

Supplemental Table S3. Known genes in the vicinity of significant SNP, di-SNP, and haplotype variants for AC and PC traits in rice.

No.	Traits	Chr	Position (bp)	P-Value	Comparative Genomics Analysis			Methods			
					Known gene ^{Ref.}	Position (bp)	Function	SNP	di-SNP	Haplotype	Rainbowr
1	AC	6	1765761	5.59E-24	Wx1 ^[1] ; OsACS6 ^[2]	1765622-1770653; 1629778-1633507	controls amylose content in rice endosperm and regulates starch grain size, influencing grain texture, cooking properties, and industrial starch applications	√			
2	AC	6	1788706-1788806	3.27E-07					√		
3	AC	6	1788806-1789622	3.32E-08						√	
4	AC	6	1788806-1789622	3.32E-08						√	
5	AC	8	1712296	3.49E-10	OsHT ^[3]	1561754-1566894	regulates amino acid allocation to improve grain yield and nutritional quality	√			
6	AC	8	3266557-3266635	3.38E-07						√	
7	AC	8	3266557-3266635	3.38E-07						√	
8	AC	10	22452009	3.23E-11	OsHUB2 ^[4]	22388699-22395755	negatively regulates flowering time and influences grain length, linking epigenetic modification to yield and quality traits in rice	√			
9	PC	1	9212287-9212288	2.01E-07					√		
10	PC	1	9212288-9212304	2.01E-07					√		
11	PC	1	21782657-21783114	2.04E-07						√	
12	PC	1	21782657-21783114	2.04E-07						√	
13	PC	1	21783114-21784878	2.04E-07						√	
14	PC	1	21783114-21784878	2.04E-07						√	
15	PC	1	22609011-22609042	3.42E-07					√		
16	PC	1	22637192-22637521	3.81E-07					√		
17	PC	1	22637694-22637719	2.35E-07					√		
18	PC	1	22639407-22639410	3.81E-07					√		
19	PC	1	22639410-22639475	3.81E-07					√		
20	PC	1	22656453-22656571	3.41E-07					√		
21	PC	1	22663389-22663442	3.78E-07					√		
22	PC	1	22663442-22663533	3.78E-07					√		
23	PC	1	22672083-22672100	1.62E-07					√		
24	PC	1	22746387-22747142	2.80E-07					√		
25	PC	1	22930182-22930194	4.51E-08					√		
26	PC	1	22930194-22930207	1.17E-07					√		
27	PC	1	22930366-22930382	1.04E-07					√		
28	PC	1	22930382-22930405	5.04E-08					√		
29	PC	1	22930382-22930414	1.89E-07						√	

30	PC	1	22932519-22932556	7.72E-08					√		
31	PC	1	22932556-22932839	4.51E-08					√		
32	PC	1	22936728-22936739	1.29E-07					√		
33	PC	1	22936739-22936921	7.72E-08					√		
34	PC	1	22937514-22938144	3.22E-07						√	
35	PC	1	22937984-22938144	7.72E-08					√		
36	PC	1	22938144-22938330	2.95E-09					√		
37	PC	1	22938330-22938351	6.48E-08					√		
38	PC	1	22942348-22942449	2.72E-07					√		
39	PC	1	22943709-22943718	1.77E-07					√		
40	PC	1	22943718-22943746	1.77E-07					√		
41	PC	1	22943746-22943842	1.77E-07					√		
42	PC	1	22943842-22943877	1.32E-07					√		
43	PC	1	22943877-22943881	1.32E-07					√		
44	PC	1	22943881-22943924	1.77E-07					√		
45	PC	1	22946346-22946932	7.72E-08					√		
46	PC	1	22946932-22946993	1.05E-07					√		
47	PC	1	22950329-22950437	1.45E-07					√		
48	PC	1	22950437-22950901	1.87E-07					√		
49	PC	1	22950901-22951321	1.87E-07					√		
50	PC	1	22951321-22951499	1.77E-07					√		
51	PC	2	2022745-2023087	1.57E-07	RGG2 ^[5]	2011707-2015438	increases grain size and influences rice grain morphology and market quality		√		
52	PC	2	2029035-2029037	1.94E-07					√		
53	PC	2	2029037-2029078	1.94E-07					√		
54	PC	2	2029181-2029803	1.94E-07					√		
55	PC	2	2029811-2029836	1.94E-07					√		
56	PC	2	2029987-2029994	1.94E-07					√		
57	PC	2	2029994-2029997	1.94E-07					√		
58	PC	2	2029997-2029999	1.94E-07					√		
59	PC	2	2029999-2030059	1.94E-07					√		
60	PC	2	2030572-2030583	2.14E-07					√		
61	PC	2	2030583-2030595	2.14E-07					√		
62	PC	2	2037679-2038289	1.94E-07					√		
63	PC	2	2038289-2039273	1.94E-07					√		

