

Table S1. Total sets of 89 SSR primers used for the initial polymorphism analysis (Li et al. 2013).

Marker Name	Seq ID	Locus (cM)	LGs in <i>B. napus</i>	Motif	Left Primer	Right Primer	Left Primer TM	Right Primer TM	Product Size (bp)
BrGMS2864	199579959	27.142	A1	(AT)10	GGGTCCTTGGTACCATATTT GC	TATTCTCGGTCTGTTCCACC TT	61.63	60.00	207
BrEMS0015	150126072	66.459	A1	(AG)16	GATCACCAGTGAAGTGA	GCTTCTGTAGCAGAGGAA A	51.47	54.99	384
BrGMS4031	225936614	88.15	A1	(AT)9	CTCGAGTATTGTGTGGCGAG TA	TGCAGGATTAGTCAGAATC CAA	60.33	59.71	200
BrGMS2431	184185743	96.323	A1	(AG)10	GGTTTGGGCTTCTAGGAAAC AT	GATAGACCAGAGCAGACC AGAAA	60.69	59.90	203
BrGMS4320	242246639	102.81	A1	(AT)23	TTGGGTAACAGATAACCCAT GC	CAACTCCACCCTCTTACAGT CC	60.96	60.03	204
BrGMS0667	110797058	13.375	A2	(AAG)8	TCTTCTTCTCCTCATCCCCTT	GGATTCTCACTTCGGAGAC CTA	60.55	59.71	170
BnGMS0103	73686895	34.241	A2	(ACT)6	GTGAGTGGAAACGTTCTAGC	AAGACTGTTACGGCTCGTC	55.01	55.46	207
BnGMS0945	206707092	40.568	A2	(AT)6	AGTGTGAGCCCTCAGAGAA C	CACATCTCTTGGAAATGCA AAC	60.84	59.61	167
BrGMS1436	110797339	74.153	A2	(AG)10	CATAATCAACGAGCATGAG CTT	GTGTTTGGTATTTGGGCTTC TC	60.08	59.89	184
BrGMS3807	223950802	76.054	A2	(AG)9	AACCTTGAGGACCCATATCC TT	GGAGACATGGACATGATGA CTG	60.08	60.40	211
BrGMS3582	215414365	29.839	A3	(ACT)4	TTAACAAGACGGGCCTTACG	TGCTAATCTCATAAGCCGA TCA	60.12	59.84	207
BrGMS1490	110796974	55.786	A3	(AT)10	ATCAAATCATCCTCCTCTCC AC	ATTTCACCATCCAATTCCCA	58.30	57.35	384
BrGMS3041	199580111	84.923	A3	(AG)10	TCACTCACGACTTCATCCTA CG	ACCAGAAGGTTACAGAGGT GCT	60.31	59.32	178
BrGMS2498	184185761	118.259	A3	(AAG)5	AGGAAACTTTCACCGAGTGC TA	AATTGTGTTCTGTGTTGAGCA GT	60.29	59.71	158
BrGMS4057	228007519	119.531	A3	(AT)10	AGCACAGGAGTGAGACAA CAT	GCTAATGTGTCATCAGCTTT CC	61.14	58.86	189

BrGMS1450	110743982	134.46 6	A3	(ATC)7	TGCTATCAACGAGACAATCC AGACGATGACGATGAGAAT TG GTG	60.24 60.05	187
BrGMS1713	110797248	68.431	A4	(AG)15	AGGATTAGGCTGTTGAATGC AGAGAGAATCGTCATGGAG TT GAG	60.06 60.45	173
BrGMS4027	225936613	69.909	A4	(AGG)5	ATCCGCATTGTCTCCATTAG CCTGCTTACAGGAGAAGAG AT GAA	59.83 60.01	198
BnGMS061 5	73681385	3.362	A5	(AT)8	GGCACGGATCTTAACCTAGT TCAAGGGCTTTCATATCTTG	55.92 55.47	163
BrGMS2252	184185696	27.532	A5	(AAG)6	GCACATGATCACAAAGATCT ATTACCTTCGGTCTCGGTTT CA AT	58.73 61.07	200
BrGMS4110	239500637	36.957	A5	(AAG)12	CAAGAATCCGACCCAAGTTT TGA CTATGGATGATCGATTT A GG	59.07 59.78	139
BrGMS1804	110797227	44.56	A5	(AT)10	CACAGTTGGGTATATTTGTA ACGATCCCCGTAGTAAAAG AGTGC ATT	60.43 60.22	305
BnGMS066 2	73679878	58.488	A5	(AT)8	CGATCGAATTGCACTGTACT ATGCACAGAGCTGAAGAA AT	56.39 55.09	205
BrGMS3653	223941022	26.348	A6	(AC)18	AGCTGTGAGAACAGTGACATGAATGGAACCAAGTGACAT GG CAA	60.37 59.84	156
BrEMS0005	150124838	31.583	A6	(AAG)12	AGGAGTTCAAAGAGGAAAC TCCTCATCTTCACCATCTTC C	55.00 55.06	316
BrGMS1894	110797247	72.022	A6	(AG)16	AAAGGGGACGTAGAACAAG GTCACACA ACTAGGACACA TGA GCC	60.28 60.41	334
BrGMS3750	223950785	116.99 1	A6	(ATC)6	GTTGGGCAAAGGTATGATGT TCCATAAATCGCCAGCTAT AA CAT	58.88 60.79	216
BrGMS4194	242246606	162.76 7	A6	(ATG)8	GCATCATCAATTGGCATATG ATCTCTCGAATCGGTGTTCT AG TC	60.32 59.72	208
BnEMS062 0	>TA4381_3 708	26.69	A7	(AG)10	TCCTCTCAATTTCTTCAGGA AAGATTCATGCCACTTCAA C	54.96 55.19	177
BrGMS2989	199580069	33.514	A7	(AG)9	GTTCAACAGGCTCAATTCTG AGCTCCTGAAATTTAGCAA TT AGC	60.54 59.21	196
BrGMS3837	223950810	46.998	A7	(AT)7	GCAGAACCGGATAGAATGT CCAATTCATGCCTAAGTG GTA GTA	59.11 59.01	298
BnEMS052 5	>TA2600_3 708	56.288	A7	(AAACC) 4	GCATTCTTATTTGAGCAATC GATCAAGCCAATAGATTGT A	54.96 50.32	165
BnGMS037 3	73676918	13.19	A8	(AT)12	CAGATAAATTTGGGTAGCTC TATGGATCTGGAAACTCGA A A	54.70 55.73	279

