

Table S1: SNP associated with different traits under heat stress at Terbol summer (TRS) and Hudeiba (HD) in 2016 and 2017 seasons using ST-GWAS model.

Environment	Trait	SNP markers	allele1	allele0	MAF	Effect	P
HD16	CT	SCONTIG105792_41	G	A	0.072	1.0599	4.95E-05
HD16	CT	SCONTIG122844_17	T	G	0.173	0.6519	5.08E-05
HD16	NPP	SCONTIG123643_47	G	A	0.051	4.2376	3.86E-05
HD16	NPP	SCONTIG126455_55	T	A	0.062	4.1744	2.65E-05
HD16	NSP	SCONTIG60075_82	A	G	0.133	2.6462	3.47E-06
HD16	NPP	SCONTIG6459_80	G	A	0.1	3.1035	8.96E-05
HD16	NPP	SNODE_159317_LENGTH_67_COV_1.000000_37	C	T	0.058	4.1477	3.09E-05
HD16	HSW	SNODE_184186_LENGTH_64_COV_1.000000_20	C	T	0.077	-19.3398	5.32E-05
HD16	PLHT	SNODE_200348_LENGTH_62_COV_1.000000_39	G	A	0.267	6.3692	7.95E-05
HD16	NPP	SNODE_39759_LENGTH_70_COV_36.099998_71	G	A	0.064	4.3175	4.3E-06
HD16	CT	SNODE_4933_LENGTH_72_COV_609.527771_51	C	T	0.067	1.1366	9.31E-05
HD16	GYP	SNODE_5492_LENGTH_64_COV_104.593750_68	G	C	0.379	1.0342	1.22E-05
HD16	NSP	SNODE_5492_LENGTH_64_COV_104.593750_68	G	C	0.379	1.8528	3.03E-05
HD16	GYP	SNODE_69629_LENGTH_63_COV_1.000000_58	T	C	0.082	2.0633	7.04E-05
HD16	GYP	SNODE_99859_LENGTH_65_COV_1.323077_30	C	T	0.052	2.9638	3.61E-06
HD16	NSP	SNODE_99859_LENGTH_65_COV_1.323077_30	C	T	0.052	5.9436	2.86E-07
HD17	CT	SCONTIG50196_81	C	T	0.052	2.0946	4.18E-07
HD17	GYP	SCONTIG60075_82	A	G	0.124	1.4752	2.4E-05
HD17	NPP	SCONTIG60075_82	A	G	0.124	1.9856	6.8E-07
HD17	NSP	SCONTIG60075_82	A	G	0.124	3.3729	5.38E-06
HD17	GYP	SCONTIG92564_52	G	A	0.054	2.0239	7.2E-05
HD17	GYP	SNODE_13817_LENGTH_63_COV_1.000000_33	T	C	0.054	2.1021	3.7E-05
HD17	DFLR	SNODE_17179_LENGTH_73_COV_15.890411_64	T	G	0.179	-7.9678	4.12E-05
HD17	PLHT	SNODE_2063_LENGTH_105_COV_111.161903_87	C	T	0.362	3.2649	4.19E-05
HD17	GYP	SNODE_39949_LENGTH_82_COV_1.024390_37	C	T	0.058	2.1881	5.98E-06

