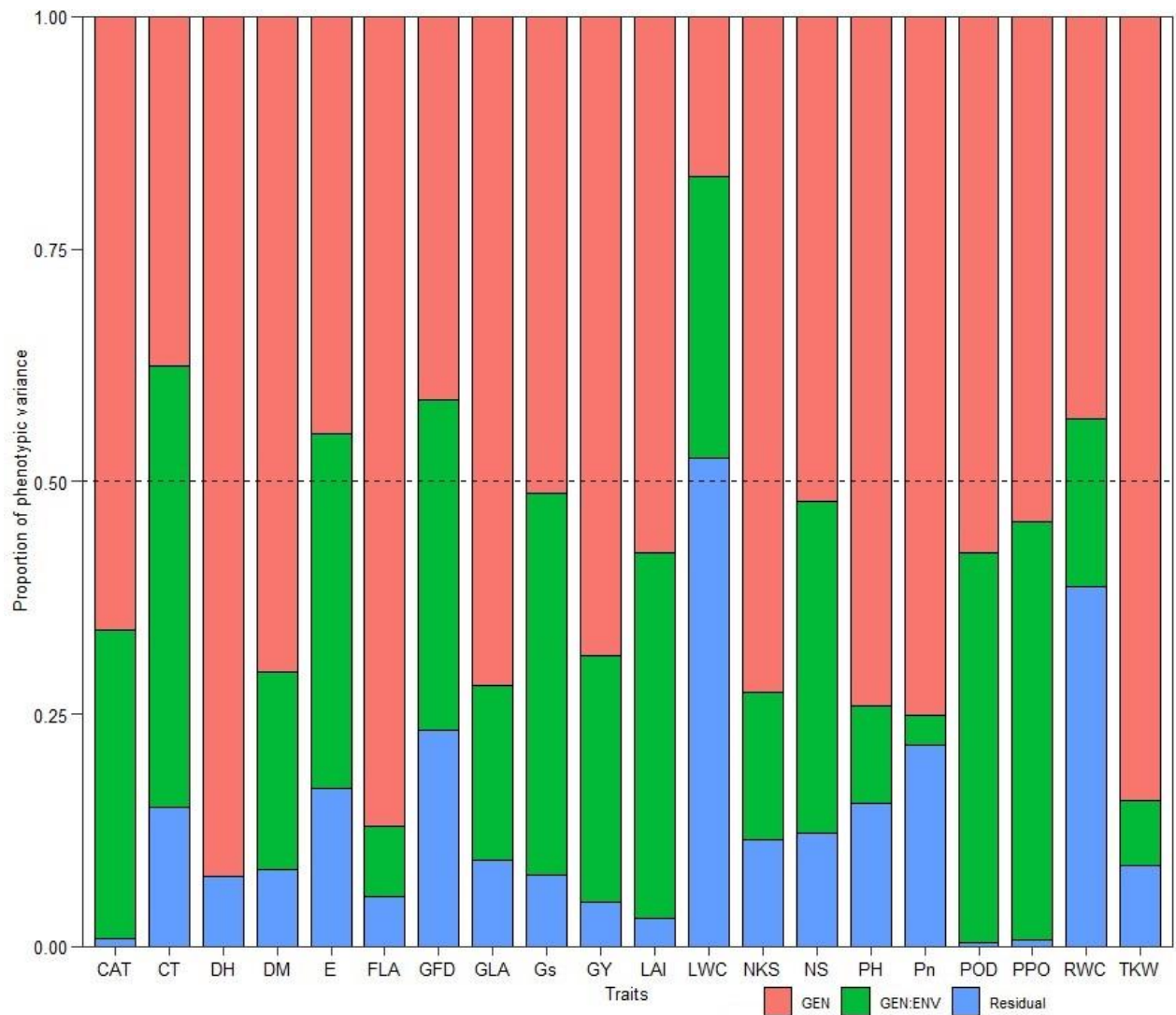


Figure S1. Estimated variance components for 20 studied traits for 20 wheat genotypes in nine environments

Table S4. Deviance analysis, estimated variance components and genetic parameters for grain yield of 20 wheat genotypes evaluated in nine environments.