BrGMS2244	184185694	29.977	A8	(AT)8	CCCAAAGCGTATAGCATAGT	TGTGCGCGTAGTCTTTAGTT	60.01	59.60	263
					CC	TC			
BrGMS2025	82654442	39.226	A8	(AGG)7	CATTGCATCTGACTCTCACC	CAAGCAGCCTAAGAAGGA	60.02	60.26	108
					AT	GTGT			
BrGMS0742	110744058	67.802	A8	(AG)14	ACACGTTGAAGCAAGTCACC	CAAAGTCCTTCCAAAACCA	59.84	59.89	135
					TA	AAC			
BrGMS2375	184185728	74.53	A8	(ACT)7	TGGCAAGAGAGTCACATTTG	GATTGTGCTGTGTCTCTGTG	59.78	60.23	199
					TT	GT			
BnEMS016 9	65294417	9.811	A9	(AG)11	ATCGCTTCATCAGCAAGA	AGAGACACGACAGAACAC	55.33	55.45	218
						AAG			
BnGMS001 4	73681333	13.118	A9	(AAG)6	ATCCGAAGAGAGGATAGAG	GTATGGACGACGAATCATC	55.04	54.97	299
					G	T			
BrGMS4252	242246622	55.124	A9	(AT)17	GCCGACCCTAGTAGACCATA	AATCAGATGACCATGGGTTT	59.18	59.66	286
					AG	G			
BnGMS071 3	206701672	70.936	A9	(AG)24	CCTCCGTGTATTCTTTTCCTG	CAGGTCCATATCATACAAC	58.70	57.51	173
						TTCC			
BrGMS0366	110744040	89.347	A9	(AAC)8	TTTGCCGAGTAACCTTTGTCA	AAAGTTGGGCTTTTAGCTTT	60.88	60.13	307
					T	CC			
BrGMS3688	223950765	38.725	A10	(AG)9	GTTGAATTGCCTCCAGTGAG	TTAGACGCAATGGTAAGA	60.54	59.91	173
					TT	GCA			
BrGMS3755	223950788	45.342	A10	(AG)9	TTATCAAGGGATTTCGGTTTG	GATTGCAGCTTTATCATCCA	60.18	60.10	189
					AC	CA			
BrGMS1218	199580196	46.339	A10	(AAG)6	GCGACCAAACACGTAAGAG	ATCATCGAAAGCCCCATAA	59.93	59.81	260
					AG	GT			
BrGMS0086	110797244	52.617	A10	(AG)16	ATATCCCAACACCGCACTAA	TTCGTCTTCATCTACGCTCA	60.14	60.02	314
					AC	AA			
BnEMS004 8	32515199	52.978	A10	(ACT)10	TCACTCTACAACCCTGTTTCA	TCTTTCTCTTCTTCATCCTCC	55.82	55.23	206
BoGMS189 7	23459492	35.982	C1	(AG)8	AAGGAGGACGATCAGCTAA	CCCTCTCTCTCTCTCTTAG	60.97	59.97	205
					ACC	GG			
BnGMS027 1	73676463	48.769	C1	(AG)25	ATGTTTCTCCATTTGTCCTG	GTTGTGTGTTCTGGGAGAAT	55.03	54.91	304
BoGMS156 5	26729121	72.051	C1	(AG)13	GATGACTTGGCGTTGATT	CTGAGAGAGAAGAAGGAG	54.31	54.79	217
						AAGA			
BnEMS028 7	>CD825965	0	C2	(AAG)9	TCATTTCTACGGAGGAGTTG	GGAGGAGAAGAATCTAGG	55.38	55.01	157
						GA			

