

基于全基因组关联分析水稻抗旱相关基因的挖掘

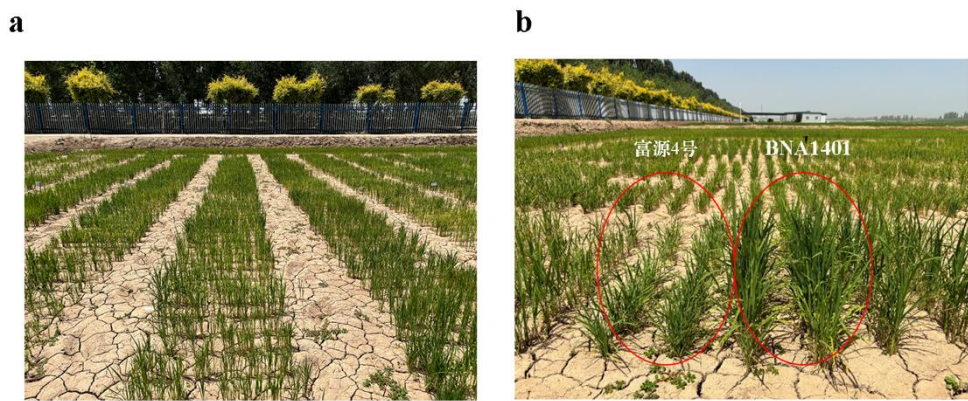
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Mining of Drought-resistance Related Genes in Rice Based on Genome-Wide Association Study

DOI: 10.13560/j.cnki.biotech.bull.1985.2025-1211



(a) 7月6日干旱胁迫下水稻群体整体表型; (b) 耐旱性表现优异的水稻资源BNA1401 (右) 和对照品种富源4号 (左)
(a) Overall phenotype of the rice population under drought stress on July 6; (b) Performance of a drought-tolerant accession, BNA1401 (right), compared with the drought-resistant check variety, Fuyuan 4 (left).

附图 1 大田干旱胁迫下水稻表型展示

Supplementary Fig. 1. Phenotypic performance of rice under field drought stress.

附表 1 定量引物序列

Table S1 Quantitative primer sequence

引物名称	正向引物	反向引物
Primer name	Forward primer (5'-3')	Reverse primer (5'-3')
qpcr-54360	GGTGACTGACGAGGTGAATTAT	TGAGCCAAGTGAAATCCTCTAC
qpcr-54474	ATATCCAACAGCTGGAGACAAG	GTTCTCGAAGGCTCCCATTT
qpcr-54560	CACCTTGGCGAGGAGATT	GTGAACCGATTCCGTTGTTC
qpcr-54570	TCGACGCGGGATACTACTT	TCGAGGATCTCTTCTGTATCG

