

Supplementary Materials:

Table S1. Description of the four parental lines used for developing the MAGIC DC1 population.

Parents	Code	GID	Origin	Agronomic relevance	Resistance relevance
SAGC-08	A	3301214	China	Short grain, thickness stem	Fe, Al, salt, Cd, drought tolerance
HHZ 5-SAL 9-Y 3-Y 1	B	2857043	IRRI-GSR	Long grain, good grain quality	Fe tolerance
BP1976B-2-3-7-TB-1-1	C	3300964	Indonesia	Long grain	Zn tolerance, blast disease resistance
PR 33282-B-8-1-1-1-1-1	D	2752173	Phil Rice	Long grain, high yielding	Al tolerance, bacterial blight resistance

Table S2. Primers used for qRT-PCR.

Genes	Forward	Reverse
OsActin (NM_197297)	CAACACCCCTGCTATGTACG	CATCACCAGAGTCCAACACAA
LOC_Os01g10600	GAGTCAGGGAGAGAGATGGC	ACCATGGATCTGTGTCAGCA
LOC_Os01g10990	TGCCATCGTTCTTGAGAGGA	AGGCCCATGTTGTACAGGTT
LOC_Os01g11250	CACAATCCATGCTGCCTCTC	CACGCTATGCTTGAACGGAT
LOC_Os02g06010	ACCATGGCCATCACTCAAGA	TATGCCACTGCCCAAGTGTA
LOC_Os02g06540	GCGCCATCTCCTTCAACTTC	CGATATGTACAGCGGTGACG
LOC_Os03g62200	ATGCCTCGACGTCATCTTCT	TCATGGTGTACCACGGGATG
LOC_Os03g62270	CCAACACCAACATGGTCCTC	GACCACCTCGTACCACCAC
LOC_Os03g62650	AGTTTCTAAAGCGCGTGCAA	TTCCACAAGGTCTCCACCAA
LOC_Os03g62750	CGGATGGTCATCCACCTCTT	AGCACCTTGTTGGCTAGGAT
LOC_Os07g37320	CTACGGGACTGCCAAGATCA	GTACTCCTCCTCGATGTCGT
LOC_Os07g37454	CTCCTCATGGGAGGATCAA	GGGAACAGCTCGATGGAGTA
LOC_Os07g37510	CGCCGTCTACTCTACTTCC	TGGAGAAGCTCGACGTTGTA
LOC_Os08g41370	CCCGTCCTCTTCTTGACTA	AAAGGGAGGAGGGAGAAGAC
LOC_Os08g42020	AAGAACTTGCTCCTGAACGC	GTCGGACTGTGACCTCATCT
LOC_Os08g42150	CTTCCTCGCCGACTCCAC	TGAAGGAGAACGGGTACTGG
LOC_Os08g42170	CTTCCTCATGACCGTCGTCT	TGGTTGATGGCGACGTAGAT

Table S3. Primers used to amplify the open reading frames of six candidate genes and OsZIP5.

Genes	Forward	Reverse
OsZIP5	ATGGCGACGGCGCGATGACCA	TCACGCCCAGATGGCGATCAT
LOC_Os02g06010	ATGTCTAATCTATCAGAGCCCTCA	TTAAGATGATGTTTGCTTCTGAGT
LOC_Os07g37510	ATGGCCGACGCGGCCACCACCCG CTGCTGA	CTACACGAGCTCCCCGTT
LOC_Os08g41370	ATGGGCGAGGCCAGGCT	TTAGAACAGCGCCTTGGGCA
LOC_Os08g42020	ATGGAGTCGACGTGCTGGTC	TCATTTGTGTCCACTGGCACTCA
LOC_Os08g42150	ATGGCCAGGACGATGACGATGAGG GTTTCTTCGCT	CTAATTCACAGTCCTACCA
LOC_Os08g42170	ATGGGAATCGCGCTGCT	TCAGTCCCAGATCATGACGACA

Table S4. Primers used to amplify the full-length LOC_Os02g06010 and its promoter

Fragment	Forward	Reverse
P1	GTTCGACATATCTGTCAACG	AGCCACGTCCCAATCCCTAAA
P2	ATCAAAGCTTCTTGGTTG	CTGGGCAATGCAAAGCAAA
P3	ACTCCATGCCAATGTGGA	GATACCCTACCACAGGTCTAAC
P4	AGGATCATTTGGCCAAAGG	AGCTCCAACCTCCACTATCT
P5	AGCACACCTACTCCAAAG	GGTTGCGCCTATCTGCCAATA

Table S5. Detailed information of 37 rice accessions.