BnEMS069 4	>CD837521	66.823	C2	(AG)10	AGATTTCTTCCCATCTCCAT	AAGCAGAAACCCACTAGAC A	55.12	55.02	160
BnGMS096 6	206705708	72.359	C2	(AG)7	ACAAAGTCGATTGATCGAGGCTCCATCGGTGGTGTCTTAA A	A	59.69	59.98	226
BoGMS203 0	26726447	100.35 4	C2	(AT)8	AACACTAGCCAAGGGTTTGT	AAGCAAATGAACCATCCAC TCT	57.88	60.00	241
BnEMS111 9	>TA8116_3 708	114.63 2	C2	(ACT)6	ACTGGAGTTTCAATTGGATG	CATCATCTTCAGCACTAGC A	55.03	55.01	209
BoGMS174 0	17816077	52.439	C3	(AG)8	CTTCCGTGGATGATGTCTTGT	AACAATGGTCGTGAAAGGG TAT	59.98	59.64	205
BoGMS243 1	26724695	77.069	C3	(AT)9	CAACCACCGACTCAAATAC	GCACCTGCAATCTCCATAC AGA ATA	60.03	59.99	211
BnGMS077 1	237766573	78.209	C3	(AAG)9	GTGATTTGGGATCAAAGACG	GACGTCGCGAAACTTCTAA A TG	59.92	59.90	242
BoGMS193 7	23580269	134.23	C3	(AG)8	TCTCTAAACCGCAGGAAATC	GAATGTTTGATGGAACCAA AT AGG	60.10	60.57	200
BnGMS000 2	73681210	135.96 1	C3	(AAT)12	TTCACATGTTTGTCTCAACG	TACCATTCTTAAGGTGCCTA	55.56	54.94	236
BoGMS057 3	23431962	11.949	C4	(AT)21	TTTGAGGTATTGTAGCAGAT	AGCATTTGTAGTTGAGGAC T AG	51.86	54.63	347
BoGMS231 9	23424309	31.46	C4	(AG)9	ACTGGTGCGGAATGAATAG	CTTTGGTGATGCCACGATA AAG GTA	60.50	60.02	165
BoGMS176 4	17848905	35.874	C4	(AT)8	TTGGAGCATCACGAAACTAC	TGCAACGTTATCACGCTTCT AC AT	60.18	59.81	189
BoGMS083 6	18718578	42.616	C4	(AT)16	CATAAACACACCGAACAAG	ACGCAATGACACACATACA AC C	55.68	55.25	146
BoGMS133 0	23667519	0	C5	(AG)13	AGGAGAAGAAGGAAGATAC	AGAAAGGAAAGAAAGACC CA AGA	54.71	54.92	184
BoGMS222 8	17832873	8.467	C5	(AG)9	CGTCGTCAGTCTCTCTCC	GTTCTTCCTTGGATTCTTC T AA	60.21	59.57	204
BnGMS080 8	237768182	57.181	C5	(ATTG)4	CTCGTGAGAAAACTGTGAT	CATGTCCCTGGAGCTCTTGT GC	59.92	60.26	221
BoGMS206 4	27005803	70.188	C5	(AG)8	ATTTGACCCACCGAAAGTA	CATCGGACGGGTCAGATAT TT T	60.92	59.77	229
BnGMS100 4	206713426	72.238	C5	(AT)7	ATGTATCTCAGCAGCCCACA	CAATCACAACAGACGTACA A TGC	60.67	59.13	248

BoGMS174 7	17824627	19.102	C6	(AG)8	TGTTATCGGAACCCTCTTGA AT	ATATAATTGACCCGTGCGT AGC	59.83	60.25	202
BrGMS2901	199579978	30.063	C6	(ACT)11	TTTATTACGACTGCCACCAA GA	CAGATGCAGGAATAGTGAC GTT	59.65	59.27	228
BnGMS035 3	73676544	40.093	C6	(AT)14	AACCAAAGAATACATCCGA A	TTGCAGAAGTTGAGACAAT G	54.73	54.89	299
BnGMS096 8	206713912	63.2	C6	(AG)7	TACATGGCAAAGAACCTCGT C	AAGTCTCAGGAAGCACGTC AA	60.13	60.04	252
BoGMS353 8	23631504	100.35 5	C6	(ACT)7	TTCACCGTCCTCTTCAGTATC A	AGGAGAATCGTCAGAATCA AGC	59.73	59.85	212
BoGMS045 4	18731031	16.082	C7	(AG)25	GCACTGAGAGAGAAAGAGT CA	TGTTGTATGGCAAGTATGTG T	54.84	54.06	202
BnGMS074 9	206717057	21.968	C7	(AAT)23	CGGTCTAGTTACCCAGATCA CC	AATCCCCTTGCCACTTATCA T	59.89	59.68	277
BoGMS249 9	17628525	74.688	C7	(AG)10	TATACGATTGCTCTCCCTCCT C	TCGTACAGGTGAATTACGC AAG	59.71	60.19	213
BnGMS038 6	73676707	86.081	C7	(AT)12	TTGGCTCATCAATGACAATA ACAATGTGGTAAACACGAA A		55.04	54.01	220
BoGMS209 5	33777290	96.37	C7	(AT)8	CCATGCTGGTAGGCAATAAG TA	TGGACCATGGGACCATAGT AGT	59.17	60.50	214
BrGMS4450	255983240	21.592	C8	(AG)9	CTCAGGTTCTGTTCAACCAA CA	CAACAGGAAATGCGATGTG TAT	60.19	59.89	203
BnEMS002 0	65288181	34.225	C8	(ACT)12	CTCTATCCGAAGTGAATGAT G	GTCGTCAACCCACACAAA	54.90	56.16	234
BnGMS050 9	75681768	74.308	C8	(AG)9	TGAATGTGCTTCTTCGTATG TTCAAGCTCGTTCACTCTCT		54.86	55.31	203
BnGMS033 6	73682775	92.809	C8	(AT)15	ACCGAATAACAAGTCGAAC A	TTGAAACACACCCATTTAC A	55.75	54.87	345
BoGMS279 1	18831180	113.89 9	C8	(AT)11	ACCGATTTCTACCCGACTTA AA	TGACATACCAACTCCCATC AAA	59.06	60.23	286
BoGMS360 8	18826017	10.69	C9	(AAG)8	TTAGAGCGATAGGGCTTAAC GA	ACACAAGCTCAACCGAGAA GAT	60.35	60.31	190
BnEMS000 8	56842972	22.2	C9	(AG)24	TTCTCTCCATCTCTTTCCA ATGAATCGTGTGCGTGAGT		54.94	57.59	179
BnEMS000 6	65290143	24.832	C9	(AG)25	CATCTCCTCTGTCTTTATCCT T	GAATCGTGTTTCGTGAGTGA	54.34	55.44	122

BoGMS128	17705762	50.978	C9	(AT)13	GTGAAGCAAGGCATAAATA	GTAGAAACAGGTCCAACCA	54.86	55.12	144
7					AA	A			
BoGMS247	33801054	79.929	C9	(AT)9	TCTGTACAGTGCCGTGTCAA	TGACTCTTACATCAATCACG	60.61	60.06	206
7					AT	GTCT			

White - markers showing no polymorphism and discarded after preliminary analyzes .

