



華中農業大學
HUAZHONG AGRICULTURAL UNIVERSITY



Screening of salt/salt-alkali resistant germplasms and dissection of genetic basis of salt/salt-alkali resistance in *Brassica napus*

Xuan Yao

Huazhong Agricultural University



Contents

- ✿ **Research background**
- ✿ **Screening germplasms for salt/salt-alkali resistance**
- ✿ **Genome-wide association studies of salt resistance using hydroponic system**
- ✿ **Genome-wide association studies of salt resistance using high-throughput phenotypic platform**
- ✿ **Genome-wide association studies of salt-alkali resistance in field**

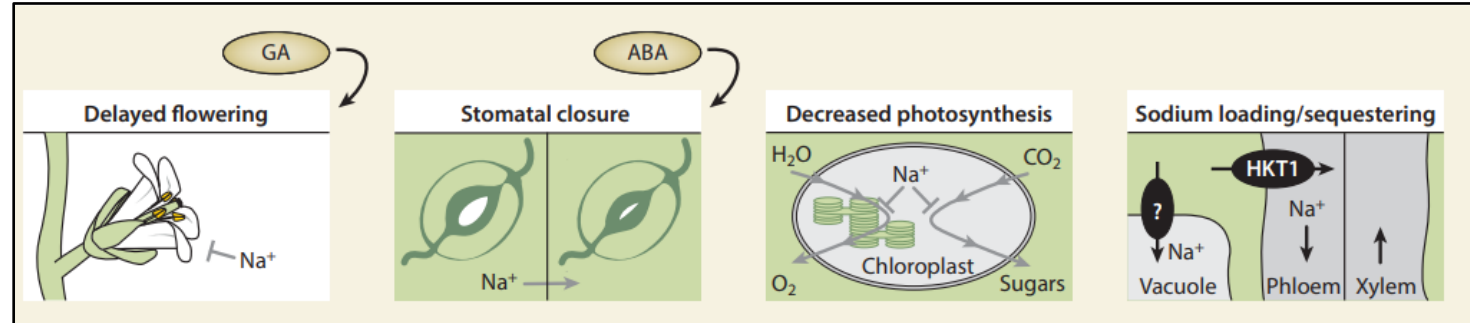


1

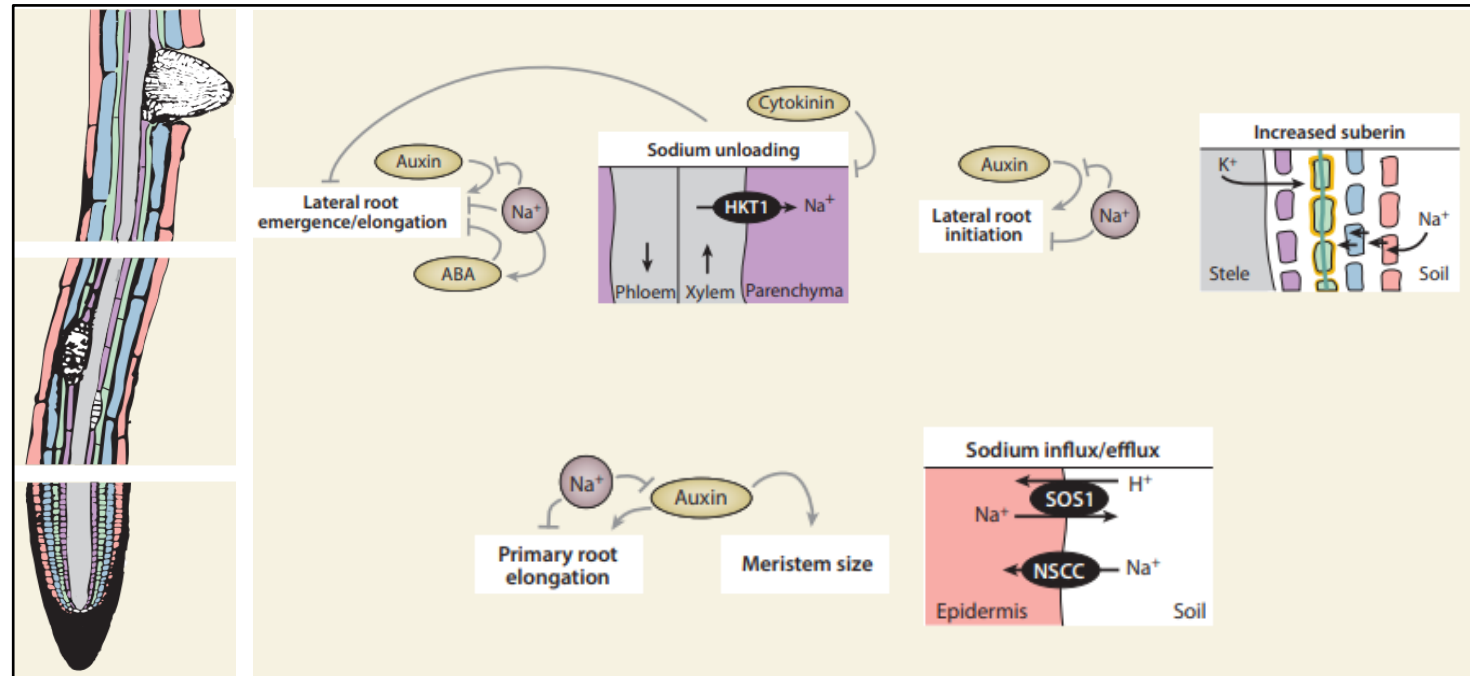
Research background

Salt-induced phenotypic changes in plants