Traits		DH	DM	GFD	NS	PH
G	χ^2	508	171	71.7	94.8	228
	p -value	1.84×10^{-112}	3.57×10^{-39}	2.55×10^{-17}	2.11×10^{-22}	1.88×10^{-51}
GEI	χ^2	0.0354	271	173	301	71.6
	p -value	0.851	7.87×10^{-61}	1.93×10^{-39}	2.33×10^{-67}	2.59×10^{-17}
REML						
Estimated variance components						
σ_g^2		11.40 (92.40)	9.67 (70.50)	2.78 (41.30)	2000.00 (52.10)	37.30 (74.20)
σ_{ge}^2		0.01 (0.07)	2.91 (21.20)	2.39 (35.50)	1370.00 (35.70)	5.25 (10.40)
σ_e^2		0.92 (7.49)	1.14 (8.29)	1.57 (23.30)	468.00 (12.20)	7.72 (15.40)
σ_p^2		12.33	13.7	6.74	3850	50.3
H^2		0.924	0.705	0.413	0.521	0.742
R^2_{gei}		0.0007	0.212	0.355	0.357	0.104
h^2_{mg}		0.997	0.964	0.896	0.922	0.977
AS		0.998	0.982	0.946	0.96	0.989
r_{ge}		0.009	0.719	0.604	0.746	0.405
$CV_g\%$		4.58	2.68	3.97	10.2	7.85
$CV_r\%$		1.3	0.92	2.98	4.92	3.57
CV ratio		3.51	2.92	1.33	2.07	2.2
SD		4.09	6.75	4.22	89.14	7.93
SE		0.18	0.29	0.18	3.84	0.34

Table S4. Cont.

Traits		FLA	GLA	LAI	LWC	RWC
G	χ^2	316	184	102	25.3	100
	p -value	1.33×10^{-70}	6.28×10^{-42}	5.13×10^{-24}	5.02×10^{-07}	1.42×10^{-23}
GEI	χ^2	157	221	705	58.1	43.6
	p -value	5.70×10^{-36}	4.47×10^{-50}	2.92×10^{-155}	2.48×10^{-01}	4.07×10^{-11}
REML						
Estimated variance components						
σ_g^2		15.00 (87.10)	190.00 (71.90)	0.42 (57.70)	1.83 (17.30)	11.00 (43.30)
σ_{ge}^2		1.29 (7.48)	49.50 (18.70)	0.28 (39.20)	3.21 (30.20)	4.57 (18.00)
σ_e^2		0.94 (5.43)	24.70 (9.34)	0.02 (3.03)	5.57 (52.50)	9.84 (38.70)
σ_p^2		17.3	264	0.721	10.6	25.4
H^2		0.871	0.719	0.577	0.173	0.433
R^2_{gei}		0.0748	0.187	0.392	0.302	0.18
h^2_{mg}		0.988	0.967	0.928	0.765	0.926
AS		0.994	0.984	0.963	0.875	0.963
r_{ge}		0.58	0.667	0.928	0.366	0.317
$CV_g\%$		18.2	17.8	19.8	1.88	4.16
$CV_r\%$		4.54	6.42	4.53	3.27	3.93
CV ratio		4.01	2.77	4.36	0.573	1.06
SD		4.34	18.61	3.32	3.99	6.32
SE		0.19	0.8	0.14287	0.17	0.27