Grey/ blue - markers that demonstrated polymorphism in parental lines, used for analyzing all the genotypes.

Blue - markers associated with trait/ heterosis effect with the same allele recurring and having the same sign of estimation in both years.

Table S2. Characteristics of 43 polymorphic SSR markers.

Marker	Linkage group	Expected product size	Obtained product sizes	Number of alleles	PIC
BrEMS0015	A1	384	372 - 410	6	1.000
BrGMS4031	A1	200	209 - 219	2	0.898
BrGMS2431	A1	203	217 - 219	2	0.898
BnGMS0103	A2	207	216 - 220	2	0.814
BrGMS1490	A3	384	300 - 404	4	0.998
BrGMS3041	A3	178	191 - 193	2	0.882
BrGMS4057	A3	189	201 - 209	3	0.994
BrGMS2252	A5	200	206 - 219	2	0.630
BrGMS4110	A5	139	170 - 179	5	0.972
BrGMS1804	A5	305	324 - 350	3	0.602
BnGMS0662	A5	205	217 - 221	3	1.000
BrGMS3653	A6	156	160 - 162	2	0.886
BrGMS2989	A7	196	205 - 207	2	0.946
BrGMS3837	A7	298	313 - 332	2	0.982
BnEMS0525	A7	165	181 - 182	2	0.890
BnGMS0373	A8	279	290 - 296	2	0.830
BrGMS2025	A8	108	122 - 125	2	0.786
BrGMS4252	A9	286	288 - 292	3	0.996
BnGMS0713	A9	173	182 - 188	4	0.886
BrGMS3688	A10	173	261 - 265	2	0.898
BrGMS1218	A10	260	295 - 315	2	0.994
BrGMS0086	A10	314	313 - 317	2	0.882
BoGMS1897	C1	205	215 - 219	3	0.912
BoGMS1565	C1	217	220 - 253	3	0.988
BnEMS0694	C2	160	170 - 172	2	0.824
BnEMS1119	C2	209	224 - 233	3	0.836
BoGMS1740	C3	205	226 - 511	4	0.842
BnGMS0771	C3	242	259 - 266	2	0.820
BoGMS0573	C4	347	351 - 359	4	0.904
BoGMS2319	C4	165	170 - 191	3	0.984
BoGMS1764	C4	189	203 - 209	2	0.894
BrGMS2901	C6	228	234 - 277	3	0.964
BnGMS0353	C6	299	313 - 315	2	0.802
BoGMS3538	C6	212	224 - 227	2	0.894
BoGMS0454	C7	202	232 - 236	3	0.920
BnGMS0749	C7	277	283 - 303	2	0.898
BoGMS2499	C7	213	209 - 228	2	0.946
BnGMS0386	C7	220	229 - 235	2	0.986
BnEMS0020	C8	234	345 - 357	2	0.880
BnGMS0509	C8	203	215 - 227	2	0.934
BnGMS0336	C8	345	351 - 366	4	0.910
BoGMS2791	C8	286	294 - 304	3	0.864
BoGMS3608	C9	190	183 - 202	3	0.938

Table S3. Markers associated with observed traits in 2015 and 2016. Highlighted traits repeat the association in both years of study.

Traits: BoF – beginning of flowering, LoF – length of flowering, PH – plant height, BPP – no. of branches per plant, SPP – no. of siliques per plant, SL – silique length, SPS – no. of seeds per silique, TSW – thousand seed weight, N/A – not associated.

Marker	2015	2016
BrEMS0015	BoF, LoF, SL, TSW	BoF, LoF, PH, BPP, SPP
BrGMS4031	BoF, LoF, TSW	SPP
BrGMS2431	BoF, LoF, TSW	SPP
BnGMS0103	LoF	SPP
BrGMS1490	LoF	BoF, LoF, PH, BPP, SPP, SPS
BrGMS3041	BoF, LoF	BoF, LoF, SPP
BrGMS4057	BoF, LoF, SL	BoF, LoF, PH, SPP
BrGMS2252	BoF, LoF, TSW	SPP
BrGMS4110	LoF	BoF, LoF, BPP, SPP, SPS
BrGMS1804	LoF, SL, SPS, TSW	BoF, LoF, BPP, SPP, TSW
BnGMS0662	LoF, SL	BoF, LoF, SPP
BrGMS3653	BoF, LoF, SPS, TSW	SPP, TSW
BrGMS2989	LoF	BoF, LoF, BPP, SPP, TSW
BrGMS3837	BoF, LoF, PH	BoF, LoF, PH, BPP, SPP, TSW
BnEMS0525	LoF	SPP
BnGMS0373	SPS	PH, SPP, TSW
BrGMS2025	LoF	BoF, LoF, PH, BPP, SPP
BrGMS4252	BoF, LoF, BPP, TSW	SPP
BnGMS0713	BoF, LoF, TSW	BoF, LoF, PH, BPP, SPP, SPS
BrGMS3688	LoF	BoF, LoF, SPP
BrGMS1218	BoF, LoF, SPS, TSW	-
BrGMS0086	LoF, BPP, SPS, TSW	BoF, LoF, BPP, SPP, SPS, TSW
BoGMS1897	-	BoF, LoF, SPP, SPS
BoGMS1565	BoF, LoF, TSW	BoF, LoF, PH, BPP, SL, SPS
BnEMS0694	LoF, SL, TSW	BoF, LoF, PH, BPP, SPP
BnEMS1119	BoF, PH, SL	PH, SPS
BoGMS1740	BoF, LoF, SL, SPS, TSW	BoF, LoF, PH, BPP, SPP, TSW
BnGMS0771	LoF, SPS	BPP, SPP, SPS
BoGMS0573	BoF, LoF	BoF, LoF, PH, TSW
BoGMS2319	BoF, LoF, SPS, TSW	SPP
BoGMS1764	BoF, LoF, TSW	SPP
BrGMS2901	BoF, LoF, PH, SL, TSW	BoF, LoF, PH, BPP, SPP
BnGMS0353	BoF, LoF, SPS, TSW	BoF, LoF, PH, BPP, SPP
BoGMS3538	BoF, LoF, TSW	SPP
BoGMS0454	BoF, PH, SPS	PH, BPP, SPP, SPS
BnGMS0749	BoF, LoF, TSW	SPP
BoGMS2499	LoF	BoF, LoF, BPP, SPP, TSW
BnGMS0386	PH, SL	PH, BPP, TSW
BnEMS0020	BoF, LoF, SPS, TSW	SPP, SPS, TSW