64	PC	2	2042447-2042539	2.14E-07					√		
65	PC	2	2046302-2046304	1.57E-07					√		
66	PC	2	2053089-2053115	2.49E-07					√		
67	PC	2	2053115-2053124	2.49E-07					√		
68	PC	2	2053515-2053552	2.49E-07					√		
69	PC	2	2053552-2053688	2.49E-07					√		
70	PC	2	2053688-2053689	2.49E-07					√		
71	PC	2	2054109-2054907	2.49E-07					√		
72	PC	2	2060558-2060824	1.44E-07					√		
73	PC	2	2076916-2077711	1.44E-07					√		
74	PC	2	2077711-2078153	1.44E-07					√		
75	PC	2	2361665-2361678	2.42E-08					√		
76	PC	2	8287130-8287139	1.98E-08	GW2 ^[6]	8115223-8121651	controls grain size and influences grain quality by altering endosperm structure		√		
77	PC	2	8287130-8287144	1.98E-08						√	
78	PC	2	11411320-11414097	1.01E-07						√	
79	PC	2	17250846-17251011	5.35E-08					√		
80	PC	2	17251011-17251585	3.35E-07					√		
81	PC	3	16736102	2.30E-09	GS3 ^[7]	16729501-16735109	negatively regulates grain length by controlling cell elongation in rice grains	√			
82	PC	3	33137092-33137378	1.16E-07					√		
83	PC	4	1598955-1598975	9.71E-08					√		
84	PC	5	7859350-7859985	1.02E-07						√	
85	PC	5	7859390-7859985	1.02E-07					√		
86	PC	5	7859985-7861008	1.02E-07					√		
87	PC	5	7859985-7861152	1.02E-07						√	
88	PC	5	7872038-7873000	1.00E-07						√	
89	PC	5	7872067-7873000	4.86E-08						√	
90	PC	5	7872067-7873000	4.86E-08						√	
91	PC	5	16811944-16812030	5.47E-08					√		
92	PC	5	16811944-16812055	2.83E-08						√	
93	PC	5	27358335-27358829	1.65E-07						√	
94	PC	6	1118153-1118252	1.33E-07						√	
95	PC	6	3424081-3424082	1.59E-07					√		
96	PC	6	4044521-4044549	2.82E-08					√		

97	PC	6	4044549-4044708	2.82E-08					√		
98	PC	6	4671391-4671753	4.62E-08						√	
99	PC	6	4671391-4671753	4.62E-08						√	
100	PC	6	5170578-5170845	5.53E-08					√		
101	PC	6	5170875-5170967	2.61E-07					√		
102	PC	6	5243571-5243611	1.06E-07					√		
103	PC	6	5243611-5244290	1.06E-07					√		
104	PC	6	5274883-5274886	1.06E-07					√		
105	PC	6	5316596-5316690	1.73E-07					√		
106	PC	6	5316749-5317423	1.06E-07					√		
107	PC	6	13903956-13904097	1.26E-07					√		
108	PC	6	13904097-13904333	8.01E-09						√	
109	PC	6	15526446-15526690	3.50E-08						√	
110	PC	6	15526690-15527143	9.64E-08					√		
111	PC	6	15754930-15755197	3.92E-08					√		
112	PC	6	15754930-15755290	1.13E-07						√	
113	PC	6	16614377-16614428	7.15E-08					√		
114	PC	6	16614428-16614527	3.48E-07					√		
115	PC	6	16647564-16647888	4.72E-08					√		
116	PC	6	16647564-16647890	4.72E-08						√	
117	PC	6	17453022-17453085	1.11E-07					√		
118	PC	6	17453085-17453088	1.11E-07					√		
119	PC	6	23600233-23600288	1.37E-07					√		
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126	PC	8	18535447-18535544	1.82E-07					√		
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133	PC	10	3992952-3993021	1.89E-07					√		
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135	PC	10	7462029-7462092	4.33E-08					√		
136	PC	10	7525328-7525368	4.33E-08					√		
137	PC	10	7525368-7525570	4.33E-08					√		
138	PC	10	8291011-8291471	3.95E-08					√		
139	PC	10	8291471-8292528	3.95E-08					√		
140	PC	10	9313773-9313820	1.52E-07					√		
141	PC	10	9313820-9313845	1.52E-07					√		
142	PC	10	10351636-10351706	4.22E-08					√		
143	PC	10	10351706-10351815	4.22E-08					√		
144	PC	10	12364113-12364433	2.54E-07						√	
145	PC	10	12364397-12364433	7.97E-08					√		
146	PC	10	22224272-22224663	1.35E-08						√	
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148	PC	10	22224663-22225008	5.44E-09						√	
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152	PC	10	22224862-22225938	1.21E-09						√	
153	PC	11	9209605-9209636	1.36E-07					√		
154	PC	11	9209693-9209811	1.29E-07					√		
155	PC	11	21802635-21802642	1.18E-07					√		
156	PC	12	365398-365399	1.12E-07					√		
157	PC	12	6159831-6159844	8.38E-09						√	
158	PC	12	6182393-6182590	1.03E-07					√		
159	PC	12	11463755-11463772	2.73E-09						√	
160	PC	12	11463759-11463772	2.73E-09					√		
161	PC	12	11463772-11463795	3.76E-09					√		
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168	PC	12	21322420-21323239	2.07E-08						√	
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173	PC	12	21337346-21337450	1.35E-07						√	
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178	PC	12	21338790-21338813	2.67E-08					√		
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184	PC	12	21338922-21339020	1.72E-07						√	
185	PC	12	21339020-21339032	2.67E-08					√		
186	PC	12	21339020-21339304	2.67E-08						√	
187	PC	12	21441392-21443558	8.39E-08						√	
188	PC	12	21449704-21450334	1.21E-07						√	
189	PC	12	21449704-21450418	1.21E-07						√	
190	PC	12	21453492-21456247	8.97E-08						√	
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192	PC	12	21470357-21472868	1.37E-07						√	
193	PC	12	21470359-21472868	1.37E-07						√	
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196	PC	12	21476019-21476078	2.03E-07						√	
197	PC	12	21476032-21476078	1.57E-07						√	
198	PC	12	21476078-21476095	4.01E-08					√		