Soil surface



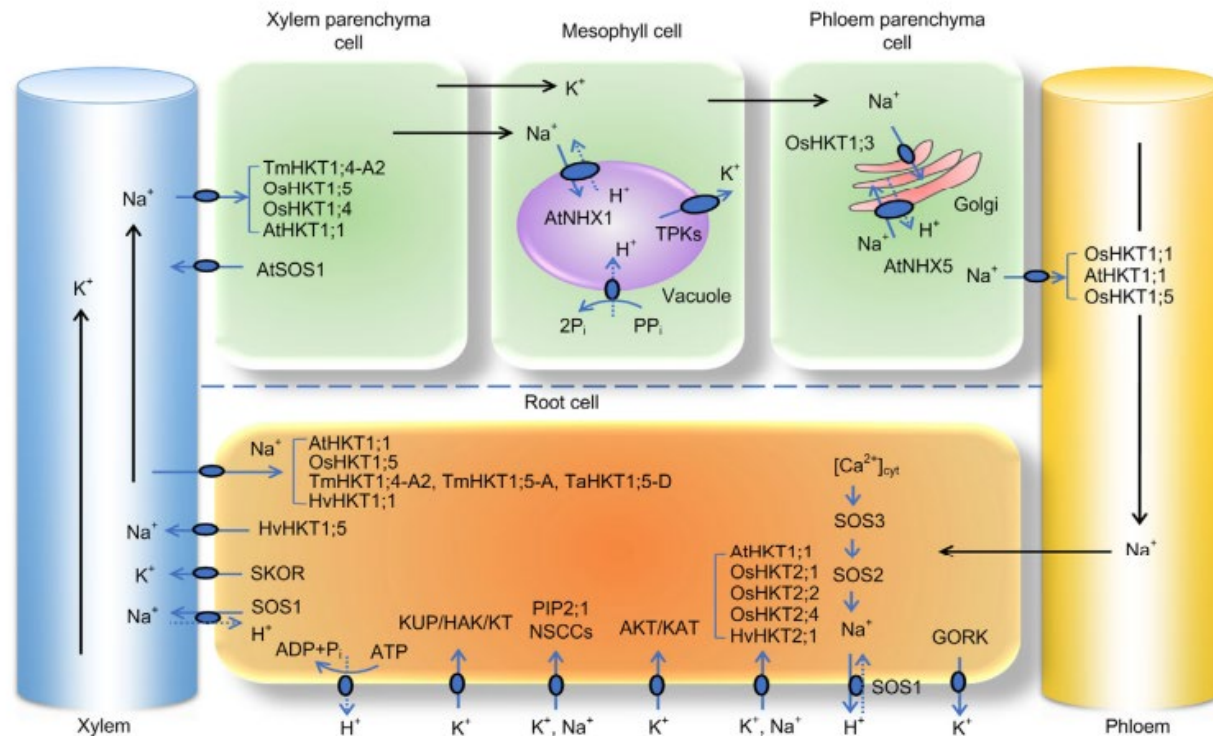
Shoot



Root

Regulatory mechanisms controlling salt resistance in plants

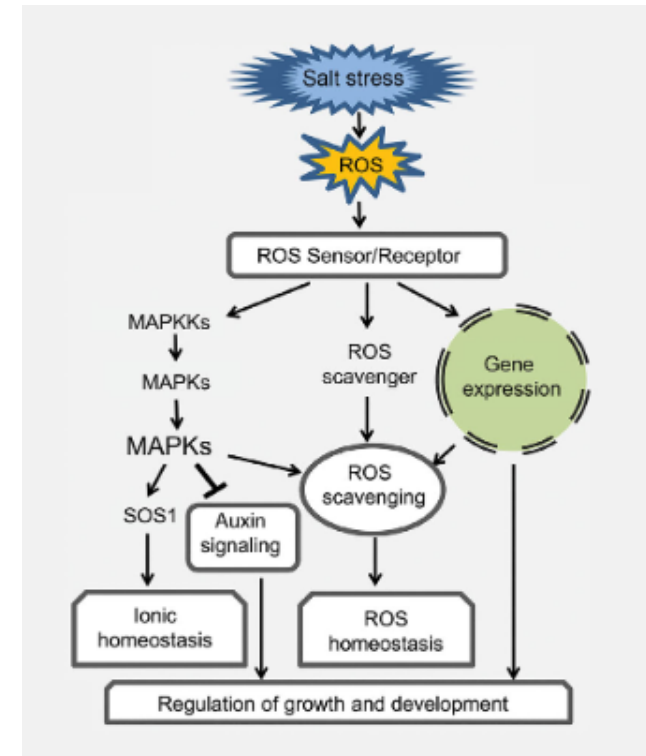
Osmotic stress response regulation



Huang et al., 2020

SOS signalling

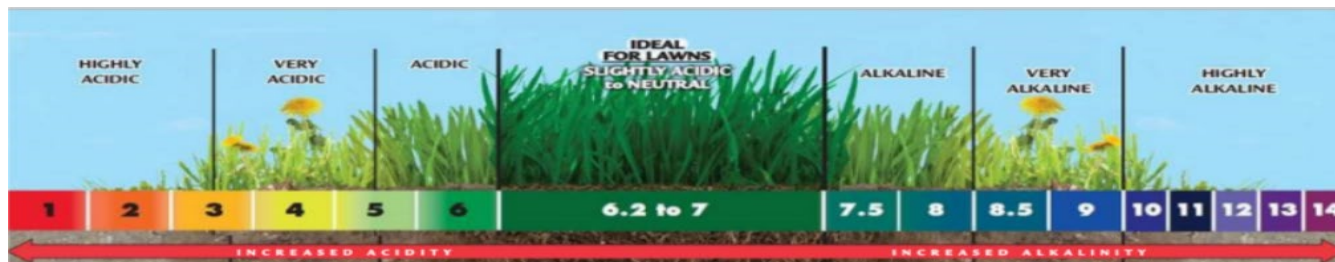
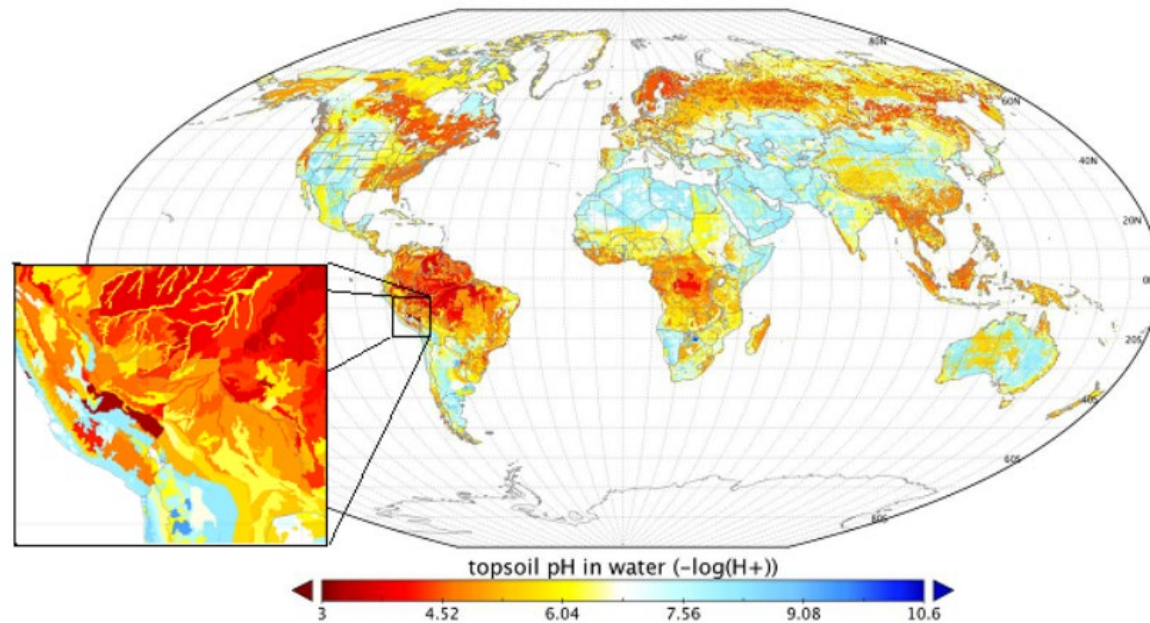
ROS signalling