BnGMS0509	BoF, LoF, PH, SPP, TSW	BoF, LoF, PH, BPP, SPP, TSW
BnGMS0336	LoF, PH	BoF, LoF, SPP, TSW
BoGMS2791	LoF	BoF, LoF, SPP, TSW
BoGMS3608	LoF, PH, SPS, TSW	-

Table S4. Characteristics of SSR markers significantly associated with studied quantitative traits. Highlighted markers have effects with the same signs in both years of field trials and were chosen for detailed analyses. Effect – estimates of regression coefficients, % – The percentage of total phenotypic variance explained by markers, PIC – polymorphic information content, BoF – beginning of flowering, LoF – length of flowering, PH – plant height, BPP – no. of branches per plant, SPP – no. of siliques per plant, SPS – no. of seeds per silique, TSW – thousand seed weight.

Trait	Marker	2015				2016			
		Allele	Effect	<i>p</i> -value	%	Allele	Effect	<i>p</i> -value	%
BoF	BrEMS0015	372	0.85	0.032	2.0	372	-0.77	0.04	1.8
		408	1.07	0.008	3.3	-	-	-	-
	BrGMS3041	191	0.78	0.050	1.6	-	-	-	-
		-	-	-	-	193	3.52	0.012	2.9
	BrGMS3837	-	-	-	-	313	-1.46	0.015	2.7
		332	-1.14	0.012	2.9	-	-	-	-
	BoGMS1565	-	-	-	-	220	-2.47	0.024	2.3
		-	-	-	-	233	10.52	<.001	9.9
	BoGMS1740	253	-1.25	0.002	4.5	-	-	-	-
		237	1.18	0.002	4.6	-	-	-	-
	BoGMS0573	-	-	-	-	511	-1.65	<.001	10.1
		353	3.69	0.043	1.7	-	-	-	-
	BrGMS2901	-	-	-	-	357	-0.77	0.046	1.6
		234	0.99	0.010	3.0	234	-0.86	0.017	2.6
	BnGMS0353	277	0.80	0.044	1.7	-	-	-	-
		315	0.96	0.017	2.6	315	-1.63	<.001	9.8
	BrGMS4057	201	0.80	0.041	1.8	-	-	-	-
		-	-	-	-	207	-1.12	0.002	4.9
	BnGMS0713	-	-	-	-	182	0.96	0.007	3.4
		-	-	-	-	184	-0.97	0.007	3.5
	BnGMS0509	188	1.02	0.011	3.0	-	-	-	-
		215	1.08	0.048	1.6	215	-1.03	0.043	1.7
		227	-1.40	<.001	6.6	-	-	-	-
LoF	BrEMS0015	372	-0.85	<.001	8.2	372	0.76	0.041	1.8
		400	-0.55	0.007	3.5	-	-	-	-
		408	-0.92	<.001	9.4	-	-	-	-
	BnGMS0103	216	-0.63	0.002	4.6	216	1.22	<.001	5.8
	BrGMS1490	400	-0.65	0.016	2.6	-	-	-	-
		404	0.96	<.001	5.4	404	-1.17	0.022	2.3
	BrGMS3041	191	-0.90	<.001	9.3	-	-	-	-
		-	-	-	-	193	-3.52	0.012	2.9

		201	-0.94	<.001	10.4	-	-	-	-
	BrGMS4057	207	-0.55	0.008	3.3	207	1.12	0.002	4.9
		209	0.71	0.003	4.3	-	-	-	-
	BrGMS4110	170	-0.74	0.003	4.3	-	-	-	-
		-	-	-	-	188	1.47	<.001	8.0
	BrGMS1804	348	0.60	0.013	2.9	-	-	-	-
		350	-1.20	<.001	15.9	350	1.81	<.001	11.7
	BnGMS0662	217	-0.49	0.017	2.6	217	1.10	0.002	4.6
		219	-0.46	0.022	2.3	-	-	-	-
	BrGMS2989	207	-0.96	<.001	6.4	207	1.58	<.001	5.7
	BrGMS3837	313	-1.11	0.001	5.3	313	1.46	0.015	2.7
		332	0.59	0.016	2.7	-	-	-	-
	BrGMS3688	-	-	-	-	261	1.27	0.01	3.1
		265	-0.58	0.005	3.9	-	-	-	-
		-	-	-	-	220	2.46	0.025	2.2
	BoGMS1565	-	-	-	-	233	-10.50	<.001	9.9
		253	0.67	0.003	4.4	-	-	-	-
	BrGMS2025	125	-0.62	0.003	4.4	125	1.16	0.001	5.2
		182	0.42	0.042	1.7	182	-0.96	0.007	3.4
	BnGMS0713	184	-0.40	0.050	1.6	184	0.98	0.006	3.5
		188	-0.92	<.001	9.4	-	-	-	-
	BrGMS0086	313	-0.84	<.001	8.5	313	0.83	0.023	2.3
	BnEMS0694	172	-1.03	<.001	10.8	172	1.67	<.001	9.1
		226	0.64	0.009	3.2	-	-	-	-
	BoGMS1740	237	-0.66	0.001	5.0	-	-	-	-
		511	-1.15	<.001	15.2	511	1.65	<.001	10.1
	BoGMS0573	357	-0.49	0.026	2.2	357	0.77	0.046	1.7
	BrGMS2901	234	-0.92	<.001	10.4	234	0.85	0.018	2.5
		237	0.67	0.016	2.6	-	-	-	-
	BnGMS0353	315	-1.02	<.001	11.9	315	1.64	<.001	9.8
	BoGMS2499	209	-0.99	<.001	8.0	209	1.28	0.003	4.1
	BnGMS0509	215	-1.14	<.001	7.8	215	1.03	0.043	1.7
		227	0.54	0.009	3.2	-	-	-	-
	BnGMS0336	362	-1.15	<.001	12.9	362	1.75	<.001	9.7
		366	1.15	0.044	1.7	-	-	-	-
	BoGMS2791	294	-1.03	<.001	10.4	294	1.24	0.002	4.6
PH	BrGMS3837	313	5.03	0.033	1.9	313	6.92	0.003	4.3
		332	-3.56	0.035	1.9	-	-	-	-
	BnEMS1119	224	4.09	0.040	1.8	224	4.42	0.023	2.3
	BrGMS2901	277	3.67	0.012	2.9	277	2.82	0.050	1.6
		232	-6.46	<.001	8.3	232	-5.41	<.001	5.9
	BoGMS0454	-	-	-	-	234	2.96	0.036	1.9
	BnGMS0386	229	4.72	0.014	2.8	229	5.69	0.003	4.4
	BnGMS0509	-	-	-	-	215	6.76	<.001	5.9

