horticulturae

MDPI

Review

Supplementary Materials: Advances in Genetics and Molecular Breeding of Broccoli

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Table S1. Genetic mapping of genes/QTLs in broccoli.

Traits	Genes/QTLs	Chr/linkage goup	Position (Mbp)	Donor	References
Head					
Bracting	BR_C08@23.2; BR_C09@49.5	8; 9	23.2; 49.5	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Head compactness	HC_C06@23.0; HC_C09@48.8	6; 9	23.0; 48.8	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Head diameter	HD_C05@2.9; HD_C07@43.6; HD_C07@46.5	5; 7; 7	2.9; 43.6; 46.5	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Head uniformity	HU_C04@34.2; HU_C09@5.6; HU_C09@48.8	4; 9; 9	34.2; 5.6; 48.8	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Head extension	HE_C06@38.5; HE_C08@28.8; HE_C09@47.7	6; 8; 9	38.5; 28.8; 47.7	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Head shape	HS_C02@41.7 HS_C08@20.6 HS_C09@37.1	2; 8; 9	41.7; 20.6; 37.1	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Overall-heading quality	OQ_C03@57.0 OQ_C04@33.3 OQ_C08@24.0 OQ_C09@49.5	3; 4; 8; 9	57; 33.3; 24; 49.5	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Shape of bud ends	SE_C08@38.0	3	55.7	Early Big (broccoli DH line);	[33]

				TO1000DH3 (Chinese kale)	
"fig" shaped bud ends	SF_C04@50.3	8	38	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Hooked sepals	SH_C01@2.1	4	50.3	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Side profile of unopened flower bud	SS_C01@6.1	1	2.1	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Sepal junction of unopened flower buds	ST_C01@3.2	1	6.1	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Bead size	BS_C01@1.3 BS_C03@36.8 BS_C05@43.0 BS_C06@3.8 BS_C07@9.9	1; 3; 5; 6; 7	1.3; 36.8; 43; 3.8; 9.9	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Bead uniformity	BU_C03@1.7 BU_C04@51.5	3; 4	1.7; 51.5	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Curd quality (Subtropical adaptation)	qCQ-2 qCQ-3 qCQ-6	2; 3; 6	-	BLM25 (broccoli); BLM29 (kale-derived broccoli)	[21]
Head diameter	Whri_HDIA_CO2.1_2002	C2(LG)	-	GDDH33 (broccoli DH line) MarDH34 (broccoli DH line)	[43]
Head weight	Whri_Hwt_CO9.1_2006	C9(LG)	-	GDDH33 (broccoli DH line) MarDH34 (broccoli DH line)	[43]
Top weight	TWT5	LG5	-	Green Magic (broccoli cultivar) Shin-Fa 1208 (broccoli cultivar)	[23]

Head weight	HWT7	LG5	-	Green Magic (broccoli cultivar) Shin-Fa 1208 (broccoli cultivar)	[23]
Head height	HH2	LG2	-	Green Magic (broccoli cultivar) Shin-Fa 1208 (broccoli cultivar)	[23]
Head width	HW2	LG2	-	Green Magic (broccoli cultivar) Shin-Fa 1208 (broccoli cultivar)	[23]
Floret width	FW1	LG1	-	Green Magic (broccoli cultivar) Shin-Fa 1208 (broccoli cultivar)	[23]
Floret height	FH1	LG2	-	Green Magic (broccoli cultivar) Shin-Fa 1208 (broccoli cultivar)	[23]
Head weight	HW-1; HW-2; HW-3; HW-4; HW-5	B; F; E; F; D	-	VI-158 (calabrese broccoli) BNC (brocolette neri)	[42]
Flowering time /vernalization					
Vernalization	BRMS215–F2-R4b; E13M1-02–F4-R3b; FLC1–pW131; BRMS023–F3-R5d; BRMS085–pW240; BRMS008–F3-R4d	2; 6; 2; 8; 9; 3	-	Green Comet (broccoli) Reiho (cabbage)	[33]
Flowering time	Ef2.1	2	2.65–2.88	93219 (broccoli inbred line) 195 (cabbage)	[34]
Flowering time	ec2h2-slg6; wg6fl0-wg7gl0; ec3b2-ec3el0	2; 6; 8	-	OSU Cr-7 (inbred broccoli line) Badger Inbred-16 (cabbage)	[45]
Flowering time	FTO2.1; FTO3.1; FTO5.1; FTO9.1; FTO9.2;	2; 3; 5; 9	-	GDDH33 (broccoli inbred line) A12DHd (Chinese kale)	[46]