附表 2 叶枯萎度显著关联的 SNP 信息

Table S2 Significantly associated SNPs for leaf wilting

Marker	Chr	Pos	p	MarkerR2	q
Chr1:15231386	1	15,231,386	9.7367e-06	0.01045	0.200822111
Chr1:15289931	1	15,289,931	1.7001e-06	0.01204	0.200822111
Chr1:16255787	1	16,255,787	4.4397e-06	0.01119	0.139945052
Chr1:19922594	1	19,922,594	6.3334e-06	0.01085	0.093163892
Chr1:27285252	1	27,285,252	8.8311e-06	0.01055	0.114621964
Chr1:27285252	1	27,285,252	6.3334e-06	0.01087	0.349364594
Chr1:33788058	1	33,788,058	7.6095e-06	0.01067	0.200822111
Chr1:6776916	1	6,776,916	4.7842e-06	0.0111	0.230706181
Chr12:17219609	12	17,219,609	1.6142e-06	0.01209	0.220170927
Chr12:18299744	12	18,299,744	5.2279e-06	0.01102	0.230706181
Chr12:18778781	12	18,778,781	9.6271e-06	0.01046	0.265526248
Chr12:25599558	12	25,599,558	7.6798e-06	0.01068	0.105908762
Chr2:13553976	2	13,553,976	8.4787e-06	0.0106	0.187081668
Chr2:24514016	2	24,514,016	6.7596e-06	0.0108	0.165722109
Chr3:21445322	3	21,445,322	4.2317e-06	0.01122	0.071824644
Chr3:21779158	3	21,779,158	5.528e-07	0.01309	0.060987384
Chr3:28502006	3	28,502,006	3.4656e-06	0.01141	0.127446862
Chr3:9327945	3	9,327,945	7.8869e-06	0.01064	0.265526248
Chr4:19298782	4	19,298,782	5.3007e-06	0.01101	0.305252131
Chr4:23013303	4	23,013,303	9.4225e-06	0.01048	0.200822111
Chr4:31991020	4	31,991,020	3.129e-07	0.0136	0.017260268
Chr4:32033623	4	32,033,623	5.753e-06	0.01092	0.200822111
Chr4:32033623	4	32,033,623	8.0508e-08	0.01484	0.008648705
Chr4:32144636	4	32,144,636	1.6585e-06	0.01207	0.036594637
Chr4:32206745	4	32,206,745	2.7314e-06	0.01162	0.05022339
Chr4:32233143	4	32,233,143	5.1916e-07	0.01313	0.021696731
Chr4:32260706	4	32,260,706	5.5895e-06	0.01095	0.200822111
Chr4:32260706	4	32,260,706	1.1759e-07	0.01449	0.008648705
Chr4:32299416	4	32,299,416	9.1621e-07	0.01261	0.022462313
Chr4:32457574	4	32,457,574	9.7488e-06	0.01044	0.200822111
Chr4:32457574	4	32,457,574	3.3491e-08	0.01564	0.007389756
Chr4:32668510	4	32,668,510	8.8672e-07	0.01264	0.022462313
Chr4:32729027	4	32,729,027	1.8594e-06	0.01197	0.037297705
Chr4:32843337	4	32,843,337	6.5439e-07	0.01292	0.021696731
Chr4:32990599	4	32,990,599	6.8832e-07	0.01288	0.021696731
Chr4:4919952	4	4,919,952	9.6747e-06	0.01048	0.426942576
Chr4:7233461	4	7,233,461	9.751e-06	0.01047	0.195595309
Chr5:10708018	5	10,708,018	8.6238e-06	0.01056	0.265526248
Chr5:11168463	5	11,168,463	5.2059e-06	0.01104	0.143584579
Chr5:19713917	5	19,713,917	2.9743e-06	0.01155	0.127446862
Chr7:1878281	7	1,878,281	2.1593e-06	0.01185	0.349364594

Chr7:27978534	7	27,978,534	3.0953e-07	0.01362	0.060987384
Chr8:17403818	8	17,403,818	2.9935e-06	0.01152	0.220170927
Chr8:7093584	8	7093584	7.689e-06	0.01067	0.305252131
Chr10:15229404	10	15,229,404	5.2344e-06	0.0094	0.082497509
Chr10:3169064	10	3,169,064	2.3761e-06	0.01176	0.127446862
Chr11:12295393	11	12,295,393	4.0332e-06	0.01128	0.349364594
Chr11:22934789	11	22,934,789	2.8648e-06	0.01156	0.220170927
Chr11:23861379	11	23,861,379	5.0204e-06	0.01108	0.349364594
Chr11:2888595	11	2,888,595	2.1295e-06	0.01183	0.200822111
Chr11:6795367	11	6,795,367	1.1887e-06	0.01239	0.087428489