		227	-4.18	0.004	4.1	-	-	-	-
BPP	BrGMS0086	313	-0.46	0.033	2.0	313	-0.41	0.033	1.9
SPP	BnGMS0509	-	-	-	-	215	-55.4	0.032	2.0
		227	-32.40	0.040	1.8	-	-	-	-
SPS	BrGMS0086	313	0.74	0.036	1.9	-	-	-	-
		317	-1.65	0.023	2.3	317	-2.13	0.002	4.9
	BnGMS0771	259	-0.85	0.028	2.1	-	-	-	-
		-	-	-	-	266	0.74	0.037	1.9
	BoGMS0454	232	-1.26	0.001	5.0	232	-0.83	0.024	2.2
		234	0.71	0.046	1.7	-	-	-	-
	BnEMS0020	345	0.70	0.049	1.6	-	-	-	-
		-	-	-	-	357	-1.71	0.030	2.1
TSW	BrGMS1804	348	0.12	0.028	2.1	-	-	-	-
		-	-	-	-	350	0.14	0.025	2.2
	BrGMS3653	160	-0.15	0.002	4.6	-	-	-	-
		-	-	-	-	162	0.36	0.010	3.1
	BrGMS0086	313	-0.11	0.018	2.5	-	-	-	-
		-	-	-	-	317	0.32	0.007	3.4
		237	-0.17	<.001	6.3	-	-	-	-
	BoGMS1740	241	0.29	0.005	3.7	241	0.26	0.038	1.8
		511	-0.12	0.019	2.5	511	0.17	0.005	3.7
	BnEMS0020	345	-0.13	0.009	3.2	-	-	-	-
		-	-	-	-	357	0.35	0.013	2.8
	BnGMS0509	227	0.10	0.033	2.0	227	0.12	0.038	1.8

Table S5. Markers associated with heterosis effect in 2015 and 2016. Highlighted traits repeat the association in both years of study.

Traits: PH – plant height, BPP – no. of branches per plant, SPP – no. of siliques per plant, SL – silique length, SPS – no. of seeds per silique, TSW – thousand seed weight, N/A – not associated.

Marker	CMS×DH		CMS/DH×Rfo	
	2015	2016	2015	2016
BrEMS0015	TSW	PH, TSW	SPP, SPS	SL
BrGMS4031	-	-	-	SL
BrGMS2431	-	-	-	SL
BnGMS0103	-	-	-	-
BrGMS1490	SPS	SL, SPS	SPS	PH
BrGMS3041	-	PH, SPS	-	-
BrGMS4057	SPS	SPS	BPP, SPP	PH
BrGMS2252	SPP, SL, SPS	SL, SPS	PH, SPS	PH
BrGMS4110	SL	SL, SPS	-	-
BrGMS1804	-	SPS	PH	-
BnGMS0662	SL	SPS	BPP, SPP, SL	SL, SPS, TSW
BrGMS3653	SL	SPP, SPS	SPP, SL	-
BrGMS2989	-	SPP, SPS	-	-

BrGMS3837	-	SL	-	-
BnEMS0525	-	-	-	SPS
BnGMS0373	SL, SPS	BPP, SPP, TSW	-	-
BrGMS2025	-	PH	PH	-
BrGMS4252	SPS	SL, SPS	-	TSW
BnGMS0713	-	SL, SPS	-	SPS
BrGMS3688	SPS	SL, SPS	SPS, TSW	PH, SL
BrGMS1218	SL	-	-	PH
BrGMS0086	SPS	SL, SPS	-	-
BoGMS1897	PH, SPS	PH, SPS	-	-
BoGMS1565	-	PH, TSW	-	-
BnEMS0694	SL, SPS	-	-	-
BnEMS1119	-	-	PH	-
BoGMS1740	BPP, SL	SPS	PH, BPP, SL	PH, BPP, TSW
BnGMS0771	SPS	-	-	-
BoGMS0573	SL	-	-	TSW
BoGMS2319	SL	-	-	-
BoGMS1764	-	-	-	-
BrGMS2901	SPS	SPP, SL, SPS	SPP, SL	-
BnGMS0353	SL	-	BPP, SPP	-
BoGMS3538	-	-	-	TSW
BoGMS0454	-	-	-	-
BnGMS0749	SPS	SL, SPS	-	-
BoGMS2499	-	-	-	-
BnGMS0386	SL	PH	-	-
BnEMS0020	PH	TSW	-	-
BnGMS0509	SPS	BPP, SPP	-	-
BnGMS0336	SL	BPP, SL, SPS, TSW	SL, SPS	-
BoGMS2791	PH	TSW	-	-
BoGMS3608	-	-	PH	SL, SPS

Table S6. Characteristics of SSR markers associated with heterosis effect for phenotypic traits in CMS×DH hybrids. Highlighted markers have effects with the same signs in both years of field trials and were chosen for detailed analyses.