HD17	NPP	SNODE_39949_LENGTH_82_COV_1.024390_37	C	T	0.058	3.1317	4.19E-06
HD17	NSP	SNODE_39949_LENGTH_82_COV_1.024390_37	C	T	0.058	5.2417	8.49E-06
HD17	DMAT	SNODE_57563_LENGTH_70_COV_5.028572_61	G	A	0.475	-3.1061	8.71E-05
TRS15	NSP	SCONTIG53986_42	C	G	0.492	-2.8965	5.02E-05
TRS15	NPP	SNODE_2216_LENGTH_63_COV_217.412704_63	C	T	0.1	6.6171	1.01E-05
TRS15	DFLR	SNODE_23772_LENGTH_65_COV_30.646154_35	G	A	0.257	5.7132	7.14E-05
TRS15	PG	SNODE_318853_LENGTH_65_COV_1.000000_65	T	A	0.105	8.6315	9.08E-06
TRS15	DFLR	SNODE_3526_LENGTH_71_COV_388.971832_48	A	G	0.07	12.7562	8.04E-05
TRS15	DFLR	SNODE_5863_LENGTH_65_COV_182.246155_71	C	T	0.129	7.9335	3.63E-05
TRS15	PG	SNODE_7398_LENGTH_62_COV_214.516129_82	G	A	0.163	6.9211	6.74E-08
TRS15	HSW	SNODE_9908_LENGTH_67_COV_43.895523_45	A	G	0.144	25.9606	3.27E-08
TRS16	NPP	SCONTIG106632_72	A	G	0.065	1.8813	6.46E-05
TRS16	NPP	SCONTIG13629_151	A	G	0.186	0.9967	2.28E-05
TRS16	NSP	SCONTIG13629_151	A	G	0.188	1.6444	8.49E-05
TRS16	NSP	SCONTIG2213_126	C	T	0.075	3.3558	3.77E-05
TRS16	NSP	SCONTIG33532_14	T	C	0.184	2.1164	6.58E-05
TRS16	NSP	SCONTIG79823_85	A	G	0.062	3.6194	1.92E-05
TRS16	GYP	SCONTIG82855_50	A	G	0.092	1.9054	1.47E-05
TRS16	NPP	SNODE_11911_LENGTH_60_COV_2.083333_21	G	A	0.065	1.9491	2.9E-05
TRS16	NPP	SNODE_14795_LENGTH_67_COV_68.791046_60	T	C	0.115	1.2877	2.43E-06
TRS16	NSP	SNODE_14795_LENGTH_67_COV_68.791046_60	T	C	0.116	2.3434	1.12E-06
TRS16	PG	SNODE_23446_LENGTH_112_COV_17.633928_126	G	A	0.455	5.6823	4.5E-05
TRS16	NSP	SNODE_344_LENGTH_74_COV_134.351349_70	A	G	0.054	3.4896	9.4E-05
TRS16	PG	SNODE_40068_LENGTH_63_COV_13.873015_43	A	G	0.383	4.0078	5.22E-05
TRS16	DMAT	SNODE_49877_LENGTH_67_COV_2.925373_66	C	T	0.095	4.6696	6.66E-06
TRS16	PG	SNODE_6662_LENGTH_69_COV_474.000000_31	T	C	0.156	5.3462	8.73E-05
TRS16	NPP	SNODE_6820_LENGTH_63_COV_471.317474_68	T	A	0.052	2.2451	6.96E-05
TRS16	NSP	SNODE_6820_LENGTH_63_COV_471.317474_68	T	A	0.053	4.0527	4.6E-05
TRS16	DFLR	SNODE_7114_LENGTH_70_COV_20.785715_58	C	T	0.11	7.2768	7.47E-07

TRS16	NPP	SNODE_7399_LENGTH_66_COV_159.287872_84	C	T	0.106	1.1522	6.4E-05
TRS16	NSP	SNODE_7399_LENGTH_66_COV_159.287872_84	C	T	0.107	2.2333	1.01E-05
TRS16	PG	SNODE_7979_LENGTH_116_COV_512.344849_106	A	G	0.078	10.1607	9.27E-05
TRS17	GYP	SCONTIG10268_58	A	G	0.069	9.2527	5.48E-05
TRS17	GYP	SCONTIG127798_64	G	T	0.063	7.9077	1.69E-05
TRS17	PLHT	SCONTIG30232_88	C	G	0.36	-7.6776	2.26E-05
TRS17	NPP	SCONTIG82391_71	T	G	0.093	15.522	4.71E-05
TRS17	NSP	SCONTIG82391_71	T	G	0.093	27.0305	2.14E-06
TRS17	GYP	SNODE_1409_LENGTH_91_COV_549.780212_63	G	T	0.076	7.9499	4.02E-06
TRS17	GYP	SNODE_2216_LENGTH_63_COV_217.412704_63	C	T	0.1	9.2485	5.88E-06
TRS17	PG	SNODE_38942_LENGTH_69_COV_118.768112_43	A	G	0.076	7.7743	7.95E-05
TRS17	PLHT	SNODE_41542_LENGTH_59_COV_3.338983_65	C	G	0.35	-7.899	5.15E-06
TRS17	GYP	SNODE_59818_LENGTH_86_COV_1.104651_64	G	T	0.089	6.6134	3.31E-05
TRS17	PLHT	SNODE_936_LENGTH_67_COV_546.776123_65	C	G	0.283	-7.5774	2.51E-05

