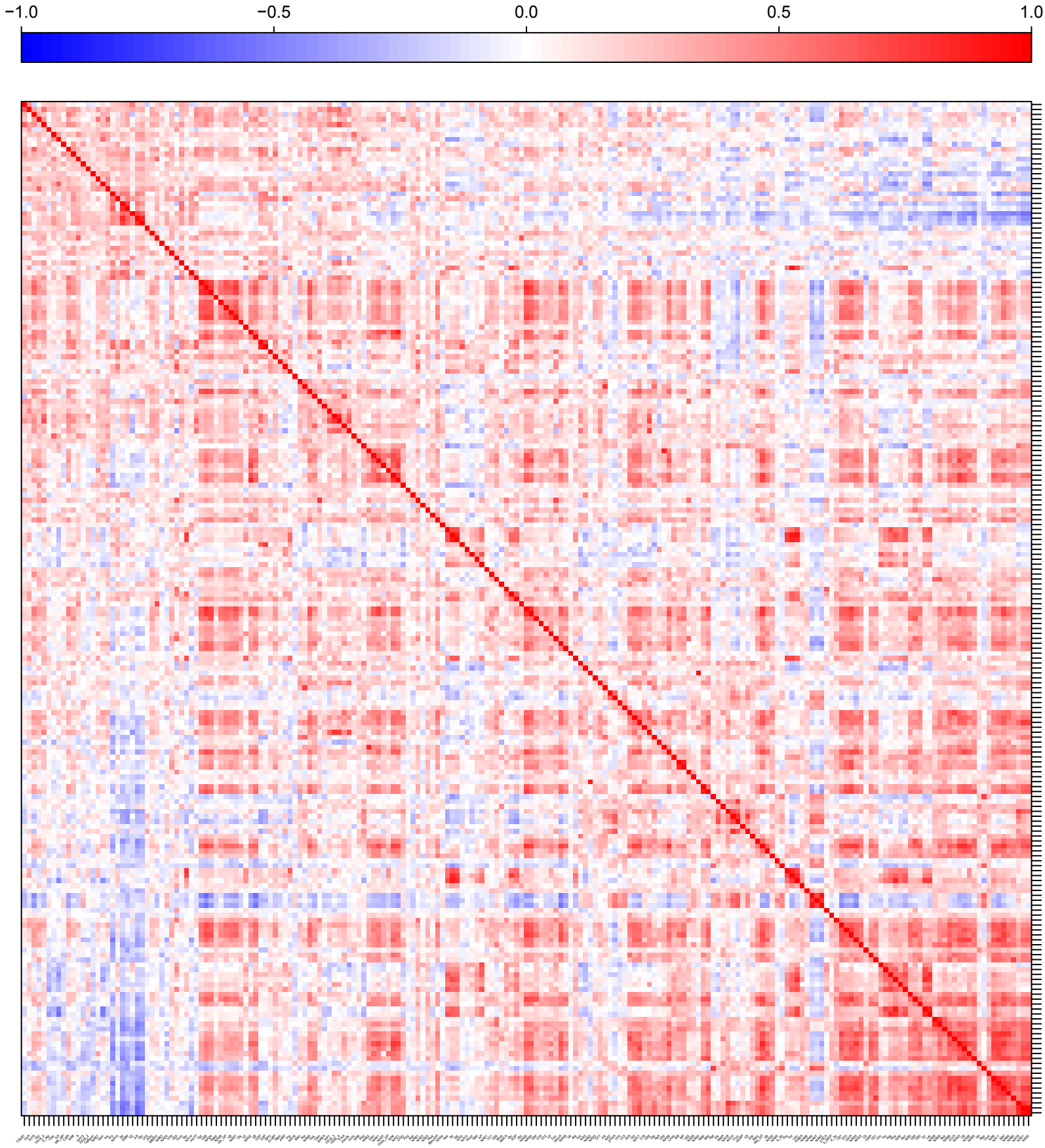
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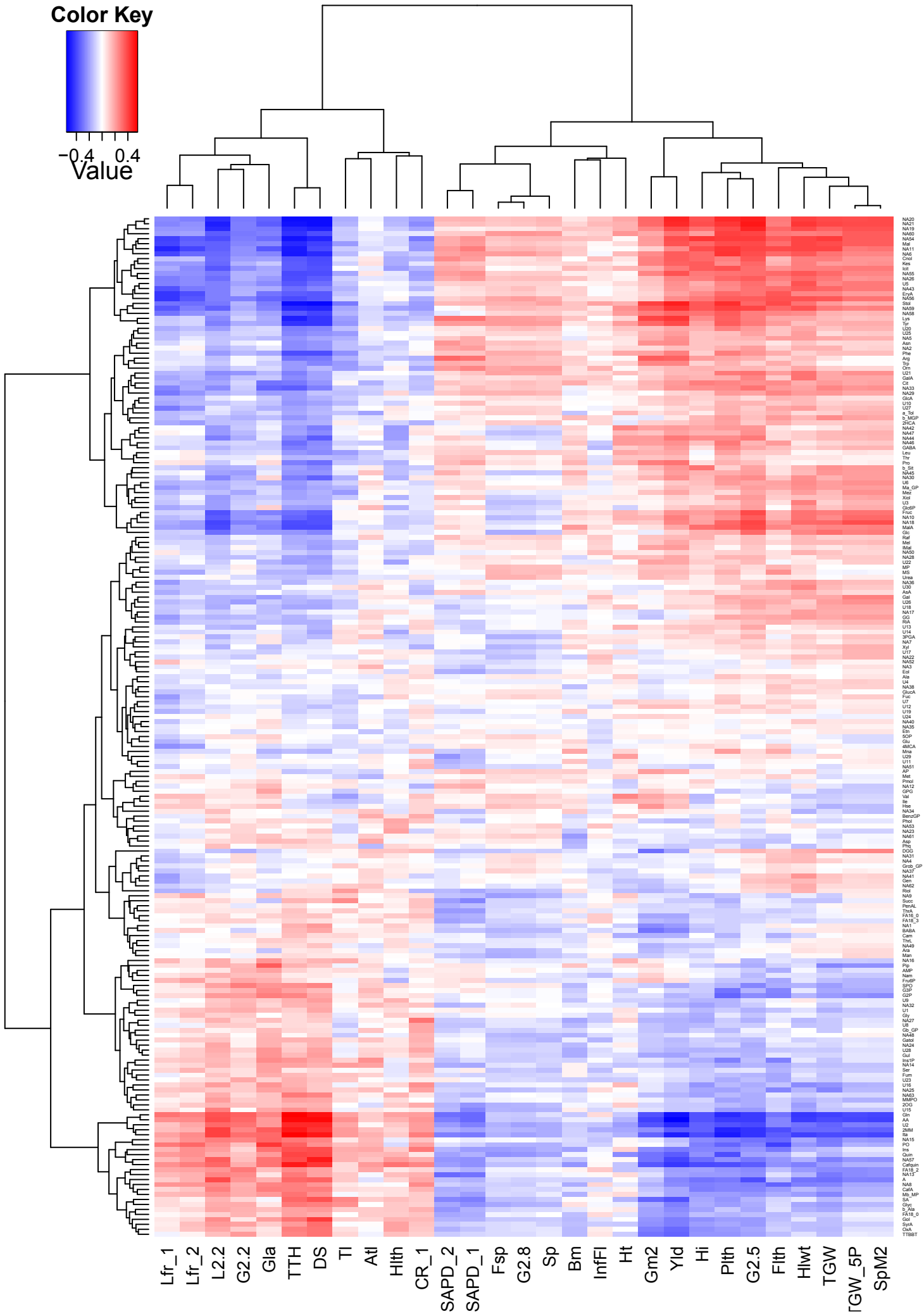
0.5
1.0

Supplemental Figure 1: Fully annotated heat map of genetic (top) and phenotypic correlations (bottom) between each of the measured metabolites of the doubled haploid wheat population. The colour assigned to a point in the heat map grid indicates the strength of a particular correlation between two traits. The level of correlation is indicated by red for positive correlations and blue for negative correlations, as depicted in the colour key. Image made with R (http://www.r-project.org/). This is the fully annotated version of Figure 1, which can be found in the manuscript.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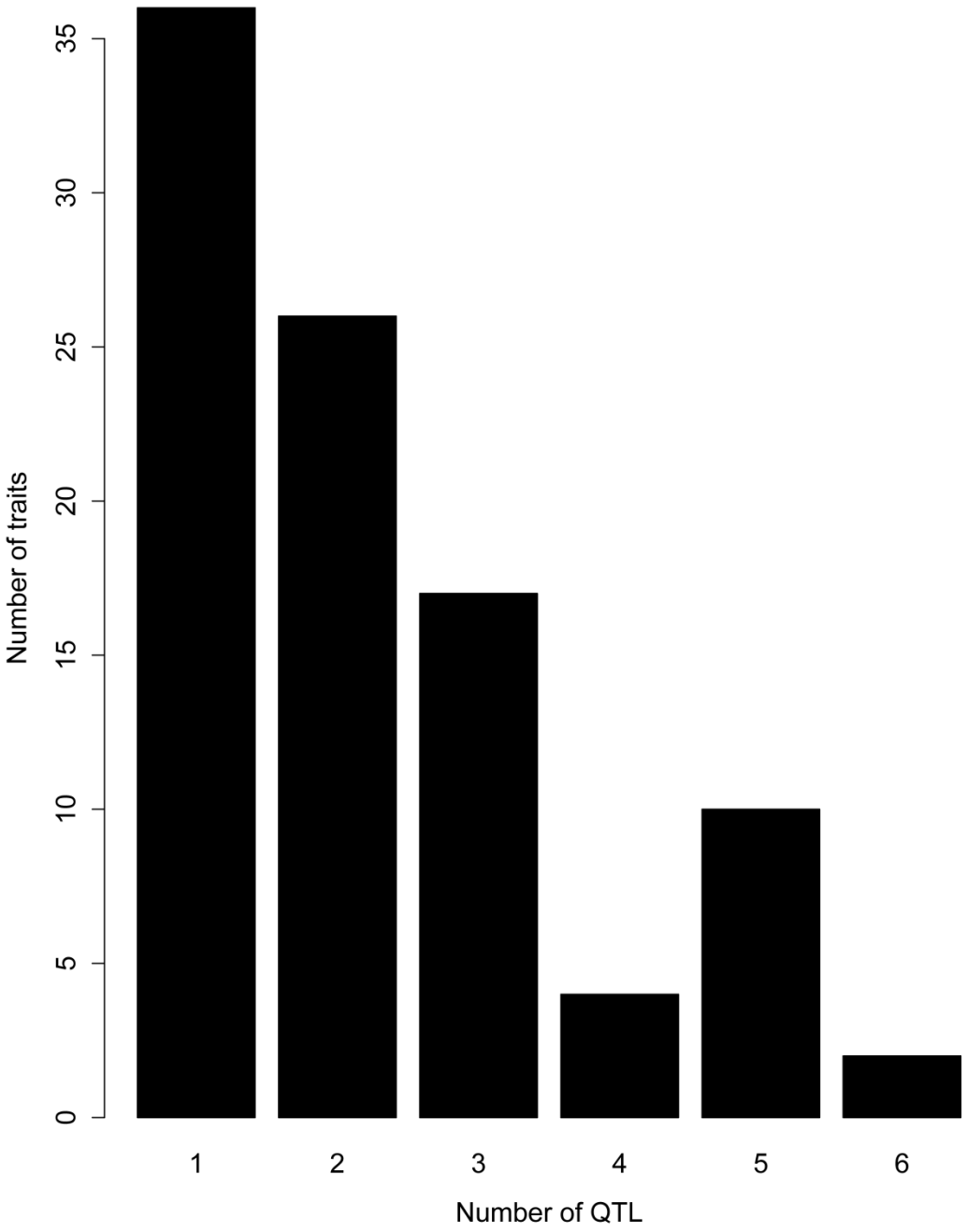
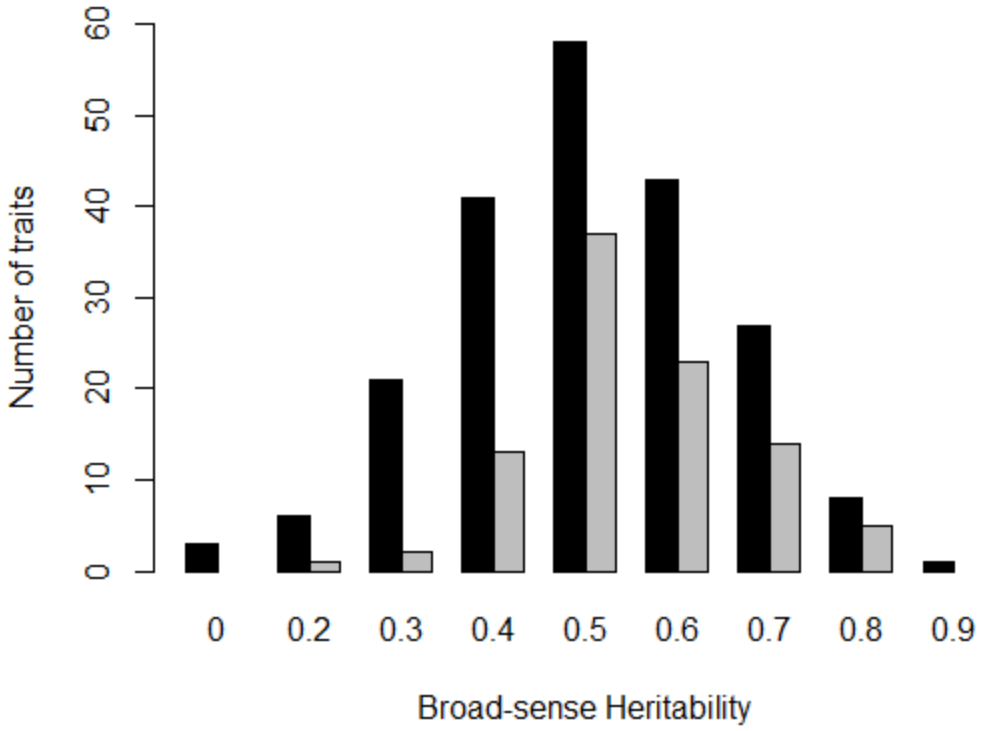
Fsp
G2.8
Sp
Bm
InfFl
Ht
Gm2
Yld
Hi
Plth
G2.5
Flth
Hlwt
TGW
TGW_5P
SpM2