Effect – estimates of regression coefficients, % – The percentage of total phenotypic variance explained by markers, PIC – polymorphic information content, PH – plant height, BPP – no. of branches per plant, SPP – no. of siliques per plant, SL – silique length, SPS – no. of seeds per silique, TSW – thousand seed weight.

Trait	Marker	2015				2016			
		Allele	Effect	<i>p</i> -value	%	Allele	Effect	<i>p</i> -value	%
PH	BrEMS0015	-	-	-	-	372	-10.45	0.001	15.0
	BrGMS3041	-	-	-	-	191	-6.80	0.042	5.4
	BoGMS1565	-	-	-	-	220	-10.69	<.001	15.8
	BoGMS2719	294	-9.91	0.044	5.2	-	-	-	-
	BrGMS2025	-	-	-	-	125	-6.27	0.016	8.0

	BoGMS1897	219	-5.28	0.036	5.7	219	-5.91	0.043	5.3
	BnGMS0386	-	-	-	-	229	3.13	0.046	5.1
	BnEMS0020	357	-9.91	0.044	5.2	-	-	-	-
BPP	BnGMS0373	-	-	-	-	290	-0.62	0.029	6.3
	BoGMS1740	511	-1.66	0.013	8.7	-	-	-	-
	BnGMS0509	-	-	-	-	227	0.692	0.014	8.5
	BnGMS0336	-	-	-	-	364	0.70	0.027	6.5
SPP	BrGMS3653	-	-	-	-	162	-340.0	0.003	12.5
	BrGMS2989	-	-	-	-	207	-231.7	0.005	11.2
	BnGMS0373	-	-	-	-	296	145.1	0.036	5.8
	BrGMS2252	219	119.7	0.035	5.8	-	-	-	-
	BrGMS2901	-	-	-	-	234	-72.00	0.028	6.4
	BnGMS0509	-	-	-	-	227	78.00	0.009	9.6
SL	BrGMS1490	-	-	-	-	358	-3.14	0.026	6.6
		170	2.73	0.007	10.2	-	-	-	-
	BrGMS4110	-	-	-	-	176	-5.36	0.006	10.9
		-	-	-	-	179	-5.36	0.006	10.9
	BrGMS3653	160	-5.02	0.003	12.5	-	-	-	-
	BrGMS3837	-	-	-	-	332	1.52	0.049	4.9
	BnGMS0373	296	4.83	0.028	6.50	-	-	-	-
	BrGMS4252	-	-	-	-	290	6.75	0.014	8.4
		-	-	-	-	292	-3.70	0.003	12.5
	BrGMS1218	295	-5.66	0.003	13.0	-	-	-	-
	BrGMS3688	-	-	-	-	261	6.75	0.014	8.4
	BrGMS0086	-	-	-	-	317	6.75	0.014	8.4
	BnEMS0694	170	3.38	0.011	9.0	-	-	-	-
	BoGMS1740	237	-2.85	0.026	6.6	-	-	-	-
	BoGMS0573	351	-10.56	<.001	24.9	-	-	-	-
	BoGMS2319	170	-10.56	<.001	24.9	-	-	-	-
	BnGMS0353	313	5.78	0.008	10.0	-	-	-	-
	BrGMS2252	206	-3.70	0.012	8.7	206	-4.15	<.001	22.4
	BnGMS0662	221	2.37	0.021	7.2	-	-	-	-
	BrGMS0713	-	-	-	-	184	3.72	0.001	15.2
		-	-	-	-	186	-3.70	0.003	12.5
	BrGMS2901	-	-	-	-	237	6.75	0.014	8.4
	BnGMS0749	-	-	-	-	303	-6.75	0.014	8.4
	BnGMS0386	235	9.22	<.001	28.1	-	-	-	-
	BrGMS0336	-	-	-	-	351	-5.36	0.006	10.9
		366	-10.56	<.001	24.9	-	-	-	-
SPS	BrGMS1490	358	-2.45	0.009	9.7	358	-3.80	<.001	25.4
	BrGMS3041	-	-	-	-	191	-2.31	0.034	5.9
	BrGMS4110	-	-	-	-	176	-3.81	0.003	12.4
		-	-	-	-	179	-3.81	0.003	12.4
	BrGMS1804	-	-	-	-	348	4.67	<.001	19.5