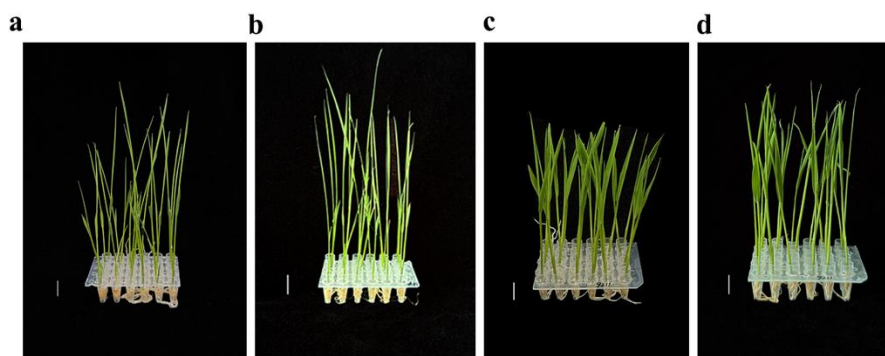
附表 3 *qLWD4-1* 位点候选基因

Table S3 Candidate genes for the *qLWD4-1* locus

候选基因	基因注释	起始位置	结束位置
Candidate gene	Gene annotation	Start position	End position
<i>LOC_Os04g53800</i>	leucoanthocyanidin reductase putative expressed	32059521	32062391
<i>LOC_Os04g53810</i>	leucoanthocyanidin reductase putative expressed	32063705	32065859
<i>LOC_Os04g53820</i>	transposon protein putative unclassified expressed	32068442	32076123
<i>LOC_Os04g53830</i>	3-beta hydroxysteroid dehydrogenase isomerase family protein putative expressed	32078551	32081906
<i>LOC_Os04g53850</i>	leucoanthocyanidin reductase putative expressed	32085528	32088329
<i>LOC_Os04g53860</i>	reductase putative expressed	32090821	32093093
<i>LOC_Os04g53890</i>	retrotransposon protein putative Ty3-gypsy subclass expressed	32113064	32117614
<i>LOC_Os04g53920</i>	leucoanthocyanidin reductase putative expressed	32131999	32135388
<i>LOC_Os04g53930</i>	organic cation transporter protein putative expressed	32137818	32141183
<i>LOC_Os04g53950</i>	glycosyl hydrolases family 16 protein protein expressed	32145679	32147540
<i>LOC_Os04g53960</i>	retrotransposon protein putative Ty1-copia subclass expressed	32151331	32152103
<i>LOC_Os04g53990</i>	ethylene-responsive protein related putative expressed	32166724	32169604
<i>LOC_Os04g53994</i>	kinase putative expressed	32173554	32177365
<i>LOC_Os04g53996</i>	protein kinase putative expressed	32183781	32184551
<i>LOC_Os04g53998</i>	kinase putative expressed	32178133	32182246
<i>LOC_Os04g54002</i>	serine threonine-protein kinase receptor precursor putative expressed	32189405	32193189
<i>LOC_Os04g54010</i>	serine threonine-protein kinase receptor precursor putative expressed	32193893	32196603
<i>LOC_Os04g54020</i>	receptor-like kinase putative expressed	32197592	32202721
<i>LOC_Os04g54040</i>	expressed protein	32206661	32207610
<i>LOC_Os04g54070</i>	receptor-like kinase putative expressed	32223116	32226952
<i>LOC_Os04g54080</i>	serine threonine-protein kinase receptor precursor putative expressed	32229075	32233640
<i>LOC_Os04g54090</i>	RALFL18 - Rapid ALKalinization Factor RALF family protein precursor expressed	32234697	32235021

LOC_Os04g54100	exostosin family protein	putative	expressed	32235313	32235699	
LOC_Os04g54110	ARK3	putative	expressed	32238374	32242528	
LOC_Os04g54120	serine threonine-protein kinase receptor precursor	putative	expressed	32244877	32248178	
LOC_Os04g54130	TKL_IRAK_DUF26-ld.1 - DUF26 kinases have homology to DUF26 containing loci	expressed		32248949	32253028	
LOC_Os04g54140	receptor-like kinase	putative	expressed	32254120	32258262	
LOC_Os04g54180	serine threonine-protein kinase receptor precursor	putative	expressed	32273357	32276952	
LOC_Os04g54190	cysteine-rich receptor-like protein kinase 8 precursor	putative	expressed	32278147	32281447	
LOC_Os04g54200	diacylglycerol kinase	putative	expressed	32286661	32291459	
LOC_Os04g54210			expressed protein	32295071	32295355	
LOC_Os04g54220			expressed protein	32296089	32296600	
LOC_Os04g54230	wound induced protein	putative	expressed	32297556	32298132	
LOC_Os04g54240	wound induced protein	putative	expressed	32301622	32302456	
LOC_Os04g54250	retrotransposon protein	putative	Ty1-copia subclass expressed	32304817	32306616	
LOC_Os04g54280	retrotransposon protein	putative	Ty1-copia subclass expressed	32319644	32323748	
LOC_Os04g54300	wound induced protein	putative	expressed	32333335	32333993	
LOC_Os04g54310			expressed protein	32336347	32337872	
LOC_Os04g54320			expressed protein	32338417	32339536	
LOC_Os04g54330	acetyltransferase	GNAT family	putative	expressed	32339069	32342426
LOC_Os04g54340	double-strand break repair protein MRE11	putative	expressed	32342580	32348446	
LOC_Os04g54350	SPRY-domain containing protein	putative	expressed	32348410	32351851	
LOC_Os04g54360	glycosyl transferase 8 domain containing protein	putative	expressed	32353487	32356043	
LOC_Os04g54370			expressed protein	32356158	32358757	
LOC_Os04g54380	aluminum resistance protein	putative	expressed	32359202	32362652	
LOC_Os04g54390	nuclease PA3	putative	expressed	32362968	32365039	
LOC_Os04g54400	BTBN12 - Bric-a-Brac	Tramtrack	Broad Complex BTB domain with non-phototropic hypocotyl 3 NPH3 and coiled-coil domains	expressed	32365684	32369961
LOC_Os04g54410			expressed protein	32370810	32378071	
LOC_Os04g54420	protein of unknown function	DUF618 domain containing protein	expressed	32378706	32382044	
LOC_Os04g54430	immediate-early protein RSP40	putative	expressed	32383898	32387161	
LOC_Os04g54440	RNA binding protein	putative	expressed	32388440	32392487	
LOC_Os04g54490			expressed protein	32414780	32415613	
LOC_Os04g54500	POLGAMMA2	putative	expressed	32418363	32423997	
LOC_Os04g54510	mTERF family protein		expressed	32424166	32425618	
LOC_Os04g54520	retrotransposon protein	putative	Ty3-gypsy subclass	32430029	32432681	
LOC_Os04g54530	retrotransposon protein	putative	unclassified	32435980	32437552	