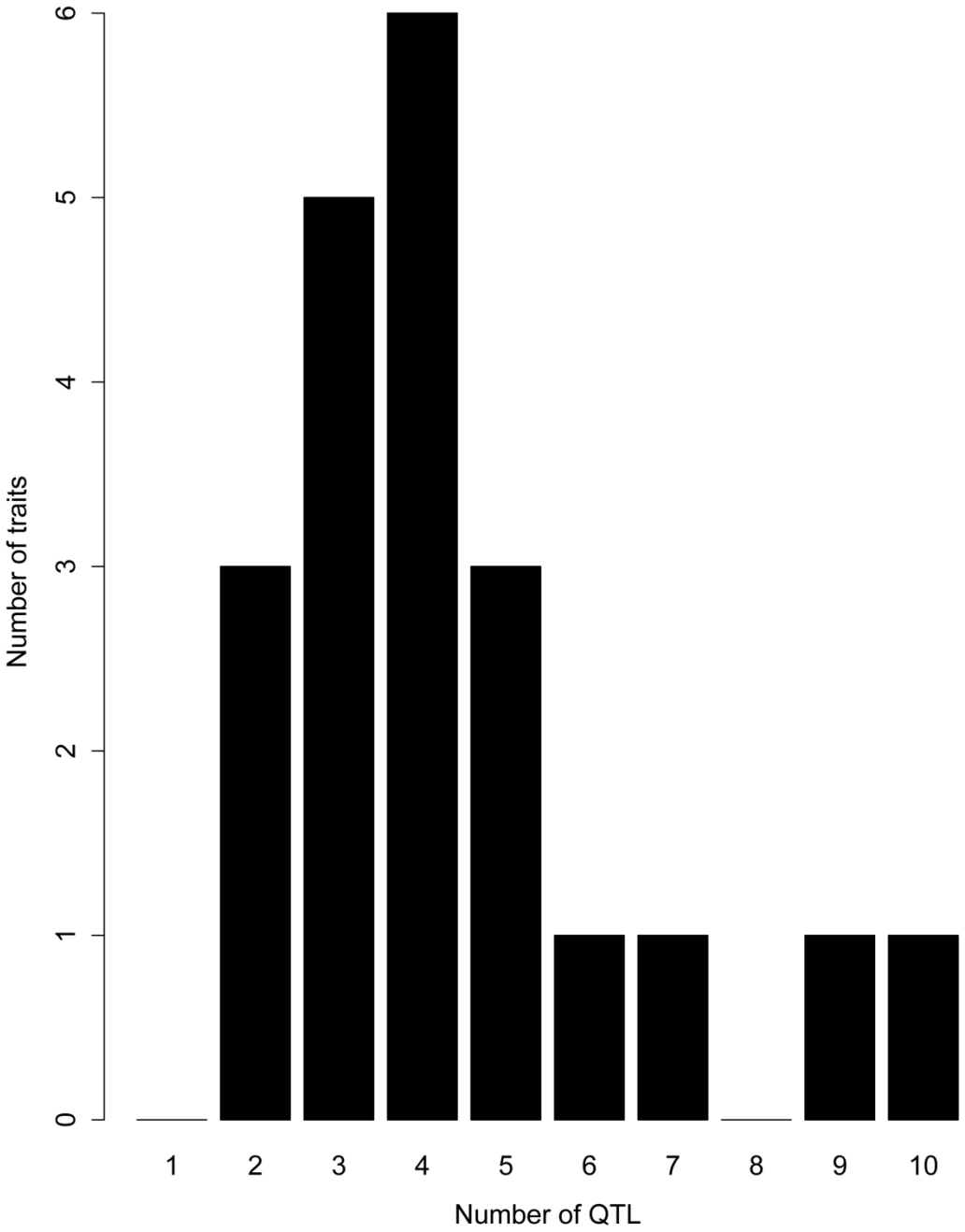
Supplemental Figure 2: Full annotated clustered heat map of the genetic correlations between the agronomic traits and the measured metabolites of the doubled haploid wheat population. Clustering of the agronomic traits is depicted by the dendrogram at top, broken into six groups, labelled A through F. Clustering of the metabolic traits is depicted by the dendrogram at left, broken into five groups, labelled 1 through 5. The colour assigned to a point in the heat map grid indicates the strength of a particular correlation between two traits. The level of correlation is indicated by red for positive correlation, blue for negative correlation, white for no correlation, as depicted in the colour key at top left. Image made with R (http://www.r-project.org/). This is the fully annotated version of Figure 3, which can be found in the manuscript.



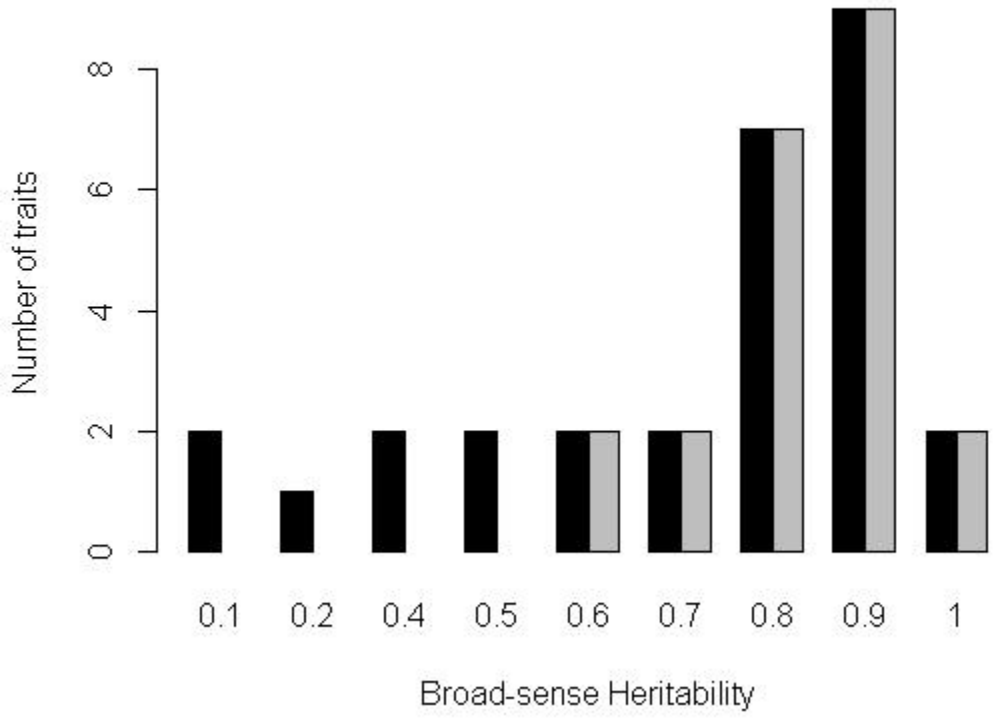
Supplemental Figure 3: Frequency distribution of the number of mQTL detected for each metabolic trait. Data is based on two biological and two technical replicates per DH line.



Supplemental Figure 4: Frequency distribution of broad-sense heritability of each detected metabolic trait in the DH population. Black and grey bars represent all measured metabolites, and metabolites for which at least one QTL was detected, respectively. Data is based on two biological and two technical replicates per DH line.



Supplemental Figure 5: Frequency distribution of the number of QTL detected for each yield or yield-related phenotypic trait. Data is based on two biological and two technical replicates per DH line.



Supplemental Figure 6: Frequency distribution of broad-sense heritability of each detected trait in the DH population. Black and grey bars represent all traits, and traits for which at least one QTL was detected, respectively. Data is based on two biological replicates per DH line.