	BrGMS3653	-	-	-	-	160	-2.10	0.014	8.4
	BrGMS2989	-	-	-	-	205	1.50	0.001	15.1
	BnGMS0373	290	-1.33	0.005	11.5	-	-	-	-
	BrGMS4252	290	4.04	0.028	6.5	290	4.86	0.008	10.0
		-	-	-	-	292	-1.79	0.038	5.6
	BrGMS3688	261	4.04	0.028	6.5	261	4.86	0.008	10.0
	BrGMS0086	317	4.04	0.028	6.5	317	4.86	0.008	10.0
	BnEMS0694	170	1.99	0.002	13.8	-	-	-	-
	BoGMS1740	-	-	-	-	226	4.67	<.001	19.5
	BnGMS0771	259	2.46	0.022	7.1	-	-	-	-
	BrGMS4057	209	2.37	0.012	9.0	209	3.39	<.001	19.8
	BrGMS2252	206	-1.89	0.009	9.6	206	-1.96	0.007	10.2
	BnGMS0662	-	-	-	-	221	1.11	0.030	6.3
		-	-	-	-	184	1.76	0.026	6.7
	BnGMS0713	-	-	-	-	186	-1.79	0.038	5.6
	BoGMS1897	219	-1.92	0.043	5.3	219	-2.71	0.004	12.1
	BrGMS2901	237	4.04	0.028	6.5	237	4.86	0.008	10.0
	BnGMS0749	303	-4.04	0.028	6.5	303	-4.86	0.008	10.0
	BnGMS0509	227	0.98	0.038	5.6	-	-	-	-
	BnGMS0336	-	-	-	-	351	-3.81	0.003	12.4
TSW		398	0.12	0.030	6.3	-	-	-	-
	BrEMS0015	-	-	-	-	410	0.13	0.013	8.7
		-	-	-	-	410	0.13	0.013	8.7
	BnGMS0373	-	-	-	-	290	0.12	0.020	7.5
	BoGMS1565	-	-	-	-	253	-0.13	0.018	7.7
	BoGMS2719	-	-	-	-	294	0.42	0.035	5.9
	BnEMS0020	-	-	-	-	357	0.42	0.035	5.9
	BnGMS0336	-	-	-	-	364	-0.14	0.013	8.7

Table S7. Characteristics of SSR markers associated with heterosis effect for phenotypic traits in CMS/DH×*Rfo* hybrids.

Effect – estimates of regression coefficients, % – The percentage of total phenotypic variance explained by markers, PIC – polymorphic information content, PH – plant height, BPP – no. of branches per plant, SPP – no. of siliques per plant, SL – silique length, SPS – no. of seeds per silique, TSW – thousand seed weight.

Trait	Marker	2015				2016			
		Allele	Effect	p-value	%	Allele	Effect	p-value	%
PH	BrGMS1490	-	-	-	-	358	3.43	0.046	5.1
	BrGMS1804	348	-2.55	0.048	5.0	-	-	-	-
	BrGMS1218	-	-	-	-	295	4.03	0.018	7.7
	BrGMS3688	-	-	-	-	265	-4.99	0.007	10.5
	BnEMS1119	227	-4.08	0.039	5.5	-	-	-	-
		-	-	-	-	226	2.65	0.047	5.0
	BoGMS1740	237	13.06	0.008	10.1	-	-	-	-
	BoGMS3608	197	3.98	0.044	5.2	-	-	-	-
		-	-	-	-	207	-3.31	0.012	8.8
	BrGMS4057	-	-	-	-	209	3.25	0.017	7.9

	BrGMS2252	-	-	-	-	206	-4.74	0.015	8.3
		219	4.77	0.037	5.7	-	-	-	-
BPP	BrGMS2025	125	2.53	0.046	5.1	-	-	-	-
	BoGMS1740	226	0.86	0.034	5.9	-	-	-	-
		-	-	-	-	241	-1.13	0.031	6.1
	BnGMS0353	313	-1.23	0.002	13.7	-	-	-	-
	BrGMS4057	207	-0.95	0.020	7.4	-	-	-	-
SPP	BnGMS0662	217	-1.08	0.012	8.9	-	-	-	-
	BrEMS0015	400	-68.6	0.027	6.6	-	-	-	-
		410	67.9	0.045	5.1	-	-	-	-
	BrGMS3653	162	-194.3	0.024	6.9	-	-	-	-
	BnGMS0353	313	-104.7	<.001	17.6	-	-	-	-
	BrGMS4057	207	-61.5	0.049	4.9	-	-	-	-
	BnGMS0662	217	-92.8	0.004	11.8	-	-	-	-
	BrGMS2901	237	-73.0	0.019	7.5	-	-	-	-
SL	BrEMS0015	-	-	-	-	408	7.26	0.010	9.3
	BrGMS3653	162	-4.36	0.020	7.5	-	-	-	-
	BrGMS3688	-	-	-	-	265	2.13	0.037	5.7
	BoGMS1740	241	-3.34	0.013	8.7	-	-	-	-
	BoGMS3608	-	-	-	-	197	2.59	0.022	7.1
	BrGMS4031	-	-	-	-	219	7.26	0.010	9.3
	BrGMS2431	-	-	-	-	219	7.26	0.010	9.3
	BnGMS0662	217	-1.48	0.039	5.5	-	-	-	-
		-	-	-	-	221	1.45	0.048	5.0
	BrGMS2901	277	-1.61	0.035	5.8	-	-	-	-
	BnGMS0336	351	6.37	0.015	8.2	-	-	-	-
SPS	BrEMS0015	398	-1.10	0.027	6.6	-	-	-	-
	BrGMS1490	400	-2.38	0.015	8.2	-	-	-	-
	BrGMS3688	261	1.25	0.019	7.5	-	-	-	-
		265	-1.18	0.050	4.9	-	-	-	-
	BoGMS3608	-	-	-	-	197	1.67	0.010	9.3
	BrGMS2252	206	-1.31	0.039	5.6	-	-	-	-
	BnGMS0662	-	-	-	-	221	0.87	0.038	5.6
	BnGMS0713	-	-	-	-	182	-0.91	0.031	6.2
	BnGMS0336	364	-0.90	0.044	5.2	-	-	-	-
TSW	BrGMS4252	-	-	-	-	292	-0.13	0.020	7.4
	BrGMS3688	261	0.12	0.046	5.1	-	-	-	-
	BoGMS1740	-	-	-	-	226	-0.08	0.030	6.3
	BoGMS0573	-	-	-	-	353	-0.35	0.016	8.0
		-	-	-	-	357	0.12	0.006	10.9
	BoGMS3538	-	-	-	-	227	0.38	0.009	9.7
	BnGMS0662	-	-	-	-	217	0.08	0.038	5.6