

Table S1. Climate variables including: maximum temperature (Tmax), minimum temperature (Tmin), average temperature (TAve), maximum humidity (Hmax), minimum humidity (Hmin), average humidity (HAve), Radiation (Rad), rain and Evapotranspiration (ETo) during different growing stages pre-flowering (Pre), flowering (Flow) and post-flowering (Post) characterizing the 9 environments (combination of location and season) of the trials.

Environ m.	Pre Tmax	Pre Tmin	Pre TAve	Pre Hmax	Pre Hmin	Pre HAve	Pre Rad	Pre Rain	Pre ETo	Flow Tmax	Flow Tmin	Flow TAve	Flow Hmax	Flow Hmin	Flow HAve	Flow Rad	Flow Rain	Flow ETo	Post Tmax	Post Tmin	Post TAve	Post Hmax	Post Hmin	Post HAve	Post Rad	Post Rain	Post ETo
AL18	16.20	4.54	9.83	98.80	52.90	82.18	1260.90	367.40	190.42	18.22	7.48	12.30	99.02	51.09	83.08	196.90	60.20	33.92	24.98	10.95	17.64	96.80	35.48	68.49	661.60	14.20	127.81
AL19	17.23	3.56	9.33	99.56	47.14	82.07	1193.90	139.00	137.60	21.73	6.25	13.51	96.62	38.14	74.06	196.40	10.20	29.12	25.88	9.43	17.70	91.02	28.50	58.60	1854.90	57.20	363.91
AL20	17.00	6.21	10.81	98.75	57.36	86.74	862.80	270.80	122.77	21.45	5.41	12.39	99.38	34.17	76.43	166.70	0.60	27.50	21.26	8.58	14.36	98.90	42.48	76.88	793.10	90.80	141.88
CO18	16.24	4.55	9.85	98.71	52.77	82.08	1285.20	369.20	194.57	17.13	7.23	11.70	100.00	55.49	85.44	156.40	58.40	26.18	24.99	10.83	17.57	96.91	34.76	68.63	688.20	14.20	132.49
CO19	17.24	3.66	9.41	99.57	47.44	82.23	1228.80	148.80	143.18	23.49	5.47	13.97	96.35	28.51	66.66	225.60	0.40	33.47	25.96	9.68	17.86	90.27	28.56	58.21	1819.30	57.20	360.50
CO20	16.89	6.17	10.74	98.71	57.38	86.70	839.60	271.80	120.78	22.17	5.12	12.44	99.40	31.98	75.62	177.80	0.20	27.44	21.11	8.66	14.35	98.92	43.17	77.32	810.60	91.20	145.95
PU18	16.12	4.51	9.78	98.79	53.10	82.33	1238.00	367.40	186.40	17.95	7.54	12.16	98.93	52.95	82.45	177.50	53.40	30.82	24.83	10.70	17.44	97.02	35.20	69.10	725.60	21.00	138.60
PU19	17.48	3.12	9.22	99.54	45.17	81.10	1211.90	71.40	140.15	22.35	4.55	13.28	94.65	24.09	59.46	237.50	0.20	36.34	26.28	9.97	18.17	90.46	29.04	58.57	1701.20	57.00	340.48
PU20	16.79	6.18	10.70	98.69	57.61	86.76	809.80	271.80	116.88	22.04	5.47	12.48	99.41	34.65	77.99	173.10	0.20	25.95	21.16	8.46	14.28	98.94	42.73	77.07	571.60	50.20	82.82

Table S2. Genotype (G), field-year environment (E) and genotype by field-year environment interaction (G x E) terms for grain yield, number of broomrapes per plant, days to flowering, biomass, plant height, powdery mildew percentage, and standing ability for the winter pea performance trials, from 2018 to 2020.