Yang et al., 2018

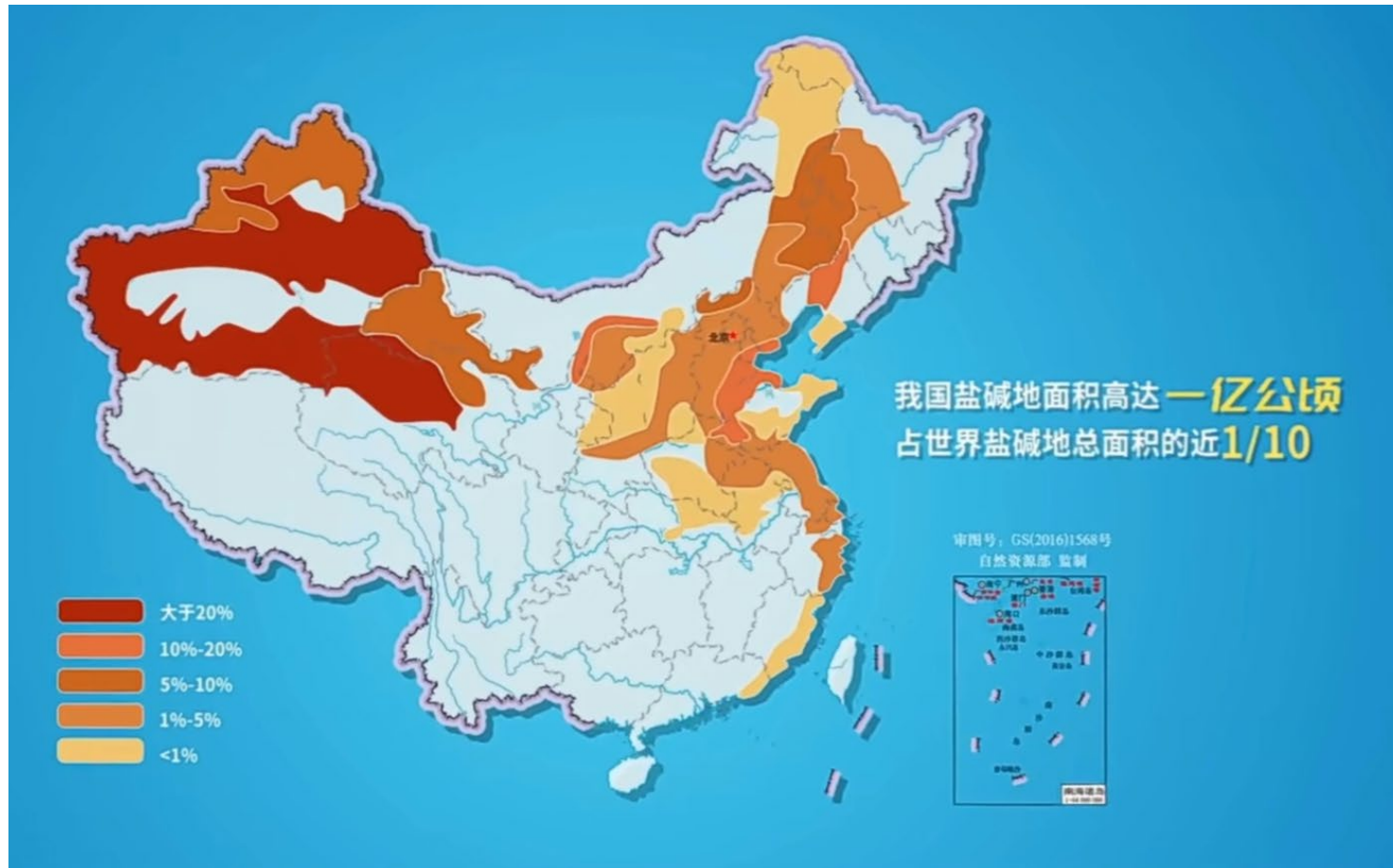
Soil pH effects on plant growth

The area of salt-alkali land in the world is as high as 950 million hectares



Denomination	pH range
Ultra acidic	< 3.5
Extremely acidic	3.5–4.4
Very strongly acidic	4.5–5.0
Strongly acidic	5.1–5.5
Moderately acidic	5.6–6.0
Slightly acidic	6.1–6.5
Neutral	6.6–7.3
Slightly alkaline	7.4–7.8
Moderately alkaline	7.9–8.4
Strongly alkaline	8.5–9.0
Very strongly alkaline	> 9.0