Supplemental Table 1: List of metabolite traits measured for 179 lines of the Excalibur/Kukri doubled haploid population

TRAIT GROUP AND NAME	ABBREVIA-TION	TMS	MEOX	LIBRARY IDENTIFIER	QUANT ION	RT	RI	CONFIDENCE (%)
Amino Acid								
Alanine	Ala	2	-	EIQTMS_110001-101_METB_1095.5_Alanine, DL-(2TMS)	116	7.65	1096	87.21
Valine	Val	2	-	EIQTMS_122001-101_METB_1220.2_Valine, DL-(2TMS)	144	9.68	1208	50
Isoleucine	Ile	2	-	EIQTMS_132002-101_METB_1300.6_Isoleucine, DL-(2TMS)	158	11.13	1288	88.63
Proline	Pro	2	-	EIQTMS_132003-101_METB_1303.4_Proline, DL-(2TMS)	142	11.26	1295	87.61
Serine	Ser	3	-	EIROE_138001-101_METB_1369.3_Serine, DL-(3TMS)	204	12.34	1354	88.8
Threonine	Thr	3	-	EIQTMS_140001-101_METB_1394_Threonine, DL-(3TMS)	218	12.79	1379	87.4
beta-Alanine	b_Ala	3	-	EIQTMS_144001-101_METB_1431.4_Alanine, beta-(3TMS)	116	12.94	1423	87
Aspartate	Asp	2	-	EIQTMS_152002-101_METB_1525_Aspartic acid, DL-(3TMS)	160	13.58	1503	85.8
Homoserine	Hse	3	-	EISTR_146001-101_METB_1454_Homoserine, DL-(3TMS)	218	13.95	1443	83.43
5-Oxoproline	5OP	2	-	EIQTMS_153002-101_METB/METB_1528.1_Pyroglutamic acid, DL-(2TMS)	156	15.33	1518	85.22
GABA	GABA	3	-	EIQTMS_153003-101_METB_1530.7_Butyric acid, 4-amino-(3TMS)	174	15.40	1521	84.84
Ornithine	Orn	3	-	EISTR_162001-101_MST/MST_1624.2_Ornithine, DL-(3TMS)	142	16.80	1594	77.44
Glutamate	Glu	3	-	EISTR_163001-101_METB_1631.4_Glutamic acid, DL-(3TMS)	246	16.90	1599	84.7
Phenylalanine	Phe	2	-	EIQTMS_164001-101_METB_1635.4_Phenylalanine, DL-(2TMS)	218	17.05	1607	82.87
Glutamine	Gln	3	-	EISTR_178001-101_METB_1785.1_Glutamine, DL-(3TMS)	227	17.63	1638	95
Asparagine	Asn	3	-	EIQTMS_168001-101_METB_1683.3_Asparagine, DL-(3TMS)	116	17.72	1642	68.32

BABA	BABA	2	-	EINIST_121001-101_METB_1210.6_Butyric acid, 3-amino-, DL-(2TMS)	189	19.60	1739	61
Arginine	Arg	3	-	EIQTMS_183001-101_METB_1832.8_Arginine, DL-, -NH3 (3TMS)	157	20.10	1769	95
Lysine	Lys	4	-	EIROE_192003-101_METB_1920.8_Lysine, DL-(4TMS)	174	21.49	1837	61.11
Tyrosine	Tyr	3	-	EISTR_194002-101_METB_1941.4_Tyrosine, DL-(3TMS)	218	21.76	1851	78.56
Tryptophan	Trp	3	-	EINIST_223001-101_METB_2218.6_Tryptophan, L-(3TMS)	202	25.46	2210	78.69
Glycine	Gly	2	-	EISTR_114001-101_METB_1118_Glycine (2TMS)	204	34.10	3022	64.77
Leucine	Leu	2	-	EIQTMS_129002-101_METB_1278.8_Leucine, DL-(2TMS)	158	10.67	1333	70.58
Methionine	Met	2	-	EITTMS_152001-101_METB_1521.2_Methionine, DL-(2TMS)	176	15.25	1513	54.43
Amine								
Ethanolamine	Etn	3	-	EITTMS_128002-101_METB_1269.1_Ethanolamine (3TMS)	174	10.62	1260	82.44
3-amino-Piperidin-2-one	AP	2	-	EISTR_147003-101_MST_1460_Piperidin-2-one, 3-amino- (2TMS)	128	14.16	1450	95
Sugar								
Xylose	Xyl	4	1	EIQTMS_166001-101_METB_1669.2_Xylose, D-(1MEOX) (4TMS)	217	17.38	1624	77.55
Arabinose	Ara	4	1	EIQTMS_166001-101_METB_1669.2_Xylose, D-(1MEOX) (4TMS)	307	17.50	1630	81.69
Fructose	Fruc	5	1	EIQTMS_187002-101_METB_1874.6_Fructose, D (1MEOX) (5TMS)	307	20.70	1796	86.93
Mannose	Man	5	1	EISTR_188002-101_METB_1888.1_Mannose, D-(1MEOX)	319	20.90	1807	87.78
Galactose	Gal	5	1	EIQTMS_188001-101_METB_1892.3_Galactose, D-(1MEOX) (5TMS)	319	20.96	1810	96
Glucose	Glc	5	1	EIROE_189002-101_METB_1897.3_Glucose, D-(1MEOX) (5TMS)	319	21.08	1816	79.3

beta-D-Methyl-glucopyranoside	b_MGP	4	-	EIQTMS_203003-101_MST_2036.2_[766; beta-D-Methylglucopyranoside (4TMS)]	319	22.12	1868	85
2-o-Glycerol-beta-D-galacto-pyranoside	Gb_GP	6	-	EIQTMS_217004-101_MST_2190.2_[834; 2-O-Glycerol-beta-D-galactopyranoside (6TMS)]	204	24.91	2152	71.69
Gulose	Gul	5	-	EIQTMS_260002-101_MST_2593.8_[896; Gulose (5TMS)]	204	24.97	2158	78.32
1-Benzylgluco-pyranoside	BenzGP	-	-	EIQTMS_241003-101_MST_2408.9_[1-Benzylglucopyranoside]	204	27.47	2392	78.48
1-Methyl-beta-D-mannopyranoside	Mb_MP	4	-	EIQTMS_244002-101_MST_2442.3_[759;1-Methyl-beta-D-mannopyranoside (4TMS)]	204	27.75	2417	81.35
2-o-Glycerol-beta-D-Galacto-pyranoside	Grob_GP	6	-	EIQTMS_217004-101_MST_2190.2_[834; 2-O-Glycerol-beta-D-galactopyranoside (6TMS)]	204	28.72	2504	76.54
1-o-methyl-beta-D-Galacto-pyranoside	Ma_GP	4	-	EIQTMS_185010-101_METB_1856.8_Galactopyranoside, 1-O-methyl-, beta-D-(4TMS)	204	29.22	2552	78
Gentiobiose	Gen	8	-	EIQTMS_285003-101_METB_2853_Gentiobiose (8TMS) {BP}	204	29.90	2607	85
Maltose	Mal	8	1	EIQTMS_274001-101_METB_2744.6_Maltose, D-(1MEOX) (8TMS)	204	31.20	2731	74.86
Isomaltose	IMal	8	1	EIQTMS_287001-101_METB_2885.1_Isomaltose (1MEOX) (8TMS)	204	31.98	2796	86.6
Melibiose	Mel	8	1	EINIST_287003-101_METB_2872.6_Melibiose (1MEOX) (8TMS)	204	32.23	2835	70.75
Raffinose	Raf	11	-	EISTR_337002-101_METB_3396_Raffinose (11TMS)	361	37.02	3343	92.7
1-Kestose	Kes	11	-	EINIST_24810_METB_3552_a-D-Glucopyranoside, 1,3,4,6,-tetrakis-O-(trimethylsilyl)-a-D-fructofuranosyl	451	37.06	3353	91.95
Melezitose	Mez	11	-	EIQTMS_346001-101_METB_3475.7_Melezitose (11TMS)	361	37.27	2989	61.48
Sugar Acid								
Threonate-1,4-lactone	ThrL	2	-	EINIST_140005-101_METB_1382.5_Threonic acid-1,4-lactone (2TMS)	247	12.67	1372	65.63
Threonate	ThrA	4	-	EIQTMS_156001-101_METB_1568.2_Threonic acid (4TMS)	292	15.83	1544	84.4

Pentonate-1,4-lactone	PenAL	3	-	EITTMS_175004-101_MST_1760.7_[Pentonic acid-1,4-lactone (3TMS)]	217	17.14	1612	65.17
2-Oxogulonate	2OG	5	1	EIGTMS_186001-101_METB_1868.4_Gulonic acid, 2-oxo-, L-(1MEOX) (5TMS)	349	18.56	1685	62.16
Galactonate	GalA	6	-	EINIST_199002-101_METB_1997.9_Galactonic acid (6TMS)	319	22.42	1885	82.66
Gluconate	GlcA	6	-	EINIST_200001-101_METB_2002.7_Gluconic acid (6TMS)	292	22.67	1899	86.72
Sugar Alcohol								
Xylitol	Xiol	5	-	EINIST_171001-101_METB_1717.6_Xylitol (5TMS)	217	18.38	1676	85.46
Ribitol	Riol	5	-	EINIST_173001-101_ISTD (quantitative)_1734.7_Ribitol, D-(5TMS)	217	18.46	1680	85.8
Galactitol	Gatol	6	-	EIROE_194001-101_METB_1941.8_Galactitol, D-(6TMS)	204	21.65	1846	71.09
myo-Inositol	Ins	6	-	EIQTMS_209002-101_METB_2091.9_Inositol, myo-(6TMS)	305	23.72	2017	88.18
Galactinol	Gol	9	-	EIQTMS_299002-101_METB_2993.5_Galactinol (9TMS)	204	33.57	2965	88.38
Erythritol	Eol	4	-	EINIST_150002-101_METB_1510.2_Erythritol (4TMS)	205	14.92	1497	63.74
Organic Acid								
Malonate	Mna	2	-	EIQTMS_122003-101_MST_1211.4_Malonic acid (2TMS)	148	9.48	1197	65.65
Succinate	Succ	2	-	EIMOR_134001-101_METB_1326_Succinic acid (2TMS)	247	11.54	1310	64.25
Glycerate	Glyc	3	-	EISTR_135003-101_METB_1339.6_Glyceric acid, DL-(3TMS)	189	11.76	1323	86.03
Itaconate	Ita	2	-	EIFIEHN_135004-101_METB_1351.7_Itaconic acid (2TMS)	215	12.06	1339	65.63
Dimethyl maleate	2MM	2	-	EINIST_137003-101_METB_1358_Maleic acid, 2-methyl-(2TMS)	259	12.18	1344	52.99
Fumarate	Fum	2	-	EIROE_137001-101_METB_1359.8_Fumaric acid (2TMS)	245	12.22	1347	70.55

Pipecolate	Pip	2	-	EINIST_137004-101_MST_1370_Pipecolic acid (2TMS)	156	12.48	1362	85.07
Malate	MalA	3	-	EIQTMS_149001-101_METB_1492.3_Malic acid, DL-(3TMS)	233	14.68	1483	84.39
Erythronate	EryA	4	-	EIQTMS_154001-101_MST_1548.7_Erythronic acid (4TMS)	292	15.53	1528	80.04
cis-Aconitate	AA	3	-	EISTR_176002-101_METB_1762.8_Aconitic acid, cis-(3TMS)	229	18.99	1707	81.52
Ribonate	RiA	5	-	EINIST_177001-101_MST_1774.2_Ribonic acid (5TMS)	292	19.23	1720	80.38
Shikimate	SA	4	-	EISTR_181002-101_METB_1820.9_Shikimic acid (4TMS)	204	19.83	1751	75.81
Glucarate	GlucA	6	-	EIQTMS_181001-101_MST_1809.8_[752; Glucaric acid (6TMS)]	292	19.91	1755	70.36
Citrate	Cit	4	-	EIQTMS_182004-101_METB/METB_1827.8_Citric acid (4TMS)	273	19.97	1758	78.07
Quinate	Quin	5	-	EIQTMS_185001-101_METB_1862.7_Quinic acid, D(-)-(5TMS)	345	20.49	1785	78.4
Syringic acid	SyrA	1	-	EINIST_291991-101_METB_1845_Trimethylsilyl 3,5-dimethoxy-4-(trimethylsilyloxy)benzoate (1TMS)	327	21.24	1824	57.42
Ascorbate	AsA	4	-	EIQTMS_195002-101_METB_1951.1_Ascorbic acid, L(+)-(4TMS)	332	21.82	1855	65.09
trans-Caffeate	CafA	3	-	EINIST_214001-101_METB_2141.4_Caffeic acid, trans-(3TMS)	396	24.47	2102	86.8
Caffeoyl quinate	Cafquin	6	-	EIQTMS_311001-101_METB_3126_Quinic acid, 3-caffeoyl-, trans-(6TMS)	345	34.83	3101	84.77
4-methoxy-trans-Cinnamate	4MCA	1	-	EINIST_184010-101_METB_1843.1_Cinnamic acid, 4-methoxy-, trans- (1TMS)	250	37.12	3355	88.01
2-hydroxy-trans-Cinnamate	2HCA	2	-	EINIST_188016-101_METB_1878.2_Cinnamic acid, 2-hydroxy-, trans- (2TMS)	308	37.15	3358	58.67
Oxalate	OxA	2	-	EIQTMS_113002-101_MST_1134.9_[Oxalic acid (2TMS)]	190	7.03	1129	92.98
Isocitrate	Icit	4	-	EIGTMS_182003-101_METB/METB_1831.6_Isocitric acid, DL-(4TMS)	245	20.00	1763	66.66