Table S4. Cont.						
Traits		NKS	TKW	CT	Pn	Gs
G	χ^2	197	303	54.4	281	86.7
	p -value	8.87×10^{-45}	7.35×10^{-68}	1.62×10^{-13}	4.13×10^{-63}	1.29×10^{-20}
GEI	χ^2	158	88	317	7.2	446
	p -value	2.57×10^{-36}	6.43×10^{-21}	5.89×10^{-71}	7.30×10^{-3}	5.14×10^{-99}
REML		Estimated variance components				
σ_g^2		20.00 (72.70%)	23.40 (84.40%)	0.16 (37.60%)	2.19 (75.20%)	0.000 (51.30%)
σ_{ge}^2		4.38 (15.90%)	1.94 (6.99%)	0.21 (47.40%)	0.09 (3.15%)	0.000 (40.90%)
σ_e^2		3.15 (11.40%)	2.40 (8.66%)	0.07 (15.00%)	0.63 (21.70%)	0.000 (7.73%)
σ_p^2		27.6	27.7	0.435	2.91	0.000863
H^2		0.727	0.844	0.376	0.752	0.513
R^2_{gei}		0.159	0.0699	0.474	0.0315	0.409
h^2_{mg}		0.971	0.987	0.866	0.985	0.914
AS		0.985	0.994	0.931	0.992	0.956
r_{ge}		0.582	0.447	0.76	0.127	0.841
$CV_g\%$		12.9	11.3	2.17	14.2	14.6
$CV_r\%$		5.1	3.62	1.37	7.63	5.66
CV ratio		2.52	3.12	1.58	1.86	2.58
SD		5.62	6.7	1.3	1.79	0.24
SE		0.24	0.29	0.06	0.08	0.01

Table S4. Cont.						
Traits		E	POD	PPO	CAT	GY
G	χ^2	76.4	98.6	88.1	131	152
	p -value	2.36×10^{-18}	3.17×10^{-23}	6.19×10^{-21}	2.85×10^{-30}	6.52×10^{-35}
GEI	χ^2	243	1390	1210	1050	457
	p -value	7.56×10^{-55}	8.46×10^{-304}	5.43×10^{-266}	9.30×10^{-230}	2.26×10^{-101}
REML		Estimated variance components				
σ_g^2		0.0652 (44.80)	0.000 (57.70)	0.000 (54.30)	0.000 (66.00)	0.62 (68.70)
σ_{ge}^2		0.0555 (38.10)	0.000 (41.90)	0.000 (44.90)	0.000 (33.10)	0.24 (26.50)
σ_e^2		0.0247 (17.00)	0.000 (0.40)	0.00 (0.72)	0.000 (0.88)	0.04 (4.81)
σ_p^2		0.145	0.000113	0.000065	0.000051	0.905
H^2		0.448	0.577	0.543	0.66	0.687
R^2_{gei}		0.381	0.419	0.449	0.331	0.265
h^2_{mg}		0.902	0.925	0.915	0.947	0.957
AS		0.95	0.962	0.957	0.973	0.978
r_{ge}		0.692	0.991	0.984	0.974	0.846
$CV_g\%$		9.81	44.5	33	38.9	17.4
$CV_r\%$		6.04	3.71	3.8	4.48	4.61
CV ratio		1.62	12	8.68	8.67	3.78
SD		0.5	0.41	0.521	0.61	1.09
SE		0.02	0.017643591	0.02242	0.02625	0.05

Table S5. Phenotypic (upper diagonal) and genotypic (below diagonal) correlations among 20 studied traits obtained from nine environments (n = 180).