Days to maturity; Days to flowering	DM_C03@6.4; DM_C09@50.0; DF_C03@6.4; DF_C09@50.0	3; 9; 3; 9	6.4; 50.0; 6.4; 50.0	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Days to curd induction (Subtropical adaptation)	qDCI-3; qDCI-4; qDCI-6; qDCI-7	3; 4; 6; 7	-	BLM25 (broccoli); BLM29 (kale-derived broccoli)	[21]
Maturity	MAT-1; MAT-2; MAT-3; MAT-4	A; E; J; D	-	VI-158 (calabrese broccoli) BNC (brocolette neri)	[42]
Hollow Stem					
Hollow Stem	QHS.C02-1; QHS.C02-2; QHS.C02-3; QHS.C03-1; QHS.C03-2; QHS.C05; QHS.C06; QHS.C09-1; QHS.C09-2	2; 2; ; 3; 3; 5; 6; 9; 9	1.48–1.72; 1.77–2.35; 51.36–51.92; 9.26–10.01; 13.16–16.00; 40.94–40.99; 23.91–24.51; 49.98–50.16; 49.98	DH16-2 (broccoli DH line); DH28-4 (broccoli DH line)	[55]
Plant arcitercture					
Lateral shoot growth	LT_C03@5.9; LT_C04@15.0; LT_C09@9.0	3; 4; 9	5.1; 10.8; 7.4	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Leaf apex	LA_C01@3.4; LA_C03@0.7; LA_C06@18.7; LA_C07@37.0; LA_C09@49.5	1; 3; 6; 7; 9	3.4; 0.7; 18.7; 37; 49.5	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Leaf margin	LM_C03@0.7; LM_C03@53.5; LM_C07@39.5	3; 3; 7	0.7; 53.5; 39.5	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Stem width	SW2	LG5	-	Green Magic (broccoli cultivar) Shin-Fa 1208 (broccoli cultivar)	[23]
Stalk diameter	Whri_STKDIA_CO3.1_2007	C3(LG)	-	GDDH33 (broccoli DH line)	[43]

				MarDH34 (broccoli DH line)	
Lamina petiole length	Whri_LPL_CO3.1	C3(LG)	-	GDDH33 (broccoli DH line) MarDH34 (broccoli DH line)	[43]
Leaf shape	whri_LS_CO3.1_2007	C3(LG)	-	GDDH33 (broccoli DH line) MarDH34 (broccoli DH line)	[43]
Lobe number	Whri_LN_CO3.1	C3(LG)	-	GDDH33 (broccoli DH line) MarDH34 (broccoli DH line)	[43]
Wing number	Whri_WN_CO3.1	C3(LG)	-	GDDH33 (broccoli DH line) MarDH34 (broccoli DH line)	[43]
Leaf apex shape	whri_LAS_CO6.1_2007	C6(LG)	-	GDDH33 (broccoli DH line) MarDH34 (broccoli DH line)	[43]
Wing petiole length	whri_WPL_CO7.1_2007	C7(LG)	-	GDDH33 (broccoli DH line) MarDH34 (broccoli DH line)	[43]
Leaf length	whri_LL_CO7.1_2007	C7(LG)	-	GDDH33 (broccoli DH line) MarDH34 (broccoli DH line)	[43]
Plant height	phc1; phc2; phc4−2; phc4−3	C01; C02; C04;	-	86101 (broccoli inbred line) 90196 (broccoli inbred line)	[52]
Maximum outer petiole length	plc6−2	C06	-	86101 (broccoli inbred line) 90196 (broccoli inbred line)	[52]
Leaf width	lwc1; lwc3−1	C01; C03	-	86101 (broccoli inbred line)	[52]