Trait	Source of variation	df ^a	Mean Squares ^b	Explained variation ^c	G + G x E / E + G + G x E (%)	% of PC1 + PC2 ^d
Grain yield (kg ha ⁻¹)	E	8	141217343***	52	39	53 + 21
	G	24	13131658***	14		
	G*E	192	2208082***	19		
	Error	432	637140	13		
	R-square	0.87				
Broomrape infection (Oc/plant)	E	8	16***	34	59	68+13
	G	24	3***	22		
	G*E	192	0.5***	27		
	Error	432	0.11	13		
	R-square	0.87				
Date flowering (Dtf)	E	8	3195***	36	61	87 + 7
	G	24	1477***	50		
	G*E	192	36***	10		
	Error	432	5	3		
	R-square	0.97				
Biomass (kg ha ⁻¹)	E	8	520845778***	52	39	63 + 15
	G	24	48902009***	15		
	G*E	192	7647117***	18		
	Error	432	2172714	12		
	R-square	0.88				
Powdery mildew DS (%)	E	8	4008***	3	97	92+ 5
	G	24	42273***	90		
	G*E	192	210***	4		
	Error	432	44	2		
	R-square	0.98				
Plant height (cm)	E	8	14441***	38	57	83+ 8
	G	24	5291***	42		
	G*E	192	147***	9		
	Error	432	59	8		
	R-square	0.91				
Standing ability (1-5)	E	5	6*	4	95	81+ 9
	G	24	20***	62		
	GE	120	1***	16		
	Error	288	0.45	17		
	R-square	0.83				

^a degrees of freedom

^b* Significant at the 0.05 level of probability; *** Significant at the 0.0001 level of probability.

^c Percentage sums of squares respect from the total sums of squares

^d Proportions of the first two Principal Components derived from singular value decomposition of the HA-GGE analysis.

Table S3. Mean dry crop biomass at harvest (kg ha⁻¹), of 19 breeding lines and 6 check cultivars grown at 9 location–year environments.

	Accession	Al-18	Al-19	Al-20	Co-18	Co-19	Co-20	Pu-18	Pu-19	Pu-20	Mean	SE	S ² xi ^a
Breeding lines	NS22	8644	6360	6496	8698	6571	3702	16014	16978	12060	9502	935	20920203
	NS35	6156	6221	6788	7679	7059	4500	16585	11587	11425	8667	710	14583796
	NS36	8558	7688	7351	7186	6805	4782	13581	8798	11894	8516	583	7228548
	NS21	8184	6896	7538	7961	8499	4875	8920	10985	12050	8434	574	4493056
	NS34	6584	5745	6932	8398	4103	4904	17365	10159	10207	8409	762	16242634
	NS81	7877	8044	6744	6111	6005	4522	7958	15244	11693	8244	675	10852273
	NS27	9076	6776	7388	6223	7723	3978	10853	9909	12067	8221	579	6290560
	NS83	7134	6577	7580	5285	7933	4896	9141	11623	12085	8028	485	6383735
	NS82	7392	7256	6549	6599	6165	4381	8696	12271	11226	7837	491	6293782
	NS8	5498	6539	4320	4133	8500	3956	12245	10909	8210	7145	619	9181285
	NS33	5874	5083	6004	6554	6680	3088	11725	8741	9067	6980	529	6395660
	NS39	6044	6151	3896	4906	3836	4260	9122	10016	9667	6433	533	6374081
	NS24	6119	5651	2840	4019	6849	2722	9306	10312	8960	6309	565	7867389
	NS20	6006	5828	4440	4149	5268	3976	9030	5814	8007	5835	395	2940166
	NS16	5962	5917	2520	4103	6409	2554	8925	8532	6683	5734	454	5319418
	NS47	5565	5271	3560	3679	4957	3082	7959	9823	5767	5518	487	4760153
	J20	5462	4873	4848	3750	4973	3666	6946	5896	6147	5173	296	1153757
	NS1	5341	5260	4336	3440	4580	2964	7416	6773	6153	5140	314	2189103
	J4	4679	4677	5768	3772	3424	3016	4774	6712	6473	4811	329	1694245
Check cultivars	Kayanne	6911	6062	1828	5115	7656	2498	11230	13658	9513	7164	740	15023190
	Messire	7711	5721	2480	3606	4929	2396	14418	11485	11060	7090	843	18891278
	Chicarrón	6317	6392	1488	5264	6067	1546	14729	11623	9253	6964	872	18877841
	Cartouche	7373	6168	996	3808	3485	1072	12561	12612	7013	6121	829	18753569
	Babieca	5688	5142	1648	3810	5939	1730	8258	11230	7780	5692	599	9696297
	Enduro	4950	5917	1376	3391	3288	1506	12714	10414	6790	5594	744	15068799
	Mean	6604	6088	4628	5265	5908	3383	10819	10484	9250	6937		
	SE	172	152	312	229	240	146	444	357	279	132		

^a S²xi = environmental variance of genotypes

Table S4. Mean flowering date (dtf) of 19 breeding lines and 6 check cultivars grown at 9 location–year environments.