ENTRY CODE	DESIGNATION	GROUP	FROM	SNP-TYPE	Zn ²⁺ concentration in brown rice (mg/kg)
XH72	NSIC Rc144 (TUBIGAN 8)	Indica	Philippines	ABC-TYPE	19.69
XH73	OM6600	Indica	Vietnam	ABC-TYPE	16.29
XH77	Sambamahsuri	Indica	India	ABC-TYPE	17.19
XH83	TDKL-Subl	Indica	Laos	ABC-TYPE	26.35
XH121	GUANGLUA14	Indica	China	ABC-TYPE	16.65
XH122	ZHENSHAN97	Indica	China	ABC-TYPE	17.22
XH127	CPSLO17	Indica	China	ABC-TYPE	17.46
XH132	KUNMINGCIAOBAIGU	Indica	China	ABC-TYPE	25.17
XH133	XINTUANHEIGU	Indica	China	ABC-TYPE	16.33
XH134	WUSHANYOUZHAN	Indica	China	ABC-TYPE	12.31
XH136	lemont	Indica	China	ABC-TYPE	16.71
XH143	XIXUAN4	Indica	China	ABC-TYPE	16.31
XH145	LONGGE113	Indica	China	ABC-TYPE	16.10
XH149	XUANENTANQINGZHAN	Indica	China	ABC-TYPE	15.71
XH151	MINKEZAO1	Indica	China	ABC-TYPE	15.01
XH153	DIJIAOWUJIAN	Indica	China	ABC-TYPE	14.44
XH154	HUANGKEZAONIANRI	Japonica	China	ABC-TYPE	25.26
XH156	77-175	Indica	China	ABC-TYPE	13.10
XH157	HONGYUN33	Indica	China	ABC-TYPE	14.00
XH159	IIXIANG	Indica	China	ABC-TYPE	12.66
XH161	XIEQINGZAOB	Indica	China	ABC-TYPE	15.79
XH162	HUAGENGXIAN74	Indica	China	ABC-TYPE	13.56
XH168	CHUNJIANG06	Indica	China	ABC-TYPE	15.76
XH199	ZHAMGU	Indica	China	ABC-TYPE	14.32
XH7	INPARI27	Indica	Indonesia	ABC-TYPE	16.05
XH9	IR20	Indica	Asia	ABC-TYPE	16.72
XH10	IR24	Indica	Asia	ABC-TYPE	17.64
XH31	IRRI106	Indica	Philippines	ABC-TYPE	16.18
XH32	IRRI108	Indica	Philippines	ABC-TYPE	19.79
XH35	IRRI116	Indica	Philippines	ABC-TYPE	15.91
XH23	IR71700-247-1-1-2	Indica	NPT	D-TYPE	14.70
XH47	IRRI 148	Indica	Philippines	D-TYPE	15.25
XH49	IRRI 151	Indica	Philippines	D-TYPE	13.87
XH50	IRRI 154	Indica	Philippines	D-TYPE	15.51
XH60	IRRI181	Indica	Philippines	D-TYPE	14.59
XH90	PSB RC6 (CARRANGLAN)	Indica	Philippines	D-TYPE	15.99
XH91	NSIC 2012 Rc304 SR	Indica	Philippines	D-TYPE	14.42

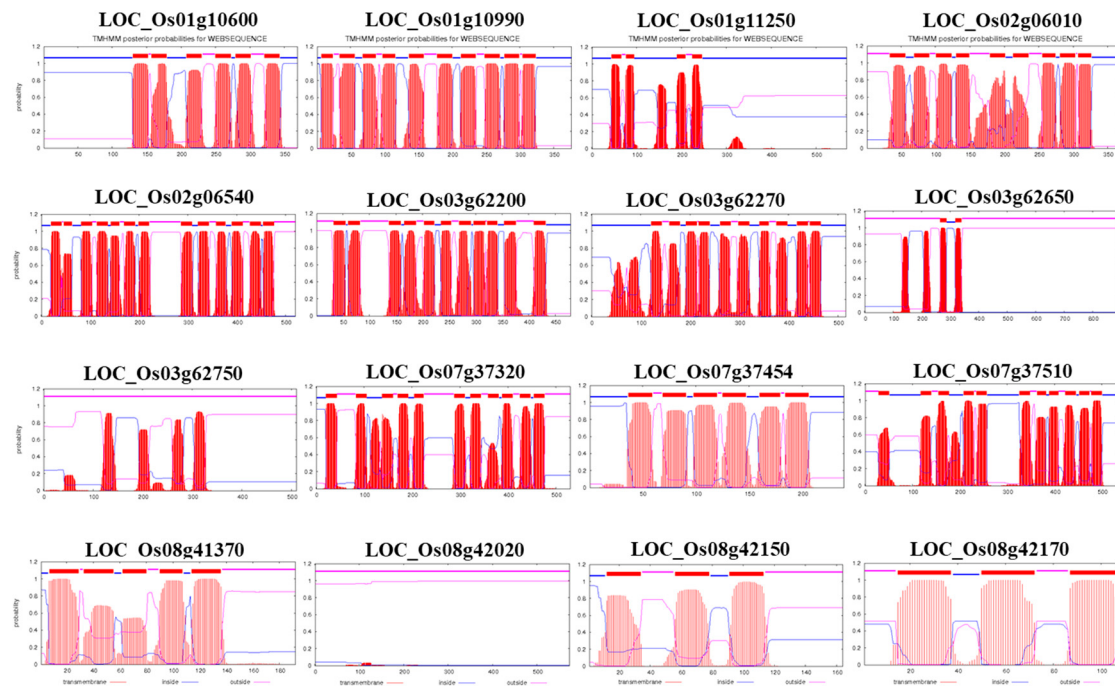


Figure S1. Predicted Topological model of proteins encoded by 16 candidate genes. The probability of transmembrane location predicted by the TMHMM 2.0 algorithm (<http://www.cbs.dtu.dk/services/TMHMM/>). The blue and magenta lines indicate internal (cytoplasmic) and external positions, respectively. The red area indicates the predicted transmembrane area.