				90196 (broccoli inbred line)	
Head color					
Purple sepal trait	qPH.C01–2; qPH.C01–4; qPH.C01–5	LG1; LG1; LG1	-	DH16–2 (broccoli DH line) DH28–4 (broccoli DH line)	[58]
Green	BoMYB2 (not activated)	C06	31.9	Broccoli-1	[57]
Abiotic stress					
Head quality under high temperature	QHT_C09; QHT_C05; QHT_C07; QHT_C03; QHT_C02; Q3 × Q5[e]	9; 5; 7; 3; 2; 3 × 5	-	USVL138 (broccoli inbred line); USVL108 (broccoli inbred line)	[15]
Head quality under high temperature	QHT_C06; QHT_C09.2;	C06; C09	2.03-2.51; 2.1-2.97	USVL118 (broccoli inbred line) USVL123 (broccoli inbred line)	[15]
Cuticular waxes (multiple resisitcance)	Bo3g001070; Bo3g008780; Bo3g122030 (candidates)	C03	0.04; 2.88; 43.12	USVL115-NG; USVL115-GL; USVL188-NG; USVL188-GL	[15]
Cuticular waxes (multiple resisitcance)	LC_C09@15.1	9	15.1	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[33]
Diseases resistance					
Downy mildew	Dm resistcance	-	-	USVL809 (broccoli DH line) USVL047 (broccoli DH line)	[82]
Downy mildew	Pp523	8	49.29-50.68	GK97362 (rapid-cycling Brassica oleracea DH line) S4 line of OL87125 (broccoli)	[79]
Clubroot (isolate: Ms6)	Pb-Bo1; Pb-Bo2; Pb-Bo5a; Pb-Bo5b; Pb-Bo9b	1;2;5;5;9	-	C10 (French kale landrace) HDEM (DH broccoli)	[95]

Clubroot (isolate: K92)	Pb-Bo1; Pb-Bo2; Pb-Bo8	1; 2; 8	-	C10 (French kale landrace) HDEM (DH broccoli)	[95]
Clubroot (isolate: Pb137-522)	Pb-Bo1; Pb-Bo3	1; 3	-	C10 (French kale landrace) HDEM (DH broccoli)	[95]
Clubroot (isolate: K92-16)	Pb-Bo1; Pb-Bo4; Pb-Bo5a	1; 4; 5	-	C10 (French kale landrace) HDEM (DH broccoli)	[95]
Clubroot (isolate: eH)	Pb-Bo1; Pb-Bo2; Pb-Bo5a; Pb-Bo5b; Pb-Bo9a	1; 2; 5; 5; 9	-	C10 (French kale landrace) HDEM (DH broccoli)	[95]
Clubroot	PbBo(Anju)1; PbBo(Anju)2; PbBo(Anju)3; PbBo(Anju)4; PbBo(GC)1	2; 2; 3; 7; 5	-	Anju (cabbage cultivar) Green Comet (broccoli cultivar)	[96]
Black rot	XccBo(Reiho)1; XccBo(Reiho)2; XccBo(GC)1;	C5; C8; C9	-	GC P09 (DH broccoli) Reiho P01 (DH cabbage)	[104,105]
Black rot	wg2gll-vg6g5; ec5e 12-ec2h2; wg6hl-tg4d2b; wg8a9b-wg4d7	1; 2; 2; 9	-	BI-16 (cabbage line) OSU Cr-7 (broccoli line)	[38]
Black rot	Xcc1.1; Xcc6.1; Xcc8.1; Xcc9.1	1; 6; 8; 9	-	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[107]
Secondary metabolites					
Glucosinolates	2.1; 2.2; 3.1; 3.2; 3.3; 3.4; 4.1; 4.2; 5.1; 5.2; 6.1; 7.1; 7.2; 7.3; 7.4; 8.1; 9.1; 9.2	-	-	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[115]
Glucosinolates	Gsl-01; Gsl-02; Gsl-03; Gsl-04; Gsl-05; Gsl-06; Gsl-07; Gsl-08; Gsl-09; Gsl-10; Gsl-11; Gsl-12; Gsl-13; Gsl-14	2; 2; 2; 3; 4; 4; 4; 5; 6; 7; 7; 9; 9; 9	-	VI-158 (DH line) BNC (brocolette neri-type broccoli)	[116]

Glucosinolates	qSF-C2; qSF-C3-0; qSF-C3-1; qSF-C3-2; qSF-C3-3; qSF-C3-4; qSF-C3-5; qSF-C3-6; qSF-C5-1; qSF-C5-2; qSF-C7;	2; 3; 3; 3; 3; 3; 3; 3; 5; 5; 7	-	86101 (broccoli inbred line) 90196 (broccoli inbred line)	[117]
Carotenoids	bocarot1; bocarot2; bocarot3	C2; C6; C6	13.1–21.7; 12.7–16.3; 45–46	VI-158 (DH line) BNC (brocolette neri-type broccoli)	[118]
Phenolic	no. 1 to no. 60	C1-C9	-	VI-158 (DH line) BNC (brocolette neri-type broccoli)	[119]
Phenolic	1.1 to 9.5	1-9	-	Early Big (broccoli DH line); TO1000DH3 (Chinese kale)	[120]