	Accession	Al-18	Al-19	Al-20	Co-18	Co-19	Co-20	Pu-18	Pu-19	Pu-20	Mean	SE	S ² xi ^a
Breeding lines	J20	95.0	106.0	93.0	98.8	111.5	91.3	95.0	102.7	91.3	98.3	1.5	50.1
	NS1	102.6	103.7	89.7	101.5	104.5	90.0	100.3	103.3	90.7	98.5	1.2	40.7
	J4	95.0	107.0	97.0	98.8	107.8	92.0	95.0	102.7	93.3	98.7	1.1	34.0
	NS39	103.5	107.0	90.3	104.0	106.7	88.7	101.3	103.3	88.0	99.2	1.5	61.8
	NS34	103.3	107.0	96.3	101.4	110.0	90.0	100.2	107.0	90.7	100.7	1.3	50.9
	NS33	105.0	111.0	96.3	109.2	110.0	93.0	105.0	104.7	92.0	102.9	1.4	53.5
	NS8	110.0	108.0	95.0	114.4	106.7	90.0	110.0	104.0	90.0	103.1	1.7	83.7
	NS20	108.1	113.7	96.3	107.2	111.8	92.7	105.8	107.0	94.0	104.1	1.5	60.1
	NS24	111.0	116.0	108.7	109.2	112.6	94.0	108.8	105.3	95.7	106.8	1.8	54.8
	NS47	110.9	113.7	101.3	110.2	115.9	96.7	108.7	107.0	98.7	107.0	1.3	45.0
	NS16	117.7	119.0	104.0	117.2	127.6	110.0	115.5	111.7	102.7	113.9	1.5	60.6
	NS83	120.0	116.7	109.2	120.7	116.6	106.7	120.0	108.7	105.2	113.8	1.2	39.0
	NS21	120.0	115.3	109.9	124.8	117.0	107.5	120.0	106.0	106.0	114.1	1.3	48.3
	NS35	120.0	116.0	110.3	124.8	117.0	107.9	120.0	107.7	106.4	114.4	1.3	43.5
	NS27	120.0	120.0	107.7	124.8	128.3	111.3	120.0	114.3	104.7	116.8	1.5	61.6
	NS81	115.0	125.0	109.0	121.7	129.4	112.7	115.0	117.7	106.7	116.9	1.4	54.6
	NS22	125.0	116.7	106.3	130.0	123.9	110.7	125.0	111.0	104.0	117.0	1.8	88.0
	NS36	125.0	116.0	114.1	130.0	121.0	111.7	125.0	111.7	110.1	118.3	1.4	51.4
	NS82	120.0	122.3	114.2	126.0	129.8	111.8	120.0	114.3	110.3	118.8	1.2	43.8
Check cvs.	Messire	100.0	103.7	89.7	104.0	105.6	90.0	100.0	104.0	90.0	98.5	1.2	45.5
	Kayanne	107.1	114.0	96.0	106.1	111.8	90.7	104.8	107.0	90.0	103.1	1.6	76.7
	Chicarrón	105.0	115.3	100.0	109.2	114.0	96.0	105.0	108.0	97.0	105.5	1.3	47.7
	Enduro	110.0	116.0	102.7	114.4	118.8	100.0	110.0	108.0	98.7	108.7	1.3	50.4
	Babieca	119.3	121.0	106.0	118.9	124.7	114.0	117.1	115.0	103.7	115.5	1.3	46.9
	Cartouche	120.0	117.7	107.0	124.8	126.5	113.3	120.0	110.3	105.3	116.1	1.4	57.2
Mean		111.5	113.9	101.9	113.9	116.2	100.5	110.6	107.9	98.5	108.4		
SE		0.9	0.6	0.8	1.1	0.9	1.1	1.0	0.5	0.8	0.4		

^a S²xi = environmental variance of genotypes

Table S5. Crop stature (cm) of 19 pea landraces and 6 check cultivars grown at 9 location–year environments.