199	PC	12	21476078-21476311	1.57E-07						√	
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203	PC	12	21501602-21501688	1.32E-08					√		
204	PC	12	21504875-21505080	9.76E-08						√	
205	PC	12	21504986-21505080	5.01E-08						√	
206	PC	12	21504986-21505612	2.24E-07						√	
207	PC	12	21504986-21505680	2.24E-07						√	
208	PC	12	21513261-21513306	6.97E-08						√	
209	PC	12	21513303-21513306	6.97E-08					√		
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211	PC	12	21513306-21513322	3.70E-07						√	
212	PC	12	21514604-21514651	1.83E-07						√	
213	PC	12	21514619-21514692	7.23E-08						√	
214	PC	12	21514651-21514710	4.30E-08						√	
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216	PC	12	21514651-21515665	1.83E-07						√	
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219	PC	12	21605226-21605285	3.95E-07						√	
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222	PC	12	21631208-21631349	1.87E-08						√	
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226	PC	12	21652172-21653247	1.06E-08						√	
227	PC	12	22437344-22437452	1.76E-07						√	
228	PC	12	22437452-22437788	3.39E-07					√		

Ref.: denoted as reference

References:

[1]. Sano, Y. (1984). Differential regulation of waxy gene expression in rice endosperm. Theoretical and Applied Genetics, 68(5), 467–473. <https://doi.org/10.1007/BF00265108>

- [2]. Matsushima, R., Maekawa, M., Kusano, M., Tomita, K., Kondo, H., Nishimura, H., ... & Sakamoto, W. (2016). Amyloplast membrane protein SUBSTANDARD STARCH GRAIN6 controls starch grain size in rice endosperm. *Plant physiology*, 170(3), 1445-1459.
- [3]. Guo, N., Gu, M., Hu, J., Qu, H., & Xu, G. (2020). Rice OsLHT1 functions in leaf-to-panicle nitrogen allocation for grain yield and quality. *Frontiers in Plant Science*, 11, 1150.
- [4]. Du, Y., He, W., Deng, C., Chen, X., Gou, L., Zhu, F., ... & Wang, T. (2016). Flowering-related RING protein 1 (FRRP1) regulates flowering time and yield potential by affecting histone H2B monoubiquitination in rice (*Oryza sativa*). *PloS one*, 11(3), e0150458.
- [5]. Miao, J., Yang, Z., Zhang, D., Wang, Y., Xu, M., Zhou, L., ... & Zhou, Y. (2019). Mutation of RGG 2, which encodes a type B heterotrimeric G protein γ subunit, increases grain size and yield production in rice. *Plant Biotechnology Journal*, 17(3), 650-664.
- [6]. Song, X. J., Huang, W., Shi, M., Zhu, M. Z., & Lin, H. X. (2007). A QTL for rice grain width and weight encodes a previously unknown RING-type E3 ubiquitin ligase. *Nature Genetics*, 39(5), 623–630.
- [7]. Fan, C., Xing, Y., Mao, H., Lu, T., Han, B., Xu, C., ... & Zhang, Q. (2006). GS3, a major QTL for grain length and weight and minor QTL for grain width and thickness in rice, encodes a putative transmembrane protein. *Theoretical and applied genetics*, 112(6), 1164-1171.