<i>LOC_Os04g54540</i>	expressed protein	32438583	32439478
<i>LOC_Os04g54550</i>	AT5MAT putative expressed	32445398	32445928
<i>LOC_Os04g54560</i>	transferase family protein putative expressed	32448490	32450325
<i>LOC_Os04g54564</i>	expressed protein	32450512	32451874
<i>LOC_Os04g54570</i>	transferase family protein putative expressed	32453265	32455214
<i>LOC_Os04g54580</i>	expressed protein	32457056	32457668
<i>LOC_Os04g54590</i>	expressed protein	32459573	32460498
<i>LOC_Os04g54600</i>	DUF617 domain containing protein expressed	32464933	32466074
<i>LOC_Os04g54610</i>	expressed protein	32476612	32477579
<i>LOC_Os04g54620</i>	expressed protein	32478832	32479294
<i>LOC_Os04g54630</i>	expressed protein	32481117	32481777
<i>LOC_Os04g54640</i>	peptidase cysteine peptidase active site putative expressed	32483013	32485554
<i>LOC_Os04g54650</i>	retrotransposon protein putative Ty3-gypsy subclass expressed	32495675	32503544
<i>LOC_Os04g54680</i>	ulp1 protease family protein putative expressed	32531424	32537198
<i>LOC_Os04g54720</i>	expressed protein	32545515	32547299
<i>LOC_Os04g54730</i>	expressed protein	32549152	32550018
<i>LOC_Os04g54740</i>	expressed protein	32552399	32556341
<i>LOC_Os04g54759</i>	expressed protein	32556873	32565405
<i>LOC_Os04g54780</i>	retrotransposon protein putative Ty3-gypsy subclass expressed	32569746	32572598
<i>LOC_Os04g54790</i>	ELMO CED-12 family protein putative expressed	32574405	32581684
<i>LOC_Os04g54800</i>	shikimate kinase putative expressed	32582126	32585724
<i>LOC_Os04g54810</i>	beta-D-xylosidase putative expressed	32588940	32595893
<i>LOC_Os04g54820</i>	programmed cell death 2 C-terminal domain-containing protein putative expressed	32600309	32603388
<i>LOC_Os04g54830</i>	expressed protein	32605092	32608651
<i>LOC_Os04g54840</i>	DNA-directed RNA polymerase subunit putative expressed	32609882	32618950
<i>LOC_Os04g54850</i>	pectinesterase putative expressed	32625802	32629134
<i>LOC_Os04g54860</i>	glutaredoxin putative expressed	32632277	32634821
<i>LOC_Os04g54870</i>	RNA recognition motif containing protein putative expressed	32633163	32637837
<i>LOC_Os04g54890</i>	expressed protein	32648181	32652728



(a) 水稻‘Nip’三叶期，20% PEG-6000 处理 0 h 表型（对照）；(b) 水稻 ‘Nip’ 三叶期，20% PEG-6000 处理 24 h 表型（干旱胁迫）(c) 水稻‘9311’三叶期，20% PEG-6000 处理 0 h 表型（对照）；(d) 水稻 ‘9311’ 三叶期，20% PEG-6000 处理 24 h 表型（干旱胁迫）

- (a) Phenotype of rice cultivar 'Nip' at the three-leaf stage under 0 h treatment with 20% PEG-6000 (control);
- (b) Phenotype of rice cultivar 'Nip' at the three-leaf stage under 24 h treatment with 20% PEG-6000 (drought stress);
- (c) Phenotype of rice cultivar '9311' at the three-leaf stage under 0 h treatment with 20% PEG-6000 (control);
- (d) Phenotype of rice cultivar '9311' at the three-leaf stage under 24 h treatment with 20% PEG-6000 (drought stress).

附图 2 水稻 ‘Nip’ 及 ‘9311’ 对 PEG-6000 模拟干旱胁迫的表型响应

Supplementary Fig 2. Phenotypic Responses of Rice Cultivars 'Nip' and '9311' to PEG-6000 Simulated Drought Stress