HD16: Hudeiba 2015/2016; HD17: Hudeiba 2015/2016; TRS15: Terbol summer planting 2015; TRS16: Terbol Summer planting 2016; TRS17: Terbol summer planting 2017

Table S2: Multi-trait genome-wide association study (MT-GWAS) results for grain yield and yield components. Underlined p-values are the significant p-values while underlined SNPs are the SNPs that were detected in multiple traits. AF: allele frequency of allele1

Trait	QTLID	SNP	allele1	allele0	AF	P
NPP	NPP_1	<u>SCONTIG124089_41</u>	T	G	0.05	3.10E-05
	NPP_2	SCONTIG42136_36	C	T	0.2	3.90E-05
	NPP_3	SCONTIG57861_63	G	A	0.12	3.40E-05
	NPP_4	<u>SCONTIG60075_82</u>	A	G	0.15	4.60E-05
	NPP_5	SCONTIG97070_42	T	C	0.06	3.20E-05
	NPP_6	SNODE_19219_LENGTH_71_COV_2.605634_17	G	A	0.08	2.00E-05
	NPP_7	<u>SNODE_39949_LENGTH_82_COV_1.024390_37</u>	C	T	0.06	4.80E-05

	NPP_8	<u>SNODE_40333_LENGTH_77_COV_34.987015_87</u>	T	A	0.18	<u>3.70E-06</u>
	NPP_9	<u>SNODE_559376_LENGTH_95_COV_1.252632_60</u>	A	T	0.45	<u>6.20E-12</u>
	NPP_10	SNODE_5667_LENGTH_63_COV_224.857147_29	G	A	0.06	8.30E-05
NSP	NSP_1	SCONTIG10268_47	C	A	0.06	4.40E-05
	NSP_2	<u>SCONTIG124089_41</u>	T	G	0.05	2.60E-05
	NSP_3	<u>SCONTIG60075_82</u>	A	G	0.14	4.40E-05
	NSP_4	<u>SCONTIG82391_71</u>	T	G	0.09	<u>3.50E-06</u>
	NSP_4	<u>SCONTIG82391_72</u>	C	T	0.09	<u>3.50E-06</u>
	NSP_4	<u>SCONTIG82391_73</u>	A	T	0.09	<u>3.50E-06</u>
	NSP_5	<u>SNODE_11884_LENGTH_82_COV_596.182922_61</u>	A	G	0.09	<u>1.00E-07</u>
	NSP_6	SNODE_159732_LENGTH_67_COV_1.000000_17	A	G	0.48	4.40E-05
	NSP_7	SNODE_18243_LENGTH_66_COV_1.000000_69	G	A	0.44	9.50E-06
	NSP_8	<u>SNODE_39949_LENGTH_82_COV_1.024390_37</u>	C	T	0.06	4.50E-05
	NSP_9	SNODE_47942_LENGTH_114_COV_3.815789_60	A	G	0.08	8.90E-05
HSW	HSW_1	SCONTIG124448_54	A	C	0.1	4.30E-05
	HSW_2	SCONTIG16540_60	C	T	0.08	3.50E-05
	HSW_3	SNODE_12987_LENGTH_81_COV_566.222229_77	A	C	0.15	1.60E-05
	HSW_4	SNODE_18703_LENGTH_72_COV_258.527771_54	T	C	0.49	4.20E-05
	HSW_5	SNODE_8714_LENGTH_71_COV_9.901408_38	A	G	0.38	2.40E-05
	HSW_6	<u>SNODE_9908_LENGTH_67_COV_43.895523_45</u>	A	G	0.17	<u>7.10E-07</u>
	HSW_7	SNODE_99859_LENGTH_65_COV_1.323077_16	C	T	0.07	5.00E-05
GYP)	GYP_1	SCONTIG2213_126	C	T	0.07	4.80E-05
	GYP_2	<u>SCONTIG60075_82</u>	A	G	0.13	1.60E-05
	GYP_3	<u>SCONTIG72702_49</u>	A	G	0.5	<u>2.30E-06</u>
	GYP_4	SNODE_14795_LENGTH_67_COV_68.791046_60	T	C	0.08	4.70E-05