	Accession	Al-18	Al-19	Al-20	Co-18	Co-19	Co-20	Pu-18	Pu-19	Pu-20	Mean	SE	S ² xi ^a
Breeding lines	J4	36.7	53.3	36.7	33.3	46.7	30.0	35.3	46.7	33.3	39.1	1.7	61.7
	NS47	43.8	63.3	33.3	34.6	53.3	33.3	37.3	56.7	30.0	42.9	2.5	145.8
	J20	63.3	63.3	53.3	38.3	60.0	36.7	38.3	56.7	36.7	49.6	2.5	142.0
	NS16	62.7	93.3	53.3	53.5	73.3	46.7	56.1	70.0	46.7	61.7	2.9	227.8
	NS1	64.4	83.3	56.7	55.1	80.0	53.3	57.8	70.0	50.0	63.4	2.3	142.9
	NS24	66.7	93.3	66.7	58.3	76.7	56.7	60.1	63.3	60.0	66.9	2.9	134.7
	NS33	66.7	90.0	63.3	65.0	86.7	50.0	68.3	86.7	50.0	69.6	3.1	230.0
	NS39	69.5	93.3	53.3	58.3	83.3	60.0	63.0	86.7	60.0	69.7	2.9	207.9
	NS20	73.8	103.3	60.0	64.6	86.7	56.7	67.3	83.3	60.0	72.9	3.2	239.9
	NS21	55.0	103.3	59.4	58.3	100.0	60.9	58.3	93.3	62.2	72.3	3.8	407.4
	NS22	56.7	96.7	66.7	60.0	83.3	63.3	53.3	83.3	73.3	70.7	3.1	210.5
	NS8	66.7	106.7	70.0	53.3	96.7	63.3	66.7	103.3	60.0	76.3	3.9	407.1
	NS34	82.1	106.7	70.0	72.9	96.7	66.7	75.6	96.7	63.3	81.2	3.1	236.0
	NS81	70.0	106.7	86.7	76.5	106.7	80.0	65.0	100.0	73.3	85.0	3.1	253.6
	NS82	73.3	120.0	76.4	84.6	106.7	77.8	71.7	103.3	79.1	88.1	3.4	302.4
	NS36	81.7	106.7	76.1	81.7	113.3	77.6	88.3	96.7	78.8	89.0	2.9	183.8
	NS35	88.3	110.0	76.9	81.7	110.0	78.4	83.3	100.0	79.7	89.8	2.5	178.6
	NS83	80.0	110.0	79.2	87.4	106.7	80.7	80.0	106.7	82.0	90.3	2.5	178.9
	NS27	83.3	106.7	93.3	86.7	100.0	83.3	81.7	100.0	80.0	90.6	2.2	94.6
Check cvs.	Messire	71.7	80.0	53.3	65.0	70.0	50.0	68.3	63.3	63.3	65.0	2.2	84.2
	Cartouche	81.7	113.3	40.0	61.7	93.3	53.3	70.0	86.7	60.0	73.3	4.6	510.2
	Enduro	66.7	103.3	50.0	70.0	96.7	63.3	76.7	86.7	56.7	74.4	3.6	324.9
	Babieca	79.4	120.0	50.0	70.1	100.0	66.7	72.8	93.3	53.3	78.4	4.5	511.7
	Chicarrón	81.7	103.3	50.0	75.0	96.7	70.0	83.3	93.3	66.7	80.0	3.4	276.8
	Kayanne	82.7	106.7	53.3	73.5	100.0	70.0	76.1	100.0	73.3	81.7	3.5	301.0
	Mean	69.9	97.5	61.1	64.7	88.9	61.1	66.2	85.1	61.3	72.9		
	SE	1.5	2.2	2.0	1.8	2.3	1.8	1.7	2.1	1.8	0.8		

^a S²xi = environmental variance of genotypes

Table S6. Crop appearance (1-5 scale) of 19 pea landraces and 6 check cultivars grown at 6 location–year environments.