Phosphorylated Compound								
Glycerol-2-phosphate	G2P	4	-	EISTR_174002-101_METB_1741.3_Glycerol-2-phosphate (4TMS)	243	18.52	1683	70.62
Glycerol-3-Phosphate	G3P	4	-	EINIST_177002-101_METB_1775.1_Glycerol-3-phosphate, DL-(4TMS)	357	19.10	1713	88.69
3-Phospho-glycerate	3PGA	4	-	EIROE_181003-101_METB_1817.9_Glyceric acid-3-phosphate (4TMS)	217	19.80	1750	66.93
Fructose-6-Phosphate	Fru6P	6	1	EIROE_232002-101_METB_2321.4_Fructose-6-phosphate (1MEOX) (6TMS)	245	26.40	2296	58.21
Glucose-6-Phosphate	Glc6P	6	1	EINIST_231001-101_METB_2323.5_Mannose-6-phosphate (1MEOX) (6TMS)	387	26.55	2309	86.73
myo-Inositol-1-Phosphate	Ins1P	7	-	EIQTMS_243001-101_METB_2430.3_Inositol-1-phosphate, myo-(7TMS)	318	27.67	2410	70.1
Sugar phosphate (putatively Ribose-5-phosphate)	SPO	5	1	EISTR_211003-101_METB_2113.1_Ribose-5-phosphate, D-(1 MEOX) (5TMS)	169	32.20	2829	66.87
Adenosine monophosphate	AMP	5	-	EISTR_307003-101_METB_3079.1_Adenosine-5-monophosphate (5TMS)	315	34.45	3061	76.75
Organic Compound								
Urea	Urea	2	-	EINIST_127002-101_METB_1260.1_Urea (2 TMS)	189	10.21	1237	69.61
Nicotinamide	Nam	1	-	EIFIEHN_150004-101_METB_1499.2_Nicotinamide (1TMS)	179	14.74	1490	82.7
2,4,6-Tri-tert.-butylbenzenethiol	TTBBT	-	-	EIQTMS_155003-101_MST_1542.3_[786; 2,4,6-Tri-tert.-butylbenzenethiol]	263	15.61	1532	69.82
Galactosylglycerol	GG	6	-	EIQTMS_231002-101_MST_2328.7_ [926;Galactosylglycerol (6TMS)]	204	26.48	2303	86.93
Phylloquinone	Phq	1	-	EINIST_233846-101_METB_3352_Phylloquinone	450	30.21	2631	53.14
Adenosine	A	4	-	EINIST_265001-101_2650.9_Adenosine (4TMS)	236	30.26	2642	74.51
alpha-Tocopherol	a_Tol	1	-	EINIST_316001-101_METB_3145.3_Tocopherol, alpha-(1TMS)	503	35.24	3145	57.03

Glycerophospho-glycerol	GPG	5	-	EIQTMS_220004-101_MST_2203_[755; alpha-Glycerophosphoglycerol (5TMS)]	357	25.07	2170	72.95
Digalactosyl-glycerol	DGG	9	-	EIQTMS_311002-101_MST_3140.1_[Digalactosylglycerol (9TMS)]/[861; beta-D-Galactopyranoside-(1,2)-glycerol (6TMS)]	204	34.81	3099	88.32
Fatty Acid or Fatty Alcohol								
Palmityl alcohol	Pmol		-	EINIST_114116-101_METB_1854_Hexadecan-1-ol	299	16.18	1551	52.6
Coniferyl alcohol	Cnol	2	-	EIQTMS_194005-101_METB_1945.7_Coniferylalcohol, trans-(2TMS)	204	21.85	1856	58.52
Palmitate	FA16_0	1	-	EINIST_205001-101_METB_2050.2_Hexadecanoic acid, n-(1TMS)	313	23.28	1967	90.5
Linoleate	FA18_2	1	-	EINIST_221003-101_METB_2211.1_Octadecadienoic acid, 9,12-(Z,Z)-,n-(1TMS)	337	25.43	2209	79.66
Linolenate	FA18_3	1	-	EINIST_222003-101_METB_2219.1_Octadecatrienoic acid, 9,12,15-(Z,Z,Z)-,n-(1TMS)	129	25.52	2216	89.17
Stearate	FA18_0	1	-	EINIST_225002-101_METB_2247_Octadecanoic acid, n-(1TMS)	341	25.82	2244	88.75
Monopalmitin	MP	2	-	EIQTMS_259002-101_MST_2602.7_[872; 1-Monohexadecanoylglycerol (2TMS)]	371	29.73	2594	73.39
Monostearin	MS	2	-	EIQTMS_278004-101_MST_2782.8_[924; 1-Monooctadecanoylglycerol (2TMS)]	399	31.74	2774	67.84
Stearyl alcohol	Stol	1	-	EISTR_215001-101_METB_2154.7_Octadecan-1-ol, n-(1TMS)	327	33.81	2991	76.54
Phytol	Phol	1	-	EINIST_217006-101_METB_2172.6_Phytol (1TMS)	143	14.96	1499	58.16
Campesterol	Cam	1	-	EINIST_319001-101_METB_3262.1_Campesterol (1TMS)	129	36.35	3268	81.8
Fucosterol	Fuc	1	-	EIQTMS_337005-101_MST_3367.3_Fucosterol [BP] (1TMS)	386	37.22	3367	70.54
beta-Sitosterol	b_Sit	1	-	EIQTMS_338002-101_METB_3355.5_beta-Sitosterol (1TMS)	129	37.09	3349	92
Inorganic Acid			-					
Monomethyl phosphate	MMPO	2	-	EINIST_119001-101_MST_1182.7_Phosphoric acid monomethyl ester (2TMS)	241	9.01	1171	86.79
Phosphate	PO	3	-	EIQTMS_129001-101_METB_1281.9_Phosphoric acid (3TMS)	299	10.71	1265	77.76

Unknown (with mass spectral library identifier, designated as 'NA')								
NA1	NA1	-	-	EITTMS_147011-101_MST_1474.9_[NA]	191	14.26	1460	51.49
NA2	NA2	-	-	EIQTMS_148010-101_MST_1483.8_[NA]	155	14.45	1471	64.51
NA3	NA3	-	-	EISTR_151009-101_MST_1518_[NA]	84	15.05	1503	75.28
NA4	NA4	-	-	EITTMS_159003-101_MST_1586.5_[NA]	306	16.20	1563	63.39
NA5	NA5	-	-	EITTMS_174004-101_MST_1741.9_[NA]	357	18.66	1691	72.82
NA6	NA6	-	-	EIQTMS_174001-101_MST_1751_[NA]	205	18.72	1694	80.27
NA7	NA7	-	-	EIQTMS_182009-101_MST_1820.4_[NA]	204	19.88	1754	72.44
NA8	NA8	-	-	EITTMS_187005-101_MST_1878.5_[NA]	275	20.76	1799	70.54
NA9	NA9	-	-	EIQTMS_192013-101_MST_1922.2_[NA]	205	21.21	1823	60.5
NA10	NA10	-	-	EIQTMS_196015-101_MST_1961.9_[NA]	217	21.96	1861	79.33
NA11	NA11	-	-	EIQTMS_197007-101_MST_1979.3_[NA]	217	22.17	1872	79.52
NA12	NA12	-	-	EIQTMS_200003-101_MST_2003.7_[NA]	447	22.56	1893	70.69
NA13	NA13	-	-	EIQTMS_201005-101_MST_2012.3_[NA]	297	22.61	1896	51.5
NA14	NA14	-	-	EIQTMS_203005-101_MST_2029.9_[NA]	393	22.84	1916	81.18
NA15	NA15	-	-	EIQTMS_207006-101_MST_2070.5_[NA]	143	23.33	1978	61.93
NA16	NA16	-	-	EIQTMS_194007-101_MST_1940.3_[NA]	204	23.54	1991	88
NA17	NA17	-	-	EIQTMS_211010-101_MST_2114.4_[NA]	319	23.92	2040	78.42
NA18	NA18	-	-	EIQTMS_211010-101_MST_2114.4_[NA]	262	24.23	2075	77.97

NA19	NA19	-	-	EIQTMS_214003-101_MST_2140.2_[NA]	205	24.31	2082	92
NA20	NA20	-	-	EIQTMS_211010-101_MST_2114.4_[NA]	320	24.36	2089	76.41
NA21	NA21	-	-	EIQTMS_214003-101_MST_2140.2_[NA]	319	24.44	2098	77.35
NA22	NA22		-	EITTMS_221004-101_MST_2216.1[NA]	205	25.02	2164	78
NA23	NA23	-	-	EITTMS_221004-101_MST_2216.1[NA]	342	25.32	2199	65.3
NA24	NA24	-	-	EIQTMS_224002-101_MST_2249_[NA]	204	25.91	2245	54.25
NA25	NA25	-	-	EIQTMS_228001-101_MST_2287_[NA]	290	26.06	2266	79.25
NA26	NA26	-	-	EIQTMS_211010-101_MST_2114.4_[NA]	217	26.20	2277	63.59
NA27	NA27	-	-	EIQTMS_239004-101_MST_2390.6_[NA]	204	26.28	2285	81.88
NA28	NA28	-	-	EIQTMS_237002-101_MST_2371.3_[NA]	204	26.68	2352	79.9
NA29	NA29	-	-	EIQTMS_239004-101_MST_2390.6_[NA]	217	27.03	2361	80.8
NA30	NA30	-	-	EIQTMS_239008-101_MST_2395.4_[NA]	217	27.22	2369	80.6
NA31	NA31	-	-	EIQTMS_242009-101_MST_2429.6_[NA]	204	27.61	2404	83.28
NA32	NA32	-	-	EIQTMS_242009-101_MST_2429.6_[NA]	157	27.69	2412	68.91
NA33	NA33	-	-	EIQTMS_271004-101_MST_2712.3_[NA]	204	28.03	2442	78.95
NA34	NA34	-	-	EIQTMS_245005-101_MST_2453.1_[NA]	497	28.06	2445	68.3
NA35	NA35	-	-	EIQTMS_252005-101_MST_2527_[NA]	204	28.63	2495	86.5
NA36	NA36	-	-	EIQTMS_271007-101_MST_2714.1_[NA]	217	28.79	2515	55.72
NA37	NA37	-	-	EITTMS_261001-101_MST_2618.2_[NA]	204	29.08	2524	63.59