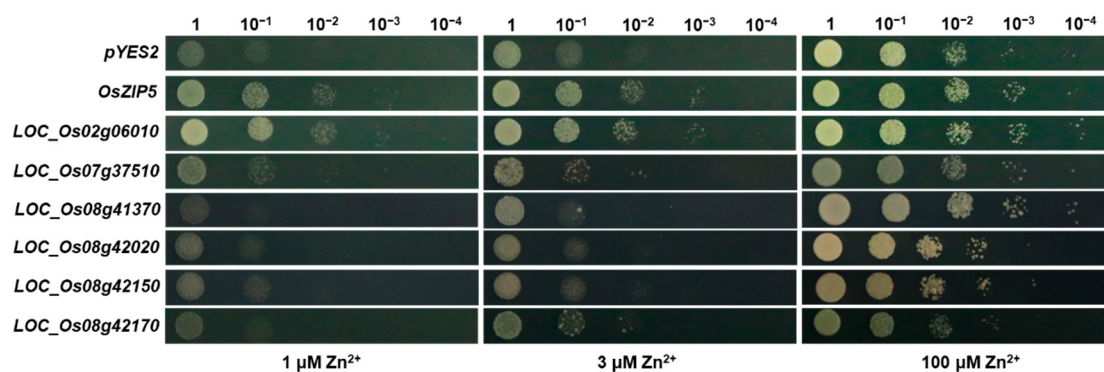


Figure S2. Complementation of the yeast mutant strain ZHY3 by *OsZIP5* and six candidate genes. Overnight yeast cell suspension of ZHY3 transformed with empty vector *pYES2*, *OsZIP5* or candidate genes were serially diluted (1:10) and spotted on the solid media containing 1, 3 or 100 $\mu\text{mol/L}$ ZnSO_4 . Pictures were taken after three days growth at 30 $^{\circ}\text{C}$.

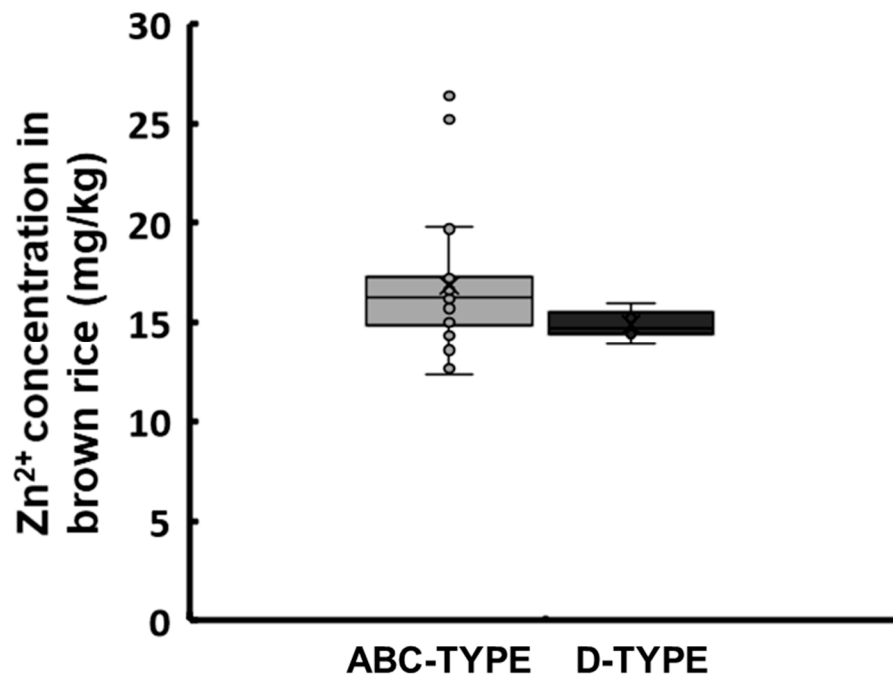


Figure S3. Haplotype analyses of *LOC_Os02g06010*. The sequence of *LOC_Os02g06010* in different rice varieties was analyzed according to the sequencing data, and SNP: -951 bp and SNP: -830 bp in the intron region of the upstream of the ATG were found in the accessions. ABC-TYP: SNP: -951 bp and SNP: -830 bp are the same as the parental lines A, B and C; D-TYPE: SNP: -951 bp and SNP: -830 bp are the same as the parental line D.