	Accession	Al-19	Al-20	Co-19	Co-20	Pu-19	Pu-20	Mean	SE	S ² xi ^a
Breeding lines	NS81	5.0	4.7	5.0	5.0	5.0	5.0	4.9	0.05	0.018
	NS36	5.0	4.3	4.0	4.7	5.0	5.0	4.7	0.11	0.184
	NS21	5.0	4.0	4.0	4.3	4.3	4.7	4.4	0.12	0.158
	NS27	4.0	5.0	4.0	4.3	4.7	4.7	4.4	0.12	0.174
	NS35	4.7	4.0	4.0	4.3	4.7	4.7	4.4	0.14	0.120
	NS83	3.7	4.0	4.3	4.0	4.7	4.7	4.2	0.15	0.168
	NS39	5.0	3.0	4.3	3.3	5.0	4.3	4.2	0.23	0.710
	NS22	4.7	4.0	4.0	3.7	5.0	4.0	4.2	0.22	0.252
	NS16	4.0	2.7	4.0	3.7	4.3	3.3	3.7	0.16	0.340
	NS8	4.3	3.7	4.0	3.3	4.7	2.3	3.7	0.25	0.714
	NS82	4.3	3.0	3.0	3.3	3.3	4.0	3.5	0.17	0.294
	NS20	4.3	2.7	3.3	2.3	2.7	4.3	3.3	0.28	0.744
	NS1	3.7	2.3	2.7	2.3	3.7	2.3	2.8	0.20	0.476
	NS33	2.0	3.3	2.7	2.0	2.3	3.0	2.6	0.23	0.294
	NS34	2.7	3.3	2.0	3.0	1.7	3.0	2.6	0.20	0.398
	NS24	1.7	3.0	1.7	2.7	2.0	2.7	2.3	0.18	0.324
	NS47	1.7	2.0	2.0	1.3	2.7	1.0	1.8	0.19	0.358
	J20	1.0	2.0	1.7	1.3	1.7	2.0	1.6	0.16	0.158
	J4	1.3	1.0	1.0	1.0	1.3	1.0	1.1	0.07	0.024
Check cultivars	Kayanne	5.0	2.0	3.7	3.7	4.7	4.3	3.9	0.27	1.140
	Chicarron	3.7	2.0	4.0	3.7	4.7	4.7	3.8	0.26	0.984
	Enduro	3.7	2.0	3.3	4.0	4.0	3.7	3.4	0.22	0.574
	Cartouche	4.3	1.7	3.3	3.0	3.7	4.3	3.4	0.25	0.954
	Messire	2.3	1.7	2.7	2.0	2.0	3.3	2.3	0.18	0.340
	Babieca	1.7	1.7	2.0	2.7	1.7	2.7	2.1	0.18	0.242
Mean		3.5	2.9	3.2	3.2	3.6	3.6	3.3		
SE		0.16	0.14	0.14	0.14	0.16	0.15	0.06		

^a S²xi = environmental variance of genotypes

Table S7. Mean percentage of powdery mildew (%) of 19 pea breeding lines and 6 check cultivars grown at 9 location–year environments.

	Accession	Al-18	Al-19	Al-20	Co-18	Co-19	Co-20	Pu-18	Pu-19	Pu-20	Mean	SE	S ² xi ^a
Breeding lines	NS8	0	0	0	0	0	3	0	0	0	0.4	0.37	1.01
	J20	0	0	0	0	0	17	0	0	0	1.9	1.01	32.11
	NS20	17	0	0	1	0	0	10	0	0	3.1	1.14	45.62
	NS47	17	0	0	2	0	3	10	0	0	3.6	1.19	37.86
	NS34	17	0	0	10	0	3	10	0	0	4.5	1.24	36.03
	NS1	19	0	0	3	0	10	11	0	3	5.2	1.41	40.03
	NS27	100	100	70	100	100	100	100	100	60	92.2	3.22	244.45
	NS22	100	100	83	100	100	97	100	100	57	93.0	2.76	213.25
	J4	100	100	87	100	100	97	100	100	63	94.1	3.78	154.36
	NS81	100	100	80	95	100	100	99	100	77	94.6	1.99	86.03
	NS16	99	100	90	95	100	97	99	100	73	94.7	1.83	77.45
	NS24	99	100	80	100	100	100	99	100	83	95.7	1.85	65.25
	NS39	99	100	90	100	100	93	99	100	83	96.1	2.06	37.01
	NS33	100	100	87	97	100	100	99	100	83	96.2	1.31	42.45
	NS82	100	100	95	99	100	99	100	100	82	97.2	1.13	35.20
	NS83	100	100	95	99	100	99	100	100	83	97.3	1.07	31.50
	NS36	100	100	95	100	100	99	100	100	83	97.3	1.13	32.05
	NS35	100	100	95	100	100	99	100	100	83	97.4	1.08	32.03
	NS21	100	100	95	100	100	99	100	100	84	97.5	1.04	28.53
Check cultivars	Kayanne	99	100	80	91	100	97	97	100	63	92.1	2.87	159.66
	Babieca	99	100	90	92	100	100	97	100	53	92.5	3.29	231.78
	Chicarrón	100	100	83	100	100	100	100	100	63	94.1	2.83	166.76
	Messire	100	100	80	100	100	100	100	100	77	95.2	1.95	90.45
	Enduro	100	100	87	100	100	100	100	100	77	95.9	2.08	69.26
	Cartouche	100	100	90	100	100	100	100	100	93	98.1	0.93	14.61
Mean		78.6	76.0	66.0	75.4	76.0	76.4	77.3	76.0	56.9	73.2		
SE		4.4	4.9	4.5	4.7	4.9	4.6	4.6	4.9	4.2	1.6		