NA38	NA38	-	-	EIQTMS_267006-101_MST_2678.6_[NA]	205	29.14	2542	70.89
NA40	NA40	-	-	EIQTMS_267006-101_MST_2678.6_[NA]	204	30.31	2646	86.12
NA41	NA41	-	-	EIQTMS_268004-101_MST_2686.8_[NA]	204	30.41	2655	85.09
NA42	NA42	-	-	EIQTMS_271008-101_MST_2716.3_[NA]	204	30.56	2669	72.72
NA43	NA43	-	-	EIQTMS_268004-101_MST_2686.8_[NA]	204	30.68	2679	85.76
NA44	NA44	-	-	EIQTMS_270003-101_MST_2700.2_[NA]	217	30.73	2684	72.96
NA45	NA45	-	-	EIQTMS_272009-101_MST_2722.6_[NA]	217	30.85	2694	78.3
NA46	NA46	-	-	EIQTMS_270003-101_MST_2700.2_[NA]	361	30.89	2701	67.3
NA47	NA47	-	-	EITTMS_273004-101_MST_2726.4_[NA]	217	30.92	2706	74.56
NA48	NA48	-	-	EIQTMS_271005-101_MST_2712.2_[NA]	204	30.97	2720	62.66
NA49	NA49	-	-	EIQTMS_271004-101_MST_2712.3_[NA]	204	31.44	2741	66.51
NA50	NA50	-	-	EIQTMS_201005-101_MST_2012.3_[NA]	297	32.09	2809	55.98
NA51	NA51	-	-	EIQTMS_286005-101_MST_2866.5_[NA]	361	32.40	2840	66.45
NA52	NA52	-	-	EIQTMS_201005-101_MST_2012.3_[NA]	297	32.56	2856	65.6
NA53	NA53	-	-	EITTMS_314002-101_MST_3145.5_[NA]	384	32.57	2858	54.37
NA54	NA54	-	-	EIQTMS_271004-101_MST_2712.3_[NA]	204	32.60	2862	71.35
NA55	NA55	-	-	EITTMS_288004-101_MST_2882.6_[NA]	361	32.70	2873	67.79
NA56	NA56	-	-	EIQTMS_290007-101_MST_2906.3_[NA]	204	32.74	2877	63.13
NA57	NA57	-	-	EIQTMS_292006-101_MST_2929.5_[NA]	204	32.91	2895	82.54

NA58	NA58	-	-	EIQTMS_201005-101_MST_2012.3_[NA]	297	33.15	2921	78.53
NA59	NA59	-	-	EIQTMS_201005-101_MST_2012.3_[NA]	297	33.43	2951	70.18
NA60	NA60	-	-	EITTMS_279003-101_MST_2794.4_[NA]	204	33.66	2997	66.58
NA61	NA61	-	-	EIQTMS_318004-101_MST_3181.7_[NA]	133	35.43	3166	66.9
NA62	NA62	-	-	EITTMS_310001-101_MST_3107_[A1]	249	35.53	3176	69.77
NA63	NA63	-	-	EIQTMS_239008-101_MST_2395.4_[NA]	204	36.95	3335	64.75
Unknown (not found in any mass spectral library)								
Unknown 1	U1	-	-	-	246	12.83	1401	-
Unknown 2	U2	-	-	-	449	22.78	1898	-
Unknown 3	U3	-	-	-	361	22.25	1880	-
Unknown 4	U4	-	-	-	216	23.94	2045	-
Unknown 5	U5	-	-	-	319	24.13	2060	-
Unknown 6	U6	-	-	-	259	25.94	2255	-
Unknown 7	U7	-	-	-	259	26.00	2269	-
Unknown 8	U8	-	-	-	204	27.13	2365	-
Unknown 9	U9	-	-	-	123	27.57	2389	-
Unknown 10	U10	-	-	-	204	28.46	2465	-
Unknown 11	U11	-	-	-	361	29.46	2601	-
Unknown 12	U12	-	-	-	361	29.52	2645	-

Unknown 13	U13	-	-	-	217	29.59	2657	-
Unknown 14	U14	-	-	-	204	31.51	2850	-
Unknown 15	U15	-	-	-	361	31.59	2869	-
Unknown 16	U16	-	-	-	361	31.77	2884	-
Unknown 17	U17	-	-	-	204	32.43	2846	-
Unknown 18	U18	-	-	-	267	32.48	2855	-
Unknown 19	U19	-	-	-	361	32.65	2869	-
Unknown 20	U20	-	-	-	204	32.83	2885	-
Unknown 21	U21	-	-	-	204	33.11	2913	
Unknown 22	U22	-	-	-	218	37.40	3378	-
Unknown 23	U23	-	-	-	531	37.55	3398	-
Unknown 24	U24	-	-	-	437	37.66	3407	-
Unknown 25	U25	-	-	-	361	37.87	3519	-
Unknown 26	U26	-	-	-	217	19.07	1720	-
Unknown 27	U27	-	-	-	246	20.21	1772	-
Unknown 28	U28	-	-	-	204	24.55	2098	-
Unknown 27	U29	-	-	-	267	31.89	2778	-
Unknown 30	U30	-	-	-	249	33.54	2960	-

Supplemental Table 2: List of yield and yield-related traits measured for 179 lines of the Excalibur/Kukri doubled haploid population

TRAIT NAME	ABBREVIATION	DESCRIPTION
Thermal Time to Heading	TTH	TTH refers to the duration to heading, but minimizes the differences in response to photoperiod due to fluctuations in temperature during growth. Thermal time to heading is calculated as $\sum [0.5(T_{max}-T_{min})-T_b]$, where T_{max} and T_{min} are the daily maximum and minimum temperatures, and $T_b=0^oC$ is the base temperature.
Glaucousness	Gla	Glaucousness (waxiness) is caused by an increase presence of epicuticular wax on the leaves. The glaucousness of the plants was scored, at anthesis, by visual assessment on a 1 to 9 scale: (1) Non glaucous; (2) Glaucous stem; (3) As 2, plus up to ¼ of the flag leaf's abaxial surface; (4) As 2, plus ¼ to ¾ of the flag leaf's abaxial surface; (5) As 2, plus all of the leafs abaxial surface; (6) As 5, plus up to ¼ of the flag leaf's adaxial surface; (7) As 5, plus up to ½ of the flag leaf's adaxial surface; (8) As 5, plus up to ¾ of the flag leaf's adaxial surface; (9) As 5, plus all of the flag leafs adaxial surface.
Leaf rolling 12_09_06	Lfr1	Leaf rolling measured at the first scoring date. Leaf rolling was scored by visual assessment using a 5 point scale developed by O'Toole et al. (1979).
Leaf rolling 18_09_06	Lfr2	Leaf rolling measured at the second scoring date. Leaf rolling was scored by visual assessment using a 5 point scale developed by O'Toole et al. (1979).
Chlorophyll 1	SPAD1	Chlorophyll content (SPAD) of flag leaves at the first scoring date. The chlorophyll content (SPAD) of flag leaves was measured during anthesis using a hand held SPAD-502 chlorophyll meter (Konica, Minolta, Tokyo, Japan). One measurement was taken on six flag leaves and the average recorded. This was repeated twice per plot, and repeated if the readings differed by > 2 units.
Chlorophyll 2	SPAD2	Chlorophyll content (SPAD) of flag leaves at the second scoring date.
Crown rot	CR	The damage caused by the fungus Fusarium pseudograminearum was scored visually on a 1 to 9 scale, where a 9 score is equal to or greater than 90% of the plants being infected.
Days to senescence	DS	Days to senescence of the plant.
Flag leaf length	Flth	The flag leaf length was measured on five randomly selected plants from each plot.
Head length	Hlth	The head length was measured on five randomly selected plants from each plot.
Peduncle length	Plth	The peduncle length (Plth) (the distance between the final node and the head) was measured on five randomly selected plants from each plot.
Plant height	Ht	Plant height was measured at physiological maturity from the soil surface to the tip of the head, excluding awns (cm).
Number of tillers	Tl	The tiller counts, on one meter sections of two rows within each plot, were conducted during stem elongation. The location was marked, and the number of tillers remaining at physiological maturity was counted.
Number of aborted tillers	Atl	Number of aborted tillers.
Infertile florets	InfFl	Number of infertile florets.
Thousand grain weight (5 Plants)	Tgw5P	Weight of a thousand grain sample (g), five plants

Supplemental Table 2: continued

TRAIT NAME	ABBREVIATION	DESCRIPTION
Fertile seeds per spike	Fsp	Number of fertile seeds per spike.
Yield/kg ha^{-1}	Yld	The plots were machine harvested and the grain cleaned. The cleaned samples were weighed to calculate the grain yield expressed in Kg per hectare
Thousand grain weight	Tgw	Weight of a thousand grain sample (g), one plant
Total seeds per spike	Sp	Number of seeds per spike
Spikes per m^2	SpM2	Spike number per meter square
Grains per m^2	Gm2	Grain number per meter square
Grain size G2.8	G2.8	Percentage of grain that does not fall through a sieve with holes of 2.8 mm (grain size larger than 2.8mm).
Grain size G2.5	G2.5	Percentage of grain that does not fall through a sieve with holes of 2.5 mm (grain size larger than 2.5mm).
Grain size G2.2	G2.2	Percentage of grain that does not fall through a sieve with holes of 2.2 mm (grain size larger than 2.2mm).
Screenings L2.2	L2.2	Percentage of unmillable material that falls through a sieve ('screen') with holes of 2.2 mm.
Test weight	Hlwt	Test weight measures the density of grain and is calculated as kg/hL. This is measured by weighing a half liter measure of grain in grams; and dividing the weight by five. It serves as an indication of milling potential of a parcel of wheat.
Harvest index	Hi	Two one meter rows were cut just prior to harvest, weighed and threshed. The threshed grain was weighed and the harvest index (Hi) calculated as the weight of the grain as a percentage of the total weight.
Total Biomass	Bm	Above ground biomass at physiological maturity.

O'Toole JC, Cruz RT, Singh TN (1979) Leaf rolling and transpiration. Plant Science Letters 16:111-114

Supplemental Table 3: Chromosome position, marker interval, LOD values and trait heritabilities for the metabolic QTL. Genetic variance: the percentage of genetic variance explained by a QTL

TRAIT NAME	QTL NAME	H^2	INTERVAL	POSITION(cM)	ALLELE	LOD	GENETIC VARIANCE
Malonate	*QMna-2A*	0.58	wmc667–WPT-9961	20.34–47.38	KUKRI	2.28	14.34
	QMna-5B		WPT-1457–barc0112	70.32–75.02	EXCAL	1.79	9.18
	QMna-7DS		CFD0021B–WPT-0789	88.75–92.43	KUKRI	2.49	11.10
Phosphate	*QPo-2A*	0.51	WPT-1657–GWM0312	86.43–112.98	EXCAL	1.66	6.58
	QPo-2B		BARC0101–WPT-1140	129.35–132.37	EXCAL	1.76	7.06
	QPo-4B		WPT-7062–WPT-8756	33.08–62.15	KUKRI	1.18	6.12
	QPo-6A		barc0113–WPT-8662	59.81–69.46	EXCAL	3.00	10.48
	QPo-7A		wmc0283–BS00010307	81.23–102.67	KUKRI	4.35	18.28
Glycerate	*QGlyc-4D*	0.72	WPT-5809–WPT-0877	6.3–41.59	EXCAL	1.77	10.00
	QGlyc-6A.1		WPT-9132–CFD0001C	24.78–27.18	KUKRI	2.12	9.14
	QGlyc-6A.2		WPT-4229–WPT-5885	117.53–121.22	KUKRI	1.39	5.96
Itaconate	*QIta-2A*	0.45	GWM0312–stm0761tcac	112.98–117.9	EXCAL	3.58	14.45
	QIta-4A		stm0092tctg–GWM0428B	0–11.9	EXCAL	2.82	12.33
	QIta-5A		WPT-9834–CFA2141	143.98–148.53	EXCAL	2.28	9.37
	QIta-7A		gwm0060–wmc0283	80.16–81.23	KUKRI	5.05	22.13
	QIta-7DL		WPT-5674–CFD0083A	24.51–31.51	KUKRI	1.27	5.23
Dimethyl maleate	*Q2mm-2A*	0.47	WPT-1657–GWM0312	86.43–112.98	EXCAL	1.77	10.48
	Q2mm-4A		GWM0428B–BARC0106	11.9–12.59	EXCAL	5.31	22.52
	Q2mm-7A		gwm0060–wmc0283	80.16–81.23	KUKRI	4.46	21.28
Pipecolate	*QPip-2A*	0.73	WPT-9961–WPT-7626	47.38–57.16	EXCAL	1.75	1.93
	QPip-4B		WMC0047–WMC0349A	22.04–23.73	EXCAL	5.01	6.90
	QPip-4D.1		WMC0457–WPT-5809	5.04–6.3	EXCAL	6.73	28.06
	QPip-4D.2		WPT-5809–WPT-0877	6.3–41.59	KUKRI	0.96	5.88
	QPip-7A		gwm0060–wmc0283	80.16–81.23	KUKRI	4.86	4.75
Aspartate	*QAsp-1AS*	0.54	cwem0012–PSP2999	6.07–11.13	KUKRI	2.08	11.45
	QAsp-3D		BARC0042–CFD0223A	6.24–25.99	EXCAL	1.63	9.06