Salt-alkali land in China



- The area of salt-alkali land is about 100 million hectares
- It is the most widely distributed in northeast, central north, northwest, coastal, and north China
- ~40% saline-alkali land contains NaCl and Na_2SO_4
- ~60% saline-alkali land contains NaHCO_3 and Na_2CO_3

Our focus

- ✿ **Screening salt/salt-alkali resistant germplasms of *Brassica napus***
- ✿ **Mapping QTLs controlling salt/salt-alkali resistance and mining genes impacting salt/salt-alkali resistance in *Brassica napus***

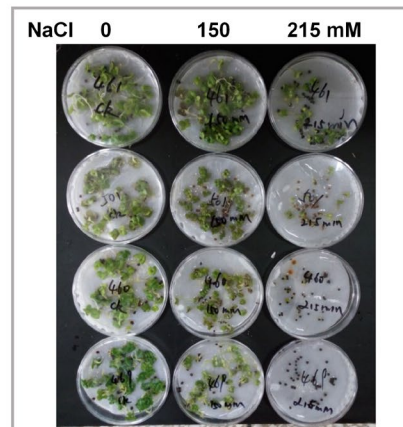
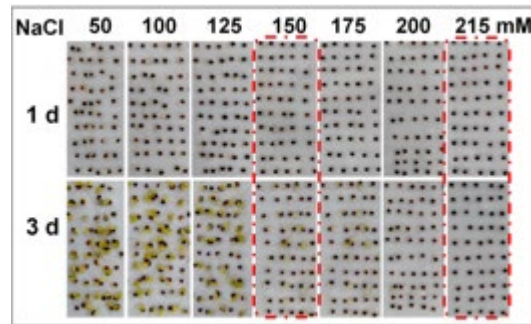
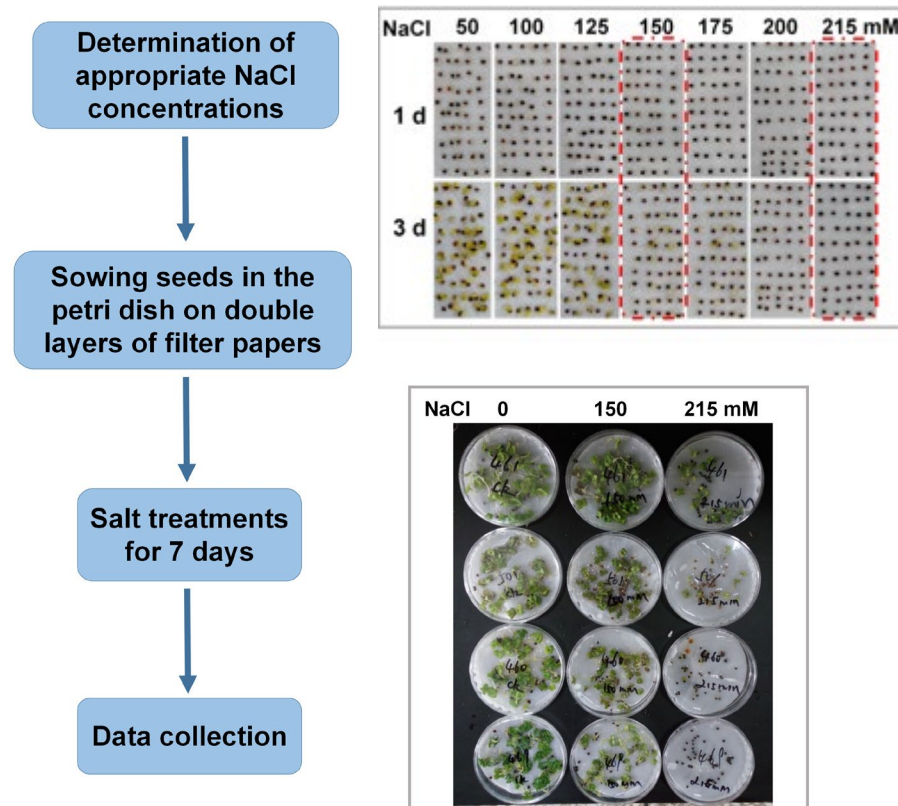
The background of the slide is a dark green horizontal band. Inside this band, there is a faint, semi-transparent image of a plant growing in a white petri dish. The plant has a single stem with a few leaves and a small flower. The number '2' is centered within a white hexagonal outline in the upper middle part of the band.

2

Screening germplasms for salt/salt-alkali resistance

Screening germplasm for salt resistance at germination stage

Flow chart of salt treatment at germination stage