^a S²xi = environmental variance of genotypes

Table S8. Mean percentage of ascochyta blight (%) of 14 pea breeding lines and 4 check elite cultivars accessed at 3 locations during 2017-2018 season

Accession	Al-18	Co-18	Pu-18	Mean	SE	S ² xi ^a
J20	50.0	70.0	50.0	56.7	5.27	133.3
J4	26.7	70.0	36.7	44.4	7.47	514.7
NS8	46.7	20.0	46.7	37.8	5.47	237.1
NS33	20.0	43.3	20.0	27.8	5.21	181.4
NS39	20.0	23.3	16.7	20.0	1.37	11.1
NS24	19.0	23.3	16.3	19.6	1.42	12.5
NS27	16.7	20.0	13.3	16.7	2.89	11.1
NS35	6.7	26.7	6.7	13.3	4.41	133.3
NS36	0.0	20.0	0.0	6.7	3.73	133.3
NS83	3.3	11.0	3.3	5.9	1.87	19.6
NS22	0.0	10.0	3.3	4.4	2.27	25.9
NS21	0.0	6.7	3.3	3.3	1.67	11.1
NS81	0.0	7.0	0.0	2.3	1.18	16.3
NS82	0.0	5.3	0.0	1.8	0.89	9.5
Messire	50.0	66.7	40.0	52.2	4.65	181.5
Cartouche	20.0	20.0	10.0	16.7	3.73	33.3
Enduro	20.0	13.3	10.0	14.4	2.42	25.9
Chicarrón	0.7	23.3	6.7	12.2	3.64	143.8
Mean	17.0	26.7	15.7	19.8		
SE	2.39	3.09	2.39	1.56		

^a S²xi = environmental variance of genotypes

Table S9. Multitrait stability index

Accession	MTSI
NS81	0.80
NS21	0.87
NS35	0.95
NS83	0.95
NS22	1.31
NS82	1.33
NS8	1.47
NS27	1.53
NS39	1.56
NS36	1.61
NS34	1.72
NS33	2.33
NS24	2.66
NS47	2.85
Kayanne	2.94
NS16	2.94
NS1	3.00
Chicarrón	3.01
NS20	3.10
Messire	3.14
J4	3.29
J20	3.55
Enduro	3.58
Cartouche	3.69

point of court in red for genotypes selected
considering a selection intensity of 25%

Table S10. Scores factor analysis for genotypes-ideotypes.

Accession	FA1
NS1	-2.02
NS16	-2.08
NS20	-1.92
NS21	-4.15
NS22	-3.71
NS24	-2.36
NS27	-3.49
NS33	-2.69
NS34	-3.30
NS35	-4.07
NS36	-3.41
NS39	-3.46
NS47	-2.17
NS8	-3.55
NS81	-4.21
NS82	-3.69
NS83	-4.07
Babieca	-1.38
Cartouche	-1.33
Chicarrón	-2.01
Enduro	-1.44
J20	-1.46
Kayanne	-2.08
Messire	-1.88
J4	-1.73
<i>Ideotipe</i>	-5.02