	GYP_5	<u>SNODE_39949_LENGTH_82_COV_1.024390_37</u>	C	T	0.05	4.80E-05
	GYP_6	<u>SNODE_40333_LENGTH_77_COV_34.987015_87</u>	T	A	0.17	8.60E-06
	GYP_7	<u>SNODE_5492_LENGTH_64_COV_104.593750_68</u>	G	C	0.38	3.30E-05
DFLR	DFLR_1	<u>SNODE_300878_LENGTH_65_COV_1.000000_26</u>	G	A	0.07	3.00E-05
	DFLR_2	<u>SNODE_4853_LENGTH_74_COV_297.162170_75</u>	C	T	0.12	7.80E-05
DMAT	DMAT_1	<u>SNODE_10083_LENGTH_100_COV_16.170000_92</u>	T	C	0.11	1.60E-05
PLHT	PLHT_1	<u>SNODE_126238_LENGTH_69_COV_1.000000_21</u>	T	C	0.51	9.90E-06
	PLHT_1	<u>SNODE_126238_LENGTH_69_COV_1.000000_60</u>	C	T	0.51	9.90E-06
	PLHT_2	<u>SNODE_144193_LENGTH_65_COV_1.000000_69</u>	C	A	0.46	4.10E-05
	PLHT_3	<u>SNODE_150825_LENGTH_64_COV_1.000000_31</u>	C	A	0.06	8.40E-06
	PLHT_3	<u>SNODE_150825_LENGTH_64_COV_1.000000_42</u>	A	C	0.06	8.40E-06
	PLHT_3	<u>SNODE_150825_LENGTH_64_COV_1.000000_64</u>	C	T	0.06	8.40E-06
	PLHT_4	<u>SNODE_88919_LENGTH_65_COV_1.000000_26</u>	A	G	0.14	6.00E-06
CL (%)	CHLC_1	<u>SNODE_11261_LENGTH_62_COV_1.048387_42</u>	C	T	0.32	8.10E-05
CT	CT_1	<u>SCONTIG122844_17</u>	T	G	0.17	9.70E-05
	CT_2	<u>SCONTIG50196_81</u>	C	T	0.06	<u>6.00E-07</u>
PG (%)	PG_1	<u>SCONTIG82855_50</u>	A	G	0.09	<u>1.50E-06</u>
	PG_2	<u>SNODE_318853_LENGTH_65_COV_1.000000_65</u>	T	A	0.11	6.50E-05
	PG_3	<u>SNODE_38942_LENGTH_69_COV_118.768112_43</u>	A	G	0.07	3.10E-05
	PG_4	<u>SNODE_50590_LENGTH_70_COV_3.571429_27</u>	G	C	0.33	5.70E-05
	PG_5	<u>SNODE_6662_LENGTH_69_COV_474.000000_31</u>	T	C	0.16	1.30E-05
	PG_6	<u>SNODE_7398_LENGTH_62_COV_214.516129_66</u>	C	T	0.16	1.30E-05
	PG_6	<u>SNODE_7398_LENGTH_62_COV_214.516129_82</u>	G	A	0.16	<u>3.50E-07</u>
	PG_7	<u>SNODE_7979_LENGTH_116_COV_512.344849_106</u>	A	G	0.08	1.60E-05