	DH	DM	GFD	NS	PH	FLA	GLA	LAI	LWC	RWC	NKS	TKW	CT	Pn	Gs	E	POD	PPO	CAT	GY
DH	1.000	0.842	-0.361	0.227	0.404	-0.417	0.074	0.377	-0.465	-0.037	-0.143	-0.687	-0.145	0.469	-0.101	0.018	-0.160	-0.148	-0.245	0.272
DM	0.835	1.000	0.229	0.322	0.350	-0.349	0.128	0.498	-0.435	0.124	-0.023	-0.757	-0.226	0.597	0.121	0.259	0.078	-0.154	-0.085	0.510
GFD	-0.339	0.226	1.000	0.135	-0.129	0.181	0.107	0.179	0.175	0.367	0.185	-0.090	-0.149	0.256	0.461	0.464	0.371	0.023	0.306	0.330
NS	0.221	0.314	0.121	1.000	0.364	-0.211	-0.033	0.582	-0.212	-0.026	-0.388	-0.146	-0.362	-0.317	-0.348	-0.122	0.252	-0.020	0.306	0.406
PH	0.396	0.343	-0.126	0.362	1.000	0.241	0.520	0.634	0.010	0.011	0.016	0.094	-0.512	0.124	0.023	-0.008	-0.119	-0.339	-0.500	0.144
FLA	-0.416	-0.346	0.174	-0.207	0.240	1.000	0.850	0.405	0.534	0.409	0.257	0.538	-0.451	0.088	0.438	0.286	-0.149	-0.157	-0.365	-0.187
GLA	0.073	0.127	0.105	-0.032	0.516	0.845	1.000	0.742	0.245	0.354	0.213	0.200	-0.611	0.316	0.394	0.340	-0.095	-0.195	-0.472	0.057
LAI	0.374	0.495	0.169	0.579	0.628	0.405	0.738	1.000	-0.177	0.157	0.025	-0.120	-0.719	0.180	0.050	0.175	0.070	-0.219	-0.198	0.435
LWC	-0.420	-0.382	0.145	-0.192	0.013	0.477	0.222	-0.151	1.000	0.494	0.039	0.402	0.100	-0.120	0.238	0.098	-0.249	-0.056	-0.091	-0.276
RWC	-0.037	0.124	0.324	-0.029	0.006	0.398	0.344	0.156	0.447	1.000	-0.200	0.047	-0.405	0.386	0.559	0.631	-0.183	-0.289	-0.181	0.055
NKS	-0.141	-0.025	0.174	-0.381	0.014	0.252	0.206	0.023	0.040	-0.195	1.000	-0.194	0.110	0.082	-0.019	-0.238	-0.221	-0.273	-0.221	0.165
TKW	-0.685	-0.752	-0.087	-0.143	0.095	0.535	0.201	-0.119	0.369	0.042	-0.190	1.000	-0.045	-0.368	0.078	-0.029	0.017	0.081	-0.119	-0.427
CT	-0.144	-0.222	-0.143	-0.350	-0.496	-0.445	-0.597	-0.704	0.100	-0.387	0.110	-0.042	1.000	-0.183	-0.290	-0.393	0.042	0.292	0.256	-0.230
Pn	0.451	0.580	0.239	-0.314	0.125	0.088	0.316	0.174	-0.067	0.376	0.085	-0.352	-0.179	1.000	0.530	0.502	-0.035	-0.070	-0.239	0.199
Gs	-0.097	0.119	0.440	-0.341	0.019	0.433	0.388	0.050	0.211	0.542	-0.018	0.074	-0.285	0.509	1.000	0.902	-0.110	0.030	-0.330	-0.258
E	0.019	0.252	0.444	-0.114	-0.009	0.280	0.337	0.172	0.082	0.593	-0.230	-0.024	-0.384	0.487	0.883	1.000	0.067	0.125	-0.235	-0.131
POD	-0.158	0.078	0.360	0.250	-0.118	-0.148	-0.094	0.070	-0.222	-0.179	-0.219	0.016	0.042	-0.034	-0.109	0.065	1.000	0.641	0.631	0.158
PPO	-0.147	-0.154	0.018	-0.019	-0.335	-0.156	-0.193	-0.218	-0.049	-0.283	-0.269	0.081	0.288	-0.066	0.030	0.124	0.641	1.000	0.617	-0.414
CAT	-0.244	-0.085	0.293	0.304	-0.497	-0.364	-0.469	-0.197	-0.088	-0.178	-0.219	-0.118	0.251	-0.234	-0.328	-0.230	0.630	0.617	1.000	-0.021
GY	0.271	0.504	0.318	0.401	0.144	-0.184	0.058	0.432	-0.251	0.052	0.163	-0.425	-0.224	0.191	-0.256	-0.129	0.158	-0.413	-0.020	1.000