	QAsp-6A		barc0113–WPT-8662	59.81–69.46	EXCAL	1.86	10.31
Malate	*QMala-5DL*	0.72	barc0239–BARC0286	39.33–40.47	KUKRI	3.47	7.29
	QMala-7A		BS00010307-BS00010605	102.67–106.88	EXCAL	6.34	15.02
Phytol	*QPhol-1AS*	0.57	WPT-9592-WPT-6455	75.24–80.53	EXCAL	1.55	4.73
	QPhol-2D		WPT-2644-WPT-4413	30.23–48.92	KUKRI	1.80	6.20
	QPhol-4A		stm0506tgag-WPT-2788	14.76–42.83	KUKRI	3.58	13.22
	QPhol-5B		WPT-4936-WPT-3661	89.13–95.82	EXCAL	3.63	11.29
	QPhol-7DS		stm0789tcacA-GWM0437	99.45–112.57	EXCAL	1.86	5.62
GABA	*QGABA-4A*	0.47	WPT-0817-barc0343	89.4–102.66	KUKRI	4.31	16.44
Erythronate	*QEryA-3B*	0.66	WPT-5390- WMC0307	128.99–130.42	EXCAL	2.67	7.21
	QEryA-4B		WPT-8756-WPT-1272	62.15–68.1	EXCAL	1.96	6.05
	QEryA-5B		WPT-4936-WPT-3661	89.13–95.82	EXCAL	3.52	9.85
	QEryA-7A		BS00010605-BS00009978	106.88–107.8	EXCAL	6.48	18.80
	QEryA-7DS		WPT-2551-gdm0088	3.04–36.03	EXCAL	2.40	8.29
2,4,6-Tri.*tert*.-butylbenzenethiol	*QTtbtt-7DL*	0.32	WPT-5674-CFD0083A	24.51– 31.51	EXCAL	1.15	29.06
Glutamine	*QGln-2A*	0.68	stm0761tcac-gdm0093	117.9–164.74	EXCAL	4.49	15.06
	QGln-2B		WPT-9668-WPT-5707	77.23–78.04	KUKRI	2.78	7.08
	QGln-4D		WPT-5809-WPT-0877	6.3–41.59	EXCAL	1.73	5.44
	QGln-5A		Vrn1A-WPT-9834	132.14–143.98	EXCAL	3.04	7.08
	QGln-7A		gwm0060-wmc0283	80.16–81.23	KUKRI	4.72	10.56
Xylitol	*QXiol-1AL*	0.58	WPT-6005- WPT-2855	19.58–25.66	KUKRI	1.34	21.79
2-Oxogulonate	*Q2OG-3B*	0.54	WPT-5064-BARC0131	71.07–77.66	KUKRI	1.74	9.58
	Q2OG-6B		WPT-2587-WPT-4764	75.45–81.5	EXCAL	3.14	18.39
***cis*-Aconitate**	*QAA-2B*	0.63	WPT-9668-WPT-5707	77.23–78.04	KUKRI	1.84	7.02
	QAA-3A		WPT-9215-WPT-3816	80.05–109.35	EXCAL	2.12	8.86
	QAA-5A		WPT-0373-wmc0075b	126.71–130.48	EXCAL	1.64	5.08
	QAA-7A		gwm0060-wmc0283	80.16–81.23	KUKRI	5.24	17.30
	QAA-7DS		stm0789tcacA-GWM0437	99.45–112.57	KUKRI	2.93	9.39
Ribonate	*QRiA-1AL*	0.52	WPT-0432-WPT-6005	19.12–19.58	KUKRI	1.05	7.13
	QRiA-6A		WPT-5885-WPT-8439	121.22–122.4	KUKRI	2.30	14.97

	QRiA-7DS		WPT-2551-gdm0088	3.04–36.03	EXCAL	1.50	12.16
3-Phosphoglycerate	*Q3PGA-2A*	0.45	WPT-7626- wmc177	57.16–75.63	EXCAL	1.88	15.30
	Q3PGA 5B		GWM0540- BARC0088A	66.58–67.64	KUKRI	2.01	15.06
Arginine	*QArg-1As*	0.73	cwem0012-PSP2999	6.07–11.13	KUKRI	1.92	14.16
Quinate	*QQuin-3B*	0.65	WPT-5390-WMC0307	128.99–130.42	EXCAL	4.22	20.78
Fructose	*QFruc-4B*	0.48	WPT-0037-WPT-3608	0–14.18	KUKRI	2.16	9.02
	QFruc-4D		WMC0457-WPT-5809	5.04–6.3	KUKRI	1.14	3.14
	QFruc-7A		wmc0283-BS00010307	81.23–102.67	EXCAL	4.49	16.46
Tyrosine	*QTyr-7A*	0.65	BS00010307-BS00010605	102.67–106.88	EXCAL	3.40	7.69
Coniferyl alcohol	*QCnol-2B*	0.41	GWM0257-WPT-9423	71.86–72.98	EXCAL	1.82	11.82
	QCnol-7A		BS00010605-BS00009978	106.88–107.8	EXCAL	2.69	18.28
	QCnol-7B		WPT-8938-WPT-0722	132.41–164.08	KUKRI	1.99	17.57
Galactonate	*QGalA-5B*	0.43	stm0661acag- barc0156	160.75–164.42	EXCAL	1.20	22.61
β-Sitosterol	*QBsit-2B*	0.82	WPT-0950-WPT-2854	140.13–142.62	EXCAL	4.59	10.98
Myo-Inositol	*QIns-1B*	0.48	WPT-1374-BARC0137	50.6–51.77	EXCAL	2.83	17.55
	QIns-6A		WPT-7820-DuPw0254	50.69–54.3	EXCAL	1.66	9.99
	QIns-7B		WPT-1826-WPT-9925	101.36–107.08	KUKRI	2.72	18.18
2-o-Glycerol-β-galactopyranoside	*QGbgp-3A*	0.58	WMC0532-WPT-0714	29.42–41.02	EXCAL	2.54	19.09
Linoleate	*FA18_2-7A*	0.54	STM0511TCTG-BARC0282	121.07–130.65	KUKRI	3.53	21.48
Fructose-6-Phosphate	*QF6p-1B*	0.41	WPT-1684-WPT-1374	40.86–50.6	EXCAL	1.72	14.82
	QF6p-5B		WPT-4936-WPT-3661	89.13–95.82	KUKRI	2.89	21.00
Glucose-6-Phosphate	*QG6p-7A*	0.64	WMC0083-STM0511TCTG	119.44–121.07	EXCAL	2.67	19.22
1-Benzylglucopyranoside	*QBenzgp-2D*	0.40	WPT-3757-CFD0050A	96.11–98.81	EXCAL	2.26	10.44
	QBenzgp-5B		WPT-6726-WPT-4936	78.79–89.13	EXCAL	3.13	15.40
Adenosine	*QA-4D*	0.63	barc0098-WMC0457	0–5.04	EXCAL	0.89	7.24
	QA-5B		WPT-9666-WPT-5914	51.97–59.54	EXCAL	1.30	12.74
Maltose	*QMal-1B*	0.49	WPT-0705-WPT-9809	62.89–103.86	EXCAL	3.08	15.17
	QMal-7A		BS00010605-BS00009978	106.88–107.8	EXCAL	8.68	28.96
Monostearin	*QMs-1AL*	0.41	WPT-0128-WPT-1011	0–13.97	EXCAL	1.71	11.41
	QMs-7A		BS00010605-BS00009978	106.88–107.8	EXCAL	3.98	26.01

Galactinol	*QGol-2B*	0.37	barc1027-BARC0160	110.23–116.69	KUKRI	2.33	19.67
	QGol-4D		WPT-5809-WPT-0877	6.3–41.59	EXCAL	1.53	15.11
Stearyl alcohol	*QStol-5A*	0.55	wmc0075b-Vrn1A	130.48–132.14	KUKRI	1.49	6.57
	QStol-7A		BS00010605-BS00009978	106.88–107.8	EXCAL	6.20	34.49
Glycine	*QGly-2D*	0.46	WPT-4413-WPT-0638	48.92–56.98	KUKRI	1.60	18.74
Adenosine monophosphate	*QAmp-3B*	0.57	WPT-1484-WPT-1191	107.08–108.79	KUKRI	1.56	9.92
	QAmp-7DL		BARC0235-GWM0428A	0–18.28	EXCAL	1.60	11.00
Caffeoylquinate	*QCafquin-1B*	0.71	WPT-7833-BARC0008	24.58–37.8	KUKRI	3.39	9.00
	QCafquin-1D		WPT-7946-CFD0083B	46.42–79.88	KUKRI	5.06	14.32
	QCafquin-4A		barc0343-WPT-8886	102.66–120.41	EXCAL	4.51	13.21
	QCafquin-7A		gwm0060-wmc0283	80.16–81.23	KUKRI	4.48	9.70
Raffinose	*QRaf-2B*	0.45	WPT-8460-WPT-9736	148.33–151.94	EXCAL	1.72	18.81
1-Kestose	*QKes-2B*	0.68	wmc0476-barc1027	109.63–110.23	EXCAL	1.63	7.44
	QKes-6A		stm0570tctga-WPT-8256	5.96–13.19	KUKRI	1.55	7.18
4-methoxy-*cis*-Cinnamate	*Q4Mca-5B*	0.53	WPT-6726-WPT-4936	78.79–89.13	EXCAL	5.65	19.97
Fucosterol	*QFuc-3A*	0.48	GWM0156A-stm0018tgag	77.2–78.3	KUKRI	5.88	27.08
3-amino-piperidin-2-one	*QAp-2A*	0.71	WPT-7626-wmc177	57.16–75.63	EXCAL	2.85	12.74
Erythritol	*QEol-1B*	0.57	WPT-7833-BARC0008	24.58–37.8	KUKRI	3.27	22.61
Isocitrate	*QIcit-4D*	0.77	WMC0457-WPT-5809	5.04–6.3	EXCAL	1.19	2.82
	QIcit-7A		wmc0283-BS00010307	81.23–102.67	EXCAL	6.36	21.45
Unknown 2	*QU2-5B*	0.69	BARC0088A-WPT-3200	67.64–69.25	EXCAL	2.43	8.49
	QU2-7A		BS00009978-stm0662acag	107.8–115.77	KUKRI	3.77	15.09
Unknown 3	*QU3-1D*	0.54	GWM0642-WPT-1799	89.54–112.74	KUKRI	1.40	6.15
	QU3-5B		WPT-6726-WPT-4936	78.79–89.13	KUKRI	1.81	7.42
	QU3-7A		wmc0283-BS00010307	81.23–102.67	EXCAL	2.31	11.05
Unknown 5	*QU5-4B*	0.4	WPT-0246-WPT-8650	68.72–72.63	EXCAL	1.09	5.97
	QU5-7A		BS00010605-BS00009978	106.88–107.8	EXCAL	4.59	24.22
	QU5-7DS		CFD0021B-WPT-0789	88.75–92.43	EXCAL	1.20	5.79
Unknown 9	*QU9-4B*	0.52	WMC0349A-GWM0149	23.73–30.78	EXCAL	1.50	16.45
Unknown 13	*QU13-7A*	0.18	BARC0282-wmc0017	130.65–132.12	EXCAL	2.69	21.82

Unknown 15	*QU15-5A*	0.49	Vrn1A-WPT-9834	132.14–143.98	EXCAL	2.01	12.26
	QU15-5DL		WPT-5766-barc0044	0–11.26	EXCAL	2.31	12.43
Unknown 18	*QU18-5A*	0.40	GWM0186-WPT-8226	86.02–92.13	KUKRI	2.85	19.40
	QU18-7A		WPT-1510-WPT-8789	14.08–14.35	EXCAL	4.84	38.03
Unknown 19	*QU19-6B*	0.75	CFD0001B-CFD0013B	59.3–60.1	EXCAL	5.24	19.54
Unknown 21	*QU21-6D*	0.63	CFD0287-barc0293	91.22–94.12	KUKRI	2.59	9.65
	QU21-6D		WPT-0408- WPT-1345	172.1–175.38	EXCAL	5.68	23.68
Unknown 22	*QU22-4B*	0.53	WPT-7062-WPT-8756	33.08–62.15	KUKRI	3.68	19.59
	QU22-6D		CFD0019C-GWM0325	85.81–87.43	EXCAL	10.15	30.11
Unknown 24	*QU24-3B*	0.70	WPT-4648–WPT-5064	70.12–71.07	KUKRI	1.13	2.37
	QU24-7A.1		BS00009404–WPT-1510	10.02–14.08	EXCAL	1.92	5.09
	QU24-7A.2		BS00010605–BS00009978	106.88–107.8	EXCAL	3.44	12.42
	QU24-7A.3		wmc0422–WPT-7299	134.69–138.13	KUKRI	1.77	6.96
	QU24-7A.4		BS00003720–BS00009886	256.64–257.83	KUKRI	1.53	4.09
Unknown 25	*QU25-7A*	0.53	BS00010605–BS00009978	106.88–107.8	EXCAL	4.09	30.45
Unknown 27	*QU27-5B*	0.43	BARC0216–GWM0540	64.42–66.58	EXCAL	1.99	15.97
	QU27-7A		BS00010605–BS00009978	106.88–107.8	EXCAL	2.15	18.06
Unknown 29	*QU29-2A*	0.47	GWM0389–BARC1138B	1.72–17.04	EXCAL	2.63	31.87
NA5	*QNa5-1AS*	0.61	WPT-8770–WPT-9317	12.64–13.49	KUKRI	1.45	12.23
	QNa5-5DL		WPT-0596–WPT-2325	153.7–164.4	EXCAL	1.14	8.73
NA6	*QNa6-5A*	0.52	WPT-0373–wmc0075b	126.71–130.48	KUKRI	2.74	7.61
	QNa6-7A		wmc0283–BS00010307	81.23–102.67	EXCAL	6.06	20.35
NA7	*QNa7-2A*	0.63	GWM0312–stm0761tcac	112.98–117.9	EXCAL	1.40	3.91
	QNa7-3D		BARC0042–CFD0223A	6.24–25.99	KUKRI	0.82	2.60
	QNa7-6B		WPT-7662–WPT-2964	0–3.32	KUKRI	3.46	11.52
	QNa7-7A		wmc0017–wmc0422	132.12–134.69	EXCAL	1.59	5.56
	QNa7-7DL		WPT-5674–CFD0083A	24.51–31.51	KUKRI	1.22	3.56
NA10	*QNa10-7A*	0.45	wmc0283–BS00010307	81.23–102.67	EXCAL	4.26	33.51
NA11	*QNa11-7A*	0.57	wmc0283–BS00010307	81.23–102.67	EXCAL	5.82	20.67
NA13	*QNa13-3A*	0.66	WPT-4407–GWM0156A	46.74–77.2	EXCAL	1.53	4.77

	QNa13-4A		wmc0603–WPT-2542	87.57–89.25	EXCAL	2.15	5.13
	QNa13-4B		WPT-7062–WPT-8756	33.08–62.15	KUKRI	2.00	8.26
	QNa13-5A		GWM0186–WPT-8226	86.02–92.13	KUKRI	1.76	4.41
	QNa13-7A		WMC0083–STM0511TCTG	119.44–121.07	KUKRI	2.54	6.89
	QNa13-7DL		WPT-5674–CFD0083A	24.51–31.51	EXCAL	0.83	1.91
NA15	*QNa15-1B*	0.46	WPT-7833–BARC0008	24.58–37.8	EXCAL	2.02	18.29
NA16	*QNa16-1AL*	0.67	WPT-6005–WPT-2855	19.58–25.66	EXCAL	1.00	3.60
	QNa16-2A		BARC1138B–wmc667	17.04–20.34	KUKRI	2.81	8.82
	QNa16-5A		Vrn1A–WPT-9834	132.14–143.98	KUKRI	1.87	6.50
	QNa16-7DS		WPT-0366–WPT-5049	0–1.14	KUKRI	2.72	8.56
NA17	*QNa17-4A*	0.5	WPT-2951–GWM0471C	153.68–164.26	KUKRI	2.14	19.38
NA18	*QNa18-4A*	0.55	stm0092tctg–GWM0428B	0–11.9	KUKRI	3.02	17.91
	QNa18-7A		CFA2049–gwm0060	78.48–80.16	EXCAL	3.62	21.42
NA19	*QNa19-4A.1*	0.61	stm0506tgag–WPT-2788	14.76–42.83	KUKRI	3.39	14.09
	QNa19-4A.2		WPT-2951–GWM0471C	153.68–164.26	KUKRI	2.67	9.92
	QNa19-7A		wmc0283–BS00010307	81.23–102.67	EXCAL	5.87	25.95
NA20	*QNa20-4A*	0.62	WPT-2951–GWM0471C	153.68–164.26	KUKRI	2.25	9.60
	QNa20-5B		WPT-1457– barc0112	70.32–75.02	KUKRI	2.74	11.23
	QNa20-7A		BS00010605–BS00009978	106.88–107.8	EXCAL	6.31	26.17
NA21	*QNa21-5B*	0.61	WPT-1457–barc0112	70.32–75.02	KUKRI	2.90	13.88
	QNa21-7A		BS00010605–BS00009978	106.88–107.8	EXCAL	6.44	31.23
NA23	*QNa23-1AS*	0.65	CFD0059–WPT-6654	63.29–65.06	KUKRI	2.13	8.67
	QNa23-4B		WPT-8756–WPT-1272	62.15–68.1	EXCAL	4.00	17.58
NA26	*QNa26-4B*	0.39	WPT-0246–WPT-8650	68.72–72.63	EXCAL	1.43	6.58
	QNa26-5A		WPT-0373–wmc0075b	126.71–130.48	KUKRI	1.76	7.21
	QNa26-7A		BS00010605–BS00009978	106.88–107.8	EXCAL	4.08	17.71
NA27	*QNa27-5B*	0.49	WPT-9666–WPT-5914	51.97–59.54	EXCAL	6.64	15.39
NA28	*QNa28-4B*	0.62	WPT-0037–WPT-3608	0–14.18	KUKRI	1.97	8.71
	QNa28-4D		WMC0457–WPT-5809	5.04–6.3	KUKRI	1.04	3.14
	QNa28-5A		WPT-8226–WPT-0373	92.13–126.71	KUKRI	2.04	8.57

NA30	*QNa30-2A.1*	0.62	WPT-7626–wmc177	57.16–75.63	EXCAL	1.08	4.85
	QNa30-2A.2		WPT-9793–WPT-6687	169.65–170.79	KUKRI	0.98	3.39
	QNa30-4D		WMC0457–WPT-5809	5.04–6.3	EXCAL	3.51	12.92
	QNa30-7A		BS00010605–BS00009978	106.88–107.8	EXCAL	3.01	13.25
NA33	*QNa33-6A*	0.46	CFD0001C–WPT-9690	27.18–27.9	KUKRI	6.18	52.74
NA41	*QNa41-1B*	0.54	WPT-1684–WPT-1374	40.86–50.6	EXCAL	7.08	25.70
NA42	*QNa42-3A*	0.47	WPT-9215–WPT-3816	80.05–109.35	EXCAL	2.49	18.19
NA43	*QNa43-5A*	0.43	WPT-8226–WPT-0373	92.13–126.71	KUKRI	1.61	16.30
NA44	*QNa44-3A*	0.52	CFA2193B–CFA2170	115.25–139	EXCAL	1.87	15.35
	QNa44-7A		CFA2049–gwm0060	78.48–80.16	EXCAL	1.26	8.98
NA45	*QNa45-2B*	0.28	WPT-3561–WPT-7757	79.27–83.54	EXCAL	3.69	18.45
	QNa45-4B		WPT-7062–WPT-8756	33.08–62.15	KUKRI	2.36	19.92
NA47	*QNa47-1D*	0.48	WPT-4971–WPT-9181	0–11.53	KUKRI	2.32	14.53
NA50	*QNa50-7A*	0.82	WPT-8789–WPT-0744	14.35–14.81	EXCAL	45.78	59.57
NA52	*QNa52-7A*	0.80	WPT-8789–WPT-0744	14.35–14.81	EXCAL	45.90	61.71
NA53	*QNa53-3A*	0.49	GWM0156A–stm0018tgag	77.2–78.3	KUKRI	8.80	28.26
	QNa53-3B		BARC0131–WPT-1484	77.66–107.08	KUKRI	4.12	19.05
	QNa53-7DS		stm0789tcacA–GWM0437	99.45–112.57	EXCAL	2.05	7.21
NA54	*QNa54-7A*	0.49	BS00010605–BS00009978	106.88–107.8	EXCAL	9.62	48.71
NA55	*QNa55-1AS.1*	0.49	PSP2999–WPT-2527	11.13–11.72	KUKRI	3.64	25.71
	QNa55-1AS.2		BARC0263B–CFD0021A	18.18–18.73	EXCAL	2.46	17.01
	QNa55-2A		WPT-9793–WPT-6687	169.65–170.79	KUKRI	1.44	1.02
	QNa55-4B		WPT-7062–WPT-8756	33.08–62.15	EXCAL	4.04	5.64
	QNa55-5A		WPT-0373–wmc0075b	126.71–130.48	KUKRI	2.00	1.65
	QNa55-7A		BS00010605–BS00009978	106.88–107.8	EXCAL	4.14	3.83
NA56	*QNa56-7A*	0.55	BS00010605–BS00009978	106.88–107.8	EXCAL	5.58	33.94
NA57	*QNa57-1B*	0.41	WPT-1374–BARC0137	50.6–51.77	EXCAL	2.54	12.89
	QNa57-2B.1		WPT-1663–WPT-0643	0–5.25	KUKRI	1.58	7.20
	QNa57-2B.2		BARC0160–GWM0388	116.69–126.03	KUKRI	2.45	14.78
	QNa57-7A		wmc0283–BS00010307	81.23–102.67	KUKRI	2.86	17.70

NA58	*QNa58-3B*	0.52	BARC0164–GWM0383	146.46–158.53	KUKRI	4.26	11.87
	QNa58-4B		WMC0349A–GWM0149	23.73–30.78	KUKRI	1.31	4.61
	QNa58-5A		WPT-8226–WPT-0373	92.13–126.71	KUKRI	2.62	9.49
	QNa58-7A.1		WPT-8789–WPT-0744	14.35–14.81	KUKRI	4.82	12.43
	QNa58-7A.2		BS00010605–BS00009978	106.88–107.8	EXCAL	6.90	18.81
NA59	*QNa59-1B*	0.57	WPT-8279–WPT-0705	60.91–62.89	EXCAL	2.68	7.42
	QNa59-5A		WPT-8226–WPT-0373	92.13–126.71	KUKRI	5.90	22.14
	QNa59-7A		BS00010605–BS00009978	106.88–107.8	EXCAL	7.17	21.28
NA60	*QNa60-5A*	0.51	WPT-0373–wmc0075b	126.71–130.48	KUKRI	3.81	15.86
	QNa60-6D		CFD0287–barc0293	91.22–94.12	KUKRI	4.01	15.86
	QNa60-7A		WMC0083–STM0511TCTG	119.44–121.07	EXCAL	2.88	13.79

Supplemental Table 4: Chromosome position, marker interval, LOD values and trait heritabilities for agronomic trait QTL

TRAIT NAME	QTL NAME	H^2	INTERVAL	POSITION (cM)	ALLELE	LOD	GENETIC VARIANCE
Thermal	*QTth-2B*	0.97	WPT-6199–WPT-0709	84.82–101.78	KUKRI	4.79	5.70
time to	*QTth-5A*		wmc0075b–Vrn1A	130.48–132.14	EXCAL	12.15	10.20
heading	*QTth-7A*		wmc0283–BS00010307	81.23–102.67	KUKRI	33.99	39.03
Glaucousness	*QGla-2A.1*	0.83	GWM0389–BARC1138B	1.72–17.04	KUKRI	1.36	4.08
	QGla-2A.2		wmc177–wmc598	75.63–76.22	EXCAL	1.81	4.48
	QGla-2B		WPT-3459–WPT-2106	5.88–8.81	KUKRI	4.51	11.56
	QGla-7A		gwm0060–wmc0283	80.16–81.23	KUKRI	4.73	13.12
Leaf rolling 1	*QLfr1-1AS*	0.79	WPT-2872–barc0350	48.98–60.29	EXCAL	2.89	6.00
	QLfr1-5A		WPT-0373–wmc0075b	126.71–130.48	EXCAL	4.64	8.13
	QLfr1-5B		GWM0540–BARC0088A	66.58–67.64	KUKRI	2.26	4.06
	QLfr1-7A		wmc0283–BS00010307	81.23–102.67	KUKRI	6.14	13.95
	QLfr1-7DL		WPT-5674–CFD0083A	24.51–31.51	KUKRI	0.92	1.58
Leaf rolling 2	*QLfr2-1AL*	0.85	WPT-6005–WPT-2855	19.58–25.66	KUKRI	1.21	2.28
	QLfr2-4B		WPT-7062–WPT-8756	33.08–62.15	KUKRI	2.48	7.51
	QLfr2-5A		wmc0075b–Vrn1A	130.48–132.14	EXCAL	3.18	5.39
	QLfr2-7A		wmc0283–BS00010307	81.23–102.67	KUKRI	6.55	15.97
Chlorophyll 1	*QSpad1-2B*	0.59	BARC0160–GWM0388	116.69–126.03	EXCAL	2.06	12.66
SPAD	*QSpad1-6B*		WPT-2587–WPT-4764	75.45–81.5	KUKRI	2.00	9.98
Chlorophyll 2	*QSpad2-1AL*	0.63	WPT-0128–WPT-1011	0–13.97	KUKRI	0.61	1.96
SPAD	*QSpad2-1B*		WPT-3753–WPT-7129	19.85–20.85	KUKRI	1.32	4.12
	QSpad2-2B		WPT-6199–WPT-0709	84.82–101.78	EXCAL	3.57	15.80
	QSpad2-3A		stm0018tgag–WPT-9215	78.3–80.05	KUKRI	2.20	5.89
Crown rot 1	*QCR-1AL*	0.74	WPT-6005–WPT-2855	19.58–25.66	EXCAL	0.77	1.11
	QCR-2A		stm0761tcac–gdm0093	117.9–164.74	KUKRI	2.23	4.83
	QCR-2B		WPT-3459–WPT-2106	5.88–8.81	KUKRI	9.98	14.08
	QCR-2D		WPT-2644–WPT-4413	30.23–48.92	EXCAL	1.71	2.89
	QCR-3B		BARC0077–WPT-0021	215.74–219.61	KUKRI	1.59	2.15

	QCR-5B		WPT-3200–WPT-1457	69.25–70.32	EXCAL	6.05	7.64
	QCR-6A		stm0570tctga–WPT-8256	5.96–13.19	EXCAL	1.53	2.15
	QCR-6B		WPT-6653–WPT-4930	31.01–32.28	EXCAL	4.12	5.70
	QCR-7A.1		gwm0060–wmc0283	80.16–81.23	KUKRI	5.43	7.34
	QCR-7A.2		gdm0125–WPT-0790	246.89–248.7	EXCAL	2.79	3.82
Days to senescence	*QDs-2B*	0.93	WPT-6199–WPT-0709	84.82–101.78	KUKRI	4.59	8.50
	QDs-4A		WMC0258–wmc0603	75.22–87.57	EXCAL	2.92	3.85
	QDs-7A		wmc0283–BS00010307	81.23–102.67	KUKRI	24.13	40.51
Flag leaf length	*QFlth-4B*	0.76	WPT-7062–WPT-8756	33.08–62.15	EXCAL	1.74	6.10
	QFlth-5A		wmc0075b–Vrn1A	130.48–132.14	KUKRI	7.83	15.41
	QFlth-5B		WPT-9666–WPT-5914	51.97–59.54	EXCAL	1.4	3.30
	QFlth-7A		wmc0283–BS00010307	81.23–102.67	EXCAL	5.14	14.39
Head length	*QHlth-2B*	0.86	gwm0120–WPT-2430	134.18–136.07	KUKRI	1.71	3.74
	QHlth-2D		WPT-8524–WPT-1991	101.03–104.7	EXCAL	1.86	3.65
	QHlth-4A		wmc0603–WPT-2542	87.57–89.25	EXCAL	6.94	13.24
	QHlth-6A		WPT-9132–CFD0001C	24.78–27.18	KUKRI	3.03	6.12
	QHlth-6D		CFD0019C–GWM0325	85.81–87.43	KUKRI	2.95	5.62
Peduncle length	*QPlth-2B*	0.89	wmc0476–barc1027	109.63–110.23	EXCAL	2.68	4.11
	QPlth-2D		WPT-8319–WPT-3757	95.27–96.11	KUKRI	1.45	1.87
	QPlth-3A		WPT-4407–GWM0156A	46.74–77.2	KUKRI	3.67	6.20
	QPlth-4A.1		WPT-7001–stm0506tgag	13.14–14.76	KUKRI	1.36	1.72
	QPlth-4A.2		WPT-2794–WPT-0610	132.71–138.75	KUKRI	3.02	5.16
	QPlth-5A		Vrn1A–WPT-9834	132.14–143.98	KUKRI	13.04	18.61
	QPlth-6D.1		WPT-1695–stm0570tctgb	5.49–7.78	EXCAL	1.51	1.71
	QPlth-6D.1		GWM0325–CFD0287	87.43–91.22	KUKRI	0.89	1.14
	QPlth-7A		gwm0060–wmc0283	80.16–81.23	EXCAL	12.81	17.65
Plant height	*QHt-2D*	0.82	WPT-3728–WPT-8319	57.56–95.27	KUKRI	1.57	4.70
	QHt-4A		WPT-2983–WPT-6440	124.48–126.53	KUKRI	1.93	4.36
	QHt-6B		CFD0013B–BARC0045	60.1–61.42	EXCAL	3.43	7.50
	QHt-6D		CFD0287–barc0293	91.22–94.12	KUKRI	3.08	6.01

Thousand grain weight of 5 plants	*QTgw5p-2A*	0.78	stm0761tcac–gdm0093	117.9–164.74	KUKRI	2.92	7.90
	QTgw5p-4A		WMC0258–wmc0603	75.22–87.57	KUKRI	4.61	8.93
	QTgw5p-7A		wmc0283–BS00010307	81.23–102.67	EXCAL	12.73	30.77
Grain yield (kg/ha)	*QYld-1B*	0.92	WPT-3475–stm0658acag	117.24–135.46	EXCAL	1.31	2.61
	QYld-2B.1		WPT-1663–WPT-0643	0–5.25	EXCAL	3.87	6.37
	QYld-2B.2		WPT-0709–BARC0091	101.78–103.62	EXCAL	4.55	9.76
	QYld-4A		WPT-2794–WPT-0610	132.71–138.75	KUKRI	1.74	3.70
	QYld-5B		WPT-9666–WPT-5914	51.97–59.54	KUKRI	6.10	11.79
	QYld-7A.1		gwm0060–wmc0283	80.16–81.23	EXCAL	5.06	11.90
	QYld-7A.2		WMC0083–STM0511TCTG	119.44–121.07	EXCAL	2.21	5.80
Thousand grain weight	*QTgw-2B*	0.86	WPT-2106–GWM0257	8.81–71.86	EXCAL	2.87	8.52
	QTgw-7A		wmc0283–BS00010307	81.23–102.67	EXCAL	12.88	24.79
Spikes/m^2	*QSpm2-2A*	0.77	stm0761tcac–gdm0093	117.9–164.74	KUKRI	2.89	7.99
	QSpm2-4A		WMC0258–wmc0603	75.22–87.57	KUKRI	4.59	9.04
	QSpm2-7A		wmc0283–BS00010307	81.23–102.67	EXCAL	12.66	31.19
Grains/m^2	*QGm2-2B*	0.84	WPT-2106–GWM0257	8.81–71.86	EXCAL	2.30	10.07
	QGm2-4A		WPT-2983–WPT-6440	124.48–126.53	KUKRI	1.56	4.09
	QGm2-5B		WPT-9666–WPT-5914	51.97–59.54	KUKRI	5.26	13.12
	QGm2-6D		CFD0019C–GWM0325	85.81–87.43	EXCAL	2.16	4.43
	QGm2-7A		gwm0060–wmc0283	80.16–81.23	EXCAL	2.78	6.29
G2.5	*QG25-2B*	0.94	WPT-2106–GWM0257	8.81–71.86	EXCAL	3.47	6.88
	QG25-4A		WMC0258–wmc0603	75.22–87.57	KUKRI	5.09	5.65
	QG25-7A		wmc0283–BS00010307	81.23–102.67	EXCAL	23.87	29.90
G2.2	*QG22-7A*	0.89	wmc0283–BS00010307	81.23–102.67	KUKRI	8.29	26.04
L2.2	*QL22-2B*	0.95	WPT-2106–GWM0257	8.81–71.86	KUKRI	2.32	7.29
	QL22-7A		wmc0283–BS00010307	81.23–102.67	KUKRI	15.05	32.32
Test weight	*QHlwt-1B*	0.89	WPT-9809–WPT-2526	103.86–114.93	EXCAL	2.38	4.56
	QHlwt-2A		gdm0093–WPT-9793	164.74–169.65	KUKRI	3.16	4.93
	QHlwt-2D		WPT-8524–WPT-1991	101.03–104.7	EXCAL	2.24	3.83
	QHlwt-7A		wmc0283–BS00010307	81.23–102.67	EXCAL	12.78	30.05

Harvest index	*QHi-2B.1*	0.71	WPT-0709–BARC0091	101.78–103.62	EXCAL	4.96	11.57
	QHi-2B.2		WPT-8460–WPT-9736	148.33–151.94	KUKRI	2.46	5.38
	QHi-4A		WPT-2794–WPT-0610	132.71–138.75	KUKRI	1.43	2.59
	QHi-5B		WPT-8604–WPT-9666	51.36–51.97	KUKRI	1.97	2.82
	QHi-6D		stm0570tctgb–CFD0019C	7.78–85.81	EXCAL	1.19	3.66
	QHi-7A		gwm0060–wmc0283	80.16–81.23	EXCAL	17.09	24.21