

Supplementary Materials

Table S1. Details of durum wheat, barley and lentil genotypes evaluated during seasons 2018-2019 and 2019-2020.

Entry	Entry GID	Pedigree	CWR	HP rate of CWR genomic contribution
Durum wheat germplasm				
Karim	800017792	Jori/Anhinga//Flamingo (Check)	none	0.00%
Zagharin2	800043194	Icasyr1/3/Gcn//Stj/Mrb3 (Check)	none	0.00%
Bonidur	800029382	IRIDE/LINEA-PSB-0114 (Check)	none	0.00%
Chicca	800018562	CandocrossH25/3/Mrf2/NormalHamari//Bcr/Lk s4/4/Berghouata1 (Check)	none	0.00%
Kundermiki	600076816	MorlF38//Bcrch1/Kund1149/3/Bicredera1/Miki (Check)	none	0.00%
Faraj	800028288	T.ararticum/3/Arthur71/Lahn//Blk2/Lahn/4/Quarmal	<i>T. araraticum</i>	25.00%
Nachit	800043267	Amedakul1/TdicoSyrCol//Loukos	<i>T. dicoccoides</i>	25.00%
Jabal	800018569	Korifla/AegSpeltoidesSyr//Mrb5	<i>Ae. speltoides</i>	25.00%
Icamoram7	600100438	ICAMORT. Araraticum0472/Ammar7	<i>T. araraticum</i>	12.50%
Icaqinzen	800018534	IcamorT.araraticum0472//Quarmal/Gbch2/3/Mgnl3/Ainzen1	<i>T. araraticum</i>	6.25%
Icaverse	600108182	Azeghar1/4/IcamorT.araraticum0462/3/Maamouri3//Vitron/Bidra1/5/Mgnl3/Ainzen1	<i>T. araraticum</i>	3.12%
Maghrour	800032178	Amedakul1/TdicoSyrCol//Cham1	<i>T. dicoccoides</i>	25.00%
Sahi	800018532	Icasyr1/3/Bcr/Sbl5//T.urartu/4/13376/Bcrch1//Ossl1/Stj5	<i>T. urartu</i>	12.50%

Zeina	273403	IcamorT.araraticum0471//IcamorT.araraticum0459/Ammar8 /4/Stj3//Dra2/Bcr/3/Ter3	T. <i>araraticum</i>	12.50%
Syryopis	800018541	Marsyr3/3/Gcn//Stj/Mrb3/4/T.Aeg.Crosses	T. <i>aegilopiodes</i>	25.00%
ADYTM18-099	800034117	Amedakul1/TdicoSyrCol//Cham1/3/Korifla/Ae gSpeltoidesSyr//Amedakul	T. <i>dicoccoides & Ae. speltoides</i>	12.50%
DAWRyt123	800034692	Mrb5/TdicoAlpCol//Cham1	T. <i>dicoccoides</i>	25.00%
IDON39-13	800031875	IcamorT.araraticum0462/4/Gdr2//SwAlg/Gdr143/3/IcamorT. araraticum0463/5/Ter1//Mrf1/Stj2	T. <i>araraticum</i>	12.50%
IDON39-18	800031458	IcamorT.araraticum041/4/IcamorT.araraticum0469/3/Bcr/Gro1//Mgn1/5/MIKI2	T. <i>araraticum</i>	12.50%
IDON39-27	800018565	Quabrach1/4/IcamorT.araraticum0462/3/Maamouri3//Vitron/Bidra1/5/Murlagost2	T. <i>araraticum</i>	3.12%
IDON39-29	800034676	Azeghar2/5/IcamorT.araraticum0462/4/Stj3//Bcr /Lks4/3/Icamor"s"/6/Stj3//Bcr/Lks4/3/Ter3	T. <i>araraticum</i>	6.25%
IDON39-54	800031879	Korifla/AegSpeltoidesSyr//Amedakul	Ae. <i>speltoides</i>	25.00%
IDON39-70	800031880	CandocrossH25/Bicredera1/3/ICAMORT.araraticum0463//Lah/Ch12504/4/Bcrch1//Ossl1/Stj5/5 /Ysf1/Otb6	T. <i>araraticum</i>	1.56%
IDON39-96	800031881	Maamouri1/5/IcamorT.araraticum0462/4/Stj3//B cr/Lks4/3/Icamors/6/Mgnl3/Ainzen1	T. <i>araraticum</i>	3.12%
Barley germplasm				
Rihane03	28901	Check (6 rows)	H. <i>vulgare L.</i>	0.00%
WI2291	28900	Check (2 rows)	H. <i>vulgare L.</i>	0.00%
Furat-3	28902	Check (2 rows)	H. <i>vulgare L.</i>	0.00%
Tamellalt	28903	Check (2 rows)	H. <i>vulgare L.</i>	0.00%

11	28897	ChiCm/An57//Albert/3/Alger/Ceres.362-1-1/4/Arta/5/Moroc9-75//WI2291/CI01387/3/H.spont.41-1	<i>H. spontaneum</i>	25.00%
2	28895	ChiCm/An57//Albert/3/Alger/Ceres.362-1-1/4/Arta/5/Moroc9-75//WI2291/CI01387/3/H.spont.41-1	<i>H. spontaneum</i>	25.00%
18	28899	ChiCm/An57//Albert/3/Alger/Ceres.362-1-1/4/Arta/5/Moroc9-75//WI2291/CI01387/3/H.spont.41-1	<i>H. spontaneum</i>	25.00%
19	5935	ChiCm/An57//Albert/3/Alger/Ceres.362-1-1/4/Arta/5/Moroc9-75//WI2291/CI01387/3/H.spont.41-1	<i>H. spontaneum</i>	25.00%
7	5864	Moroc9-75//WI2291/CI01387/3/H.spont.41-1/4/Arta/3/Arar/H.spont.19-15//Hml	<i>H. spontaneum</i>	12.50%
1	5873	SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1/5/Roho/4/Zanbaka/3/ER/Apm//Lignee131	<i>H. spontaneum</i>	12.50%
4	28896	Soufara-02/3/RM1508/Por//WI2269/4/Hml-02/ArabiAbiad//ER/Apm/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	12.50%
21	5918	Clipper//WI2291*2/WI2269/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	12.50%
17	5865	Moroc9-75//WI2291/CI01387/3/H.spont.41-1/5/Clipper/Volla/3/Arr/Esp//Alger/Ceres362-1-1/4/Hml	<i>H. spontaneum</i>	12.50%
9	5849	Moroc9-75//WI2291/CI01387/3/H.spont.41-1/4/Arta/3/Arar/H.spont.19-15//Hml	<i>H. spontaneum</i>	12.50%
24	5900	Clipper//WI2291*2/WI2269/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	12.50%
13	5920	WI2291/Tadmor/4/ChiCm/An57//Albert/3/Alger/Ceres362-1-1/5/SLB34-40/4/SLB15-05/3/H.spont.21-3/Arar84//WI2291/Bgs	<i>H. spontaneum</i>	6.75%
20	5883	Moroc9-75//WI2291/CI01387/3/H.spont.41-1/5/Clipper/Volla/3/Arr/Esp//Alger/Ceres362-1-1/4/Hml	<i>H. spontaneum</i>	6.75%

10	5939	ChiCm/An57//Albert/3/Alger/Ceres362-1-1/4/Arta/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	25.00%
5	5846	Clipper//WI2291*2/WI2269/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	25.00%
15	5925	Roho/4/Zanbaka/3/ER/Apm//Lignee131/5/Moroc9-75//WI2291/CI01387/3/H.spont.41-1	<i>H. spontaneum</i>	37.50%
23	5922	Soufara-02/3/RM1508/Por//WI2269/4/Hml-02/ArabiAbiad//ER/Apm/5/Moroc9-75//WI2291/CI01387/3/H.spont.41-1	<i>H. spontaneum</i>	12.50%
22	5904	Moroc9-75//WI2291/CI01387/3/H.spont.41-1/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	25.00%
16	28898	ChiCm/An57//Albert/3/Alger/Ceres.362-1-1/4/Arta/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	12.50%
8	5895	Moroc9-75//WI2291/WI2269/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	25.00%
6	5929	Clipper//WI2291*2/WI2269/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	12.50%
3	5890	WI2291/Tadmor/4/ChiCm/An57//Albert/3/Alger/Ceres362-1-1/5/SLB34-40/4/SLB15-05/3/H.spont.21-3/Arar84//WI2291/Bgs	<i>H. spontaneum</i>	6.75%
12	5905	ChiCm/An57//Albert/3/Alger/Ceres362-1-1/4/Arta/5/SLB15-05/4/H.spont.96-3/3/Roho//Alger/Ceres362-1-1	<i>H. spontaneum</i>	6.75%
14	5934	Zanbaka/5/Pyo/Cam//Avt/RM1508/3/Pon/4/Moroc9-75/ArabiAswad/7/ArabiAbiad/Arar//H.spont.41-5/Tadmor	<i>H. spontaneum</i>	12.50%
Lentil germplasm				
2018-CWR-1325	22519	ILL4605 (Standard check)	none	0.00%
2018-CWR-1301	4916	ILL6002/ILWL118/1-1	<i>L. orientalis</i>	3.125%

2018-CWR-1302	4934	ILL4605/ILWL118/1SPS	L. <i>orientalis</i>	3.125%
2018-CWR-1303	4935	ILL4605/ILWL118/2SPS	L. <i>orientalis</i>	3.125%
2018-CWR-1304	4936	ILL4605/ILWL118/3SPS	L. <i>orientalis</i>	3.125%
2018-CWR-1305	4937	ILL4605/ILWL118/6SPS	L. <i>orientalis</i>	3.125%
2018-CWR-1306	4938	ILL4605/ILWL118/9SPS	L. <i>orientalis</i>	3.125%
2018-CWR-1307	4944	ILL7986/ILWL074/10SPS	L. <i>orientalis</i>	3.125%
2018-CWR-1308	20	ILL6002/ILWL118/1-3	L. <i>orientalis</i>	3.125%
2018-CWR-1309	41	ILL7978/ILWL118/3-8	L. <i>orientalis</i>	3.125%
2018-CWR-1310	53	ILL7978/ILWL118/3-1	L. <i>orientalis</i>	3.125%
2018-CWR-1311	56	ILL7978/ILWL118/1-4	L. <i>orientalis</i>	3.125%
2018-CWR-1312	67	ILL2585/ILWL90/2	L. <i>orientalis</i>	3.125%
2018-CWR-1313	4633	ILL7978/ILWL118/3-5	L. <i>orientalis</i>	3.125%
2018-CWR-1314	4638	ILL7978/ILWL118/3-9	L. <i>orientalis</i>	3.125%
2018-CWR-1315	4652	ILL7978/ILWL118/1-2	L. <i>orientalis</i>	3.125%
2018-CWR-1316	4653	ILL7978/ILWL118/5-4	L. <i>orientalis</i>	3.125%
2018-CWR-1317	4732	ILL2585/ILWL90/9-5	L. <i>orientalis</i>	3.125%
2018-CWR-1318	4733	ILL7978/ILWL118/2-1	L. <i>orientalis</i>	3.125%
2018-CWR-1319	4741	Sel-99/209/ILWL118/5-1	L. <i>orientalis</i>	3.125%

2018-CWR-1320	4675	ILL7978/ILWL118/5-2	<i>L. orientalis</i>	3.125%
2018-CWR-1321	4688	ILL7978/ILWL118/3-2	<i>L. orientalis</i>	3.125%
2018-CWR-1322	4704	ILL2585/ILWL90/11	<i>L. orientalis</i>	3.125%
2018-CWR-1323	4717	ILL2585/ILWL90/4-3	<i>L. orientalis</i>	3.125%
2018-CWR-1324	4757	ILL7978/ILWL118/2-7	<i>L. orientalis</i>	3.125%

Table S2. Experimental farms used for field evaluation during the seasons 2018-2019 and 2019-2020

Location	Country	Season	Grain yield average			Altitude (m a.s.l.)	Soil	Climate	Temperature (°C)		Moisture (mm)
			Durum	Barley	Lentil				Tmin	Tmax	
Akkar	Lebanon	2019-2020	4115	-	-	30	Sandy clay	Mediterranean/temperate	6.9	28.0	823
Annoceur	Morocco	2018-2019	1360	2648	-	1440	Lime-clay	Mediterranean/warm and temperate	10.8	27.7	251
		2019-2020	3717	4431	1314				10.9	26.6	423
Debre Zeit	Ethiopia	2019-2020	1685	657	536	1880	Vertisol	Subtropical highland	13.5	25.0	580
Dheraa	Ethiopia	2019-2020	3335	1690	1505	2200	Light soil	Tepid semi-arid mid highlands	13.4	26.0	540
Fanaye	Senegal	2019-2020	2946	843	327	17	Sandy clay	Sahelian climate	14.7	35.2	380
Jemaa Shaim	Morocco	2018-2019	-	3660	-	170	Calcic cambisol	Hot steppe	13.1	25.6	216
Kfardan	Lebanon	2018-2019	3578	-	-	1050	Vertisol	Mediterranean/temperate	4.6	17.4	533
		2019-2020	5822	4977	-				5.6	18.7	516
Marchouch	Morocco	2018-2019	5148	2834	1272	398	Clay vertisol	Mediterranean/warm and temperate	6.2	21.0	285
		2019-2020	858	2545	808				7.6	21.1	230

Melk Zhar	Morocco	2019-2020	5091	-	-	137	Sandy limestone	Mediterranean/hot and temperate	9.6	23.7	430
Sidi el Aidi	Morocco	2018-2019	1714	2145	-	226	Vertisol	Mediterranean/hot and temperate	8.4	25.0	216
		2019-2020	1777	521	237				7.6	23.0	206
Tel Amara	Lebanon	2018-2019	3800	-	-	915	Eutric cambisols	Mediterranean/temperate	8.4	25.6	770
		2019-2020	3920	-	-				7.3	23.5	727
Terbol	Lebanon	2018-2019	6365	-	-	897	Chromic vertisol	Mediterranean/temperate	6.9	18.7	732
		2019-2020	6220	5428	2187				3.9	18.6	697
Tessaout	Morocco	2018-2019	5584	3974	-	472	Calcic Xerosols	Hot steppe	7.3	24.2	448
		2019-2020	2422	3150	1261				4.1	26.3	374

Table S3. Essential management practices for durum wheat, barley and lentil on the different experimental sites.

Site	Durum wheat		Barley		Lentil		Irrigation System
	Fertilization	Weeding treatment	Fertilization	Weeding treatment	Fertilization	Weeding treatment	
Akkar20	NPK-15-15-15; Urea 46%	2.4 D-Deer @1.5 L/ha		-		-	Rainfed
Annoceur19	NPK-15-15-15; NH4NO3-33-0-0	PALLAS 45 OD 0.5 l/ha; MUSTANG 306 SE 0.6 l/ha	NPK15-15-15; NH4NO3-33-0-0	AXIAL 045 EC 1l/ha; MUSTANG 306 SE 0.6 l/ha		-	Sprinkle
Annoceur20	NPK-15-15-15; NH4NO3-33-0-0	PALLAS 45 OD 0.5 l/ha; MUSTANG 306 SE 0.6 l/ha	NPK15-15-15; NH4NO3-33-0-0	AXIAL 045 EC 1l/ha; MUSTANG 306 SE 0.6 l/ha	NPK-6-20-30	Pre-emergence Herbicide “Challenge® 600”	Sprinkle
DebreZeit20	NPK-15-15-15; Urea 46%	Mechanical	NPK15-15-15	Mechanical	none	Mechanical	Rainfed
Dheraa20	NPK-15-15-15; Urea 46%	Mechanical	NPK15-15-15	Mechanical	none	Mechanical	Rainfed
Fanaye20	NPK-15-15-15; Urea 46%	Mechanical	NPK-15-15-15; Urea 46%	Mechanical	NPK-15-15-15	Mechanical	Gravity
JemaaShaim19	-	-	NPK15-15-15; NH4NO3-33-0-0	Mechanical		-	Rainfed
Kfardan19	NPK-15-15-15; Urea 46%	2.4 D-Deer @1.5 L/ha; Pallas @ 400 cc/ha		-		-	Rainfed
Kfardan20	NPK-15-15-15; Urea 46%	2.4 D-Deer @1.5 L/ha; Pallas @ 400 cc/ha	NPK15-15-15	2,4-D 1.25 L/ha		-	Rainfed
Marchouch19	NPK-15-15-15; NH4NO3-33-0-0	PALLAS 45 OD 0.5 l/ha; MUSTANG 306 SE 0.6 l/ha	NPK15-15-15; NH4NO3-33-0-0	AXIAL 045 EC 1l/ha; MUSTANG 306 SE 0.6 l/ha	NPK-6-20-30	Pre-emergence Herbicide “Challenge® 600”	Rainfed

Marchouch20	NPK-15-15-15; NH4NO3-33-0-0	PALLAS 45 OD 0.5 l/ha; MUSTANG 306 SE 0.6 l/ha	NPK15-15-15; NH4NO3-33-0-0	AXIAL 045 EC 1l/ha; MUSTANG 306 SE 0.6 l/ha	NPK-6- 20-30	Pre-emergence Herbicide “Challenge® 600”	Rainfed
Melk Zhar20	50-50-50 U of N; 50 U of P and K	DERBY 175 SC 50 cc/ha		-		-	Drip
Sidi el Aidi19	NPK-15-15-15; NH4NO3-33-0-0	PALLAS 45 OD 0.5 l/ha; MUSTANG 306 SE 0.6 l/ha	NPK15-15-15; NH4NO3-33-0-0	AXIAL 045 EC 1l/ha; MUSTANG 306 SE 0.6 l/ha		-	Rainfed
Sidi el Aidi20	NPK-15-15-15; NH4NO3-33-0-0	PALLAS 45 OD 0.5 l/ha; MUSTANG 306 SE 0.6 l/ha	NPK15-15-15; NH4NO3-33-0-0	AXIAL 045 EC 1l/ha; MUSTANG 306 SE 0.6 l/ha	NPK-6- 20-30	Pre-emergence Herbicide “Challenge® 600”	Rainfed
Tel Amara19	NPK-15-15-15; Urea 46%	2.4 D-Deer @1.5 L/ha		-		-	Sprinkle
Tel Amara20	NPK-15-15-15; Urea 46%	2.4 D-Deer @1.5 L/ha		-		-	Sprinkle
Terbol19	NPK-15-15-15; Urea 46%	2.4 D-Deer @1.5 L/ha		-		-	Sprinkle
Terbol20	NPK-15-15-15; Urea 46%	2.4 D-Deer @1.5 L/ha	NPK15-15-15; NH4NO3-33-0-0	2,4-D 1.25 L/ha	NPK-6- 20-30	Pre-emergence Herbicide “Challenge® 600”	Sprinkle
Tessaout19	NPK-15-15-15; NH4NO3-33-0-0	PALLAS 45 OD 0.5 l/ha; MUSTANG 306 SE 0.6 l/ha	NPK15-15-15; NH4NO3-33-0-0	AXIAL 045 EC 1l/ha; MUSTANG 306 SE 0.6 l/ha		-	Gravity
Tessaout20	NPK-15-15-15; NH4NO3-33-0-0	PALLAS 45 OD 0.5 l/ha; MUSTANG 306 SE 0.6 l/ha	NPK15-15-15; NH4NO3-33-0-0	AXIAL 045 EC 1l/ha; MUSTANG 306 SE 0.6 l/ha	NPK-6- 20-30	Pre-emergence Herbicide “Challenge® 600”	Gravity

Table S4. Analysis of variance for all traits of durum wheat, barley and lentil across locations, the value of each Source of variation (SOV: E, G, and GxE) is presented as ratio of the total variation.

Traits	SOV	Durum wheat		Barley		Lentil	
		Df	Value	Df	value	Df	Value
GY	G	23	1.80***	27	6.35***	24	4.38***
	E	18	85.24***	8	67.19***	8	72.11***
	GxE	414	7.15***	216	17.41***	190	13.82***
	H2		0.79		0.70		0.53
	CV		12.92		18.56		25.62
	Max		3980.90		3196.55		1112.66
	LSD		213.70		375.70		162.80
TSW	G	23	5.37***	27	16.06***	24	41.01***
	E	18	79.60***	8	62.58***	8	23.18***
	GxE	414	6.91***	216	14.85***	192	23.13***
	H2		0.93		0.88		0.97
	CV		8.88		5.40		6.38
	Max		45.76		51.97		52.13
	LSD		1.98		2.77		5.85
DTH (D50 for lentil)	G	23	0.34***	27	5.64***	24	3.89***
	E	16	98.49***	7	89.56***	7	89.74***
	GxE	368	0.59***	189	2.93**	168	4.72***
	H2		0.88		0.92		0.78
	CV		2.18		2.37		3.84
	Max		114.13		108.15		65.44
	LSD		1.01		1.67		1.34
DTM	G	23	0.11***	27	3.37***	24	1.25***
	E	10	99.39***	6	90.25***	8	93.79***
	GxE	230	0.26***	162	3.75***	192	4.28***
	H2		0.74		0.78		0.61
	CV		1.20		2.15		2.33
	Max		147.55		149.51		116.33
	LSD		0.84		2.10		1.54
PLH	G	23	4.45***	27	2.39***	24	5.63***
	E	17	79.84***	8	88.88***	7	62.57***
	GxE	391	6.82***	216	5.43***	168	15.42***
	H2		0.92		0.72		0.38
	CV		4.85		6.23		14.45
	Max		93.34		82.70		29.94
	LSD		1.90		3.36		2.24
GL	G	23	33.00***	27	65.65***	24	76.99***
	E	8	46.98***	7	17.67***	4	3.77***
	GxE	184	9.14***	189	12.85***	96	16.15***

	H2		0.95		0.97		0.98
	CV		1.77		2.42		1.96
	Max		7.45		8.88		6.06
	LSD		0.10		0.27		0.22
GW	G	23	14.49***	27	71.77***	24	74.70***
	E	8	76.58***	7	18.93***	4	6.85***
	GxE	184	4.57***	189	7.48***	96	14.44***
	H2		0.94		0.97		0.93
	CV		1.93		1.44		2.60
	Max		3.41		3.41		5.52
	LSD		0.06		0.07		0.20

GY, grain yield; TSW; 1000-seed weight, DTH; days to heading cereals, D50F; days to flowering for lentil, DTM; days to maturity, PLH; plant height, GL; grain length, GW; grain width. * p<0.05, **p<0.01 and ***p<0.001

Table S5. Grain yield (kg ha⁻¹), plant height (cm), and phenological traits for durum wheat, barley and lentil across environments.

Genotype	GY	PLH	DTH(D50F)	DTM
Durum wheat				
800034117	3887.08	89.24	109.84	144.39
Bonidur	3703.18	90.11	109.60	146.26
Chicca	3502.43	90.08	112.43	145.75
800034692	3580.16	90.13	111.74	145.84
Faraj	3506.73	88.38	113.65	147.48
600100438	3797.67	81.86	111.72	145.87
800018534	3948.03	89.56	110.09	145.26
600108182	3755.18	85.09	109.91	145.30
800031875	3513.36	90.91	110.92	145.99
800031458	3676.43	93.34	109.12	145.23
800018565	3556.88	90.68	111.80	146.37
800034676	3390.01	87.82	110.03	145.30
800031879	3563.58	89.23	111.25	145.13
800031880	3351.52	86.11	114.13	147.01
800031881	3400.59	89.40	112.28	146.69
800018569	3811.86	91.42	110.23	145.40
Karim	3294.61	85.19	112.73	147.55
Kundermiki	3740.40	86.75	110.64	145.35
800032178	3881.71	88.39	109.22	144.19
Nachit	3840.82	89.04	110.19	144.93
Sahi	3740.86	86.20	111.40	145.64
800018541	3642.85	91.98	109.57	144.85
Zagharin2	3664.62	91.14	109.76	145.37
273403	3980.90	84.11	112.17	146.27
Barley				
5873	3129.94	77.12	98.26	142.18

5939	2876.84	79.76	103.03	145.08
28897	2919.29	78.11	100.79	143.59
5905	3030.58	81.77	102.36	145.66
5920	2749.74	82.02	104.45	144.72
5934	2699.06	80.49	105.85	147.01
5925	2826.99	80.47	101.36	145.17
28898	2768.16	80.14	107.82	149.06
5865	2420.34	76.14	104.88	145.85
28899	3196.55	80.18	102.20	145.61
5935	2905.92	82.70	102.47	145.13
28895	3009.74	75.71	104.03	146.63
5883	2534.09	79.13	101.08	145.02
5918	3013.98	82.01	102.23	145.63
5904	2808.49	81.05	97.19	141.76
5922	2562.42	79.58	102.41	145.06
5900	2749.72	82.48	103.56	146.43
WI2291	3195.98	78.01	100.92	143.29
Rihane03	3140.55	75.92	104.85	146.67
Furat-3	3101.97	74.59	103.22	145.36
Tamellalt	2933.24	77.52	108.15	149.52
5890	2673.65	81.19	104.89	147.27
28896	3065.25	77.37	100.82	143.28
5846	3092.36	80.83	101.14	144.34
5929	3040.71	79.38	96.37	143.13
5864	2431.17	78.47	102.75	145.26
5895	3148.59	80.23	100.70	144.25
5849	2583.49	78.63	103.51	145.35
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Lentil				
4916	1049.17	29.94	59.64	112.40
53	1061.14	27.88	64.28	114.39
56	975.31	27.71	65.45	116.25
67	905.41	28.23	63.91	114.46
4633	1085.71	27.00	62.79	114.38
4638	1090.55	28.00	62.80	113.81
4652	1058.43	27.56	61.47	113.97
4653	1112.66	27.51	64.04	116.33
4732	951.69	27.02	64.32	115.85
4733	1013.40	27.55	60.80	113.28
4741	908.83	29.46	62.39	114.38
4934	1037.70	27.79	59.38	110.94
4675	1045.73	27.57	61.94	115.52
4688	863.66	27.01	59.90	110.96
4704	934.88	28.14	58.89	110.99
4717	980.38	27.94	63.56	114.32
4757	1105.67	27.20	60.75	113.38
Bakria	1074.58	28.55	59.28	110.84

4935	1084.35	28.20	59.58	111.31
4936	1067.85	27.91	58.85	110.72
4937	1050.62	27.95	59.88	111.46
4938	1072.95	27.84	58.87	110.49
4944	963.10	27.99	63.16	113.65
20	1012.68	29.18	60.46	113.78
41	1025.16	27.49	63.30	115.70

GY; grain yield, DTH; days to heading cereals, D50F; days to flowering for lentil, DTM; days to maturity, PLH; plant height.

Table S6. Analysis of variance for the traits of the 8 selected entries of barley across Lebanon, Senegal and Ethiopia environments conducted during 2019-2020 cropping season. the value of each Source of variation (SOV: G, E, and GxE) is presented as ratio of the total variation.

SOV	df	GY	TSW	DTH	DTM	PLH
G	7	1.83*	6.09*	0.09*	0.16*	7.25*
E	4	94.10*	69.41*	99.76*	99.63*	69.21*
GxE	28	3.73*	22.78*	0.13*	0.19*	22.06*
H ²		0.26	0.62	0.60	0.64	0.85
CV		5.25	4.08	0.93	0.64	3.38
Max		4269.17	50.07	108.67	145.00	101.67
LSD		402.27	3.53	3.35	2.12	8.64

GY, grain yield; TSW; 1000-seed weight, DTH; days to heading, DTM; days to maturity, PLH; plant height. * p<0.001.

Table S7. Analysis of variance for quality traits of durum wheat, barley and lentil across locations, the value of each Source of variation (SOV: E, G, and GxE) is presented as ratio of the total variation.

Traits	SOV	Durum wheat		Barley		Lentil	
		Df	Value	Df	Value	Df	Value
GPC	G	23	22.15***	27	4.88***	24	22.92***
	E	8	28.47***	7	81.76***	4	54.78***
	GxE	184	34.59***	189	8.73***	96	15.09***
	H ²		0.65		0.72		0.79
	CV		4.47		5.00		1.08
	Max		13.97		13.96		24.27
	LSD		0.24		0.47		0.13
Fe	G	23	16.17***	27	6.55***	24	18.99***
	E	8	24.28***	7	54.66***	4	23.12***
	GxE	184	39.22***	189	33.14***	96	55.12***
	H ²		0.20		0.20		0.63
	CV		41.00		12.00		9.10
	Max		30.90		41.52		78.24
	LSD		3.16		3.03		2.61
Zn	G	23	2.94*	27	3.30		18.13***

	E	8	69.46***	7	49.98***	32.11***
	GxE	184	9.90	189	26.64**	46.22***
	H2		0.29		0.10	0.45
	CV		20.00		5.00	9.49
	Max		35.84		37.38	61.24
	LSD		2.67		3.98	2.43
YI	G	23	35.95***			
	E	8	34.95***			
	GxE	184	22.31***			
	H2		0.79			
	CV		4.69			
	Max		18.42			
	LSD		0.23			
MIXO	G	23	47.71***			
	E	3	5.01***			
	GxE	69	27.51***			
	H2		0.93			
	CV		14.16			
	Max		7.31			
	LSD		0.36			
β-glucan	G			27	9.24***	
	E			7	28.67	
	GxE			189	38.09***	
	H2				0.33	
	CV				22.00	
	Max				5.81	
	LSD				0.91	

GPC; grain protein content, Fe; iron content, Zn; zinc content, YI; yellow pigment index, MIXO; mixo-score. * p<0.05, **p<0.01 and ***p<0.001.

Table S8. Grain yield (kg ha⁻¹), plant height (cm), 1000-seed weight (g) and phenological traits of the eight CWR elites of barley at Terbol20, Kfardan20, Debre Zeit20, Dheraa20 and Fanaye20.

Genotype	GY	DTH	DTM	PLH	TSW
Terbol20 environment					
5873	6080.83	133.50	171.50	101.50	49.25
28896	5250.83	134.50	174.00	101.50	51.90
5846	5826.67	132.50	172.50	109.00	50.65
5895	5023.33	134.50	174.50	101.00	49.20
5939	4530.00	134.50	174.50	104.50	49.10
5918	6136.67	134.00	174.00	105.00	54.60
Furat-3	4985.00	129.50	170.00	81.00	49.25
Chams	5584.17	135.00	176.00	94.50	46.25
Kfardan20 environment					
5873	5477.50	132.00	171.00	106.50	44.85
28896	5055.83	133.50	172.50	102.50	45.20
5846	4187.50	130.00	172.50	112.50	49.80
5895	5067.50	131.00	173.00	108.50	48.50
5939	4338.33	132.00	172.50	109.00	43.30
5918	4915.00	132.50	171.50	109.50	49.90
Furat-3	5303.33	131.00	168.50	89.50	47.05
Chams	5474.17	135.00	175.00	108.50	39.55
Debre Zeit20 environment					
5873	583.33	48.00	69.00	70.00	28.00
28896	293.33	50.00	68.00	65.00	34.00
5846	318.33	48.00	72.00	65.00	30.00
5895	430.00	48.00	70.00	60.00	36.00
5939	441.67	50.00	75.00	80.00	30.00
5918	696.67	51.00	76.00	80.00	34.00
Furat-3	981.67	47.00	69.00	75.00	36.00
Arsi	1515.00	52.00	83.00	110.00	40.00
Dheraa20 environment					
5873	2785.00	50.00	83.00	85.00	36.00
28896	2948.33	51.00	85.00	85.00	48.00
5846	1535.00	49.00	80.00	90.00	32.00
5895	1671.67	49.00	82.00	85.00	44.00
5939	821.67	49.00	80.00	80.00	28.00
5918	863.33	54.00	80.00	80.00	28.00
Furat-3	1468.33	49.00	77.00	80.00	28.00
Arsi	1426.67	55.00	85.00	85.00	40.00
Fanaye20 environment					
5873	1249.70	53.50	83.50	72.13	48.00
28896	912.00	55.00	84.00	72.50	47.00
5846	1134.00	53.50	82.00	83.38	45.50
5895	582.00	54.00	85.00	75.00	52.50
5939	812.00	59.50	86.00	75.38	49.00

5918	540.00	56.00	86.00	70.00	45.50
Furat-3	990.00	57.00	85.00	69.75	49.00
Ksiba	528.00	52.50	84.00	69.00	42.50

GY; grain yield, DTH; days to heading, DTM; days to maturity, PLH; plant height, TSW; 1000-seed weight.

Table S9. Pearson correlation between grain yield, plant height, days to flowering and climatic matrix of durum wheat, barley and lentil across all environments.

	GY			PLH			DTH		D50F
	Durum	Barley	Lentil	Durum	Barley	Lentil	Durum	Barley	Lentil
T _{min} (BS)	-0.28	0.25	-0.38	-0.33	-0.50	0.31	-0.69**	-0.27	-0.84**
T _{min} (VS)	-0.45	0.04	-0.42	-0.46	-0.42	0.22	-0.82**	0.55	-0.76*
T _{min} (F)	-0.36	0.37	-0.25	-0.18	-0.05	0.03	-0.52*	0.54	-0.52
T _{min} (GF)	-0.20	0.43	-0.42	-0.11	-0.07	0.16	-0.43	0.48	-0.51
T _{min} (M)	-0.20	0.20	-0.40	-0.11	-0.18	0.01	-0.25	0.56	-0.28
T _{max} (BS)	-0.17	-0.45	-0.29	-0.35	-0.67	0.45	-0.50*	0.55	-0.60
T _{max} (VS)	-0.46*	0.22	-0.77*	-0.33	0.21	0.38	-0.68**	0.46	-0.09
T _{max} (F)	-0.50*	0.21	-0.67	-0.26	0.27	0.49	-0.49*	0.30	-0.10
T _{max} (GF)	-0.18	0.70*	-0.56	-0.10	0.47	0.51	-0.21	0.13	-0.12
T _{max} (M)	0.14	0.37	-0.14	0.23	0.48	0.14	0.13	0.43	0.28
Rh(BS)	-0.13	-0.08	0.04	0.19	0.44	-0.65	0.28	-0.16	0.45
Rh(VS)	0.05	-0.23	0.44	0.25	0.37	-0.55	0.39	-0.60	0.25
Rh(F)	0.07	0.08	0.38	0.20	0.06	-0.60	0.32	-0.48	0.25
Rh(GF)	-0.20	-0.42	0.34	-0.05	-0.01	-0.57	0.10	-0.27	0.44
Rh(M)	-0.30	-0.22	0.09	-0.17	-0.02	-0.46	-0.01	-0.44	0.47
WI(BS)	-0.11	-0.01	0.00	0.02	-0.03	-0.20	-0.35	-0.16	-0.63
WI(VS)	0.59**	0.47	0.71*	0.49*	0.75*	-0.10	0.37	-0.36	-0.47
WI(F)	-0.11	0.50	0.10	-0.05	0.62	-0.09	-0.41	0.02	0.70
WI(GF)	-0.05	0.73*	0.32	0.03	0.70*	0.39	-0.24	-0.16	-0.09
WI(M)	0.20	-0.03	0.49	-0.12	0.22	-0.13	0.13	-0.35	0.12

T_{min}, average minimum daily temperature; T_{max}, average maximum daily temperature, Rh, relative humidity; WI, water input in mm. In each climatic factor, BS corresponds to one month before sowing; VS, vegetative stage; F, flowering period; GF, grain filling period; M, maturity period, * p<0.05 and **<0.01.

Table S10. Pearson correlation coefficient between grain yield and plant height, days to heading, days to 50%flowering for lentil, days to maturity and 1000-seeds weight per cluster in durum wheat, barley and lentil.

Crop	Cluster	Trait	PLH	DTH/D50F	DTM	TSW
Durum wheat	E1	Grain yield	-0.02	0.44**	0.50**	0.41**
	E2		0.39	0.51**	0.73**	0.63**
	E3		0.16	0.15	0.15	0.10
	E4		0.29	-0.46**	-0.82**	0.19
	E5		-0.48*	-0.20	-0.43**	-0.04
	E1	Grain yield	-0.39	0.52**	-0.05	-0.41
	E2		0.34	0.06	-0.09	0.18
	E3		0.47	-0.13	-0.35	0.11
	E4		-0.34	-0.20	0.18	0.56**
	E5		-0.25	-0.27	-0.15	0.51**
Lentil	E1	Grain yield	-	-	-	-
	E2		0.18	0.23	0.12	-0.14
	E3		0.25	-0.61**	-0.55**	0.58**
	E4		0.11	0.07	0.17	0.34
	E5		-0.03	-0.08	0.07	0.67**

* and ** indicate significant correlation at 0.05 and 0.01, respectively. PLH; plant height, DTH; days to heading for durum wheat and barley, D50F; days to 50% of flowering for lentil, DTM; days to maturity and TSW; 1000-seed weight.

Table S11. Average values (BLUES) for food transformation characteristics of the CWR-derived elites and checks of durum wheat, barley and lentil across environments in Morocco.

Genotype	GPC (%)	Zn (mg kg ⁻¹)	Fe (mg kg ⁻¹)	TSW (g)	GL (mm)	GW (mm)	YI (b*)	MIXO	β-glucan (%)
Durum wheat									
800018532	13.97	35.84	23.09	45.36	7.3	3.41	17.99	5.06	
800034117	13.85	28.89	22.32	44.87	7.32	3.29	17.33	4.83	
800034692	13.65	28.66	27.4	40.37	6.93	3.20	17.67	5.34	
600100438	12.73	27.51	25.06	37.99	7.06	3.12	17.92	3.31	
800018534	12.75	31.48	28.48	42.46	7.21	3.19	17.63	5.99	
600108182	13.18	28.00	30.90	40.49	7.08	3.16	17.73	3.89	
800031875	13.27	29.87	21.26	40.79	7.15	3.18	17.55	5.21	
800031458	12.83	31.33	24.96	44.67	7.30	3.33	17.40	4.37	
800018565	13.11	34.81	20.63	42.87	7.11	3.23	17.41	2.36	
800034676	12.95	35.00	23.92	37.60	6.76	3.17	17.51	5.99	

800031879	13.95	30.92	18.14	43.71	7.24	3.26	17.56	5.28
800031880	13.66	32.73	22.34	40.83	7.23	3.19	16.89	3.38
800031881	13.21	32.02	24.14	43.95	7.10	3.30	16.94	6.09
800018569	13.83	29.84	18.55	45.02	7.37	3.30	17.54	5.05
800032178	13.89	32.75	24.12	44.82	7.25	3.33	18.38	5.59
800018541	13.51	30.08	26.46	44.97	7.45	3.34	17.77	5.73
273403	12.70	32.63	26.02	39.95	6.96	3.21	17.56	7.31
800043267	13.97	30.89	30.44	45.76	7.33	3.34	17.81	5.11
800028288	12.74	31.86	19.58	38.78	7.20	3.16	17.35	3.77
Bonidur	13.27	33.48	21.11	41.43	7.33	3.13	17.44	4.10
Chicca	13.53	32.49	23.58	42.45	7.11	3.28	16.54	3.31
Karim	12.96	26.08	24.70	39.38	7.15	3.14	17.05	4.87
Kundermiki	13.12	27.93	18.82	37.16	6.98	3.06	16.80	4.70
Zagharin2	13.93	31.48	21.73	44.51	7.23	3.30	18.42	5.34
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Barley								
5925	12.69	32.62	34.00	47.94	8.32	3.41		5.81
5864	13.02	35.20	31.87	41.36	8.35	3.19		5.51
5849	12.67	34.06	33.35	42.26	8.26	3.20		5.4
5904	13.11	33.91	30.70	48.65	8.54	3.35		5.38
5895	11.83	32.46	36.82	48.94	8.63	3.32		5.33
28898	12.60	37.38	41.33	46.48	8.21	3.35		5.23
5900	13.33	35.35	26.54	49.06	8.42	3.39		5.21
28899	13.15	32.83	32.31	49.67	8.12	3.39		5.19
28896	12.32	32.46	34.74	46.81	8.18	3.35		4.95
5883	13.96	34.66	32.37	46.75	7.87	3.38		4.9
5935	13.01	34.49	36.83	46.72	8.04	3.36		4.88
5873	12.41	33.71	32.55	48.93	8.88	3.36		4.86
28897	12.97	31.31	32.21	46.37	7.93	3.33		4.82
5929	12.76	33.48	26.06	51.97	8.80	3.40		4.57
5922	13.72	33.90	35.76	45.70	7.91	3.36		4.48
5865	12.88	34.93	39.88	42.92	8.25	3.23		4.47
5918	12.96	32.22	28.02	49.18	8.28	3.41		4.47
5920	13.67	32.87	32.67	42.22	6.92	2.75		4.41
5846	12.54	33.58	37.72	49.26	8.74	3.37		4.39
5890	12.96	32.77	29.22	40.52	6.22	2.64		4.37
5934	12.91	33.20	31.20	44.84	7.53	2.89		4.36
28895	12.81	35.10	39.84	45.39	8.02	3.32		4.18
5905	12.95	36.24	27.78	47.93	8.21	3.41		4.08
5939	13.00	31.06	36.56	45.63	8.21	3.36		4
Rihane03	11.98	32.39	41.52	42.59	8.38	3.20		5.07
WI2291	12.19	31.23	35.53	47.23	8.16	3.37		4.66
Furat-3	12.45	30.58	33.24	48.76	8.88	3.34		4.29
Tamellalt	12.53	34.89	30.92	43.19	7.67	3.35		4.07
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Lentil								
4916	23.68	45.71	55.06	49.32	5.97	5.45		
53	22.53	51.49	42.45	41.13	5.25	4.85		

56	23.37	50.39	71.86	37.13	5.15	4.71
67	22.81	45.37	50.03	24.38	4.41	3.97
4633	22.78	48.14	50.54	42.60	5.36	4.90
4638	22.91	57.83	36.84	40.13	5.23	4.90
4652	23.45	54.91	78.24	38.13	5.12	4.73
4653	23.95	41.68	52.77	38.63	5.31	4.82
4732	23.24	42.13	54.23	36.18	4.99	4.51
4733	23.79	39.88	55.05	37.31	5.12	4.61
4741	23.31	48.95	42.64	27.88	4.59	4.13
4934	23.48	48.41	57.98	49.16	5.81	5.31
4675	23.62	46.35	36.68	38.92	5.25	4.76
4688	23.21	43.67	47.63	27.38	4.46	4.10
4704	23.60	37.08	44.39	27.38	4.53	4.16
4717	22.70	48.83	38.94	32.38	4.84	4.45
4757	23.84	59.43	51.45	35.77	5.05	4.53
4935	23.42	48.95	54.55	47.90	5.75	5.25
4936	23.52	54.07	53.48	47.41	5.77	5.28
4937	23.46	47.38	51.63	48.49	5.77	5.29
4938	23.49	44.80	65.21	45.14	5.62	5.15
4944	22.87	44.79	41.00	41.13	5.52	5.01
20	24.27	35.16	37.75	52.13	6.06	5.52
41	22.91	61.24	50.00	41.78	5.32	4.85
Bakria	23.48	52.10	52.11	46.41	5.71	5.22

GPC; grain protein content, Zn; zinc content, Fe; iron content, TSW; 1000-seed weight, GL; grain length, GW; grain width, YI; yellow pigment index and MIXO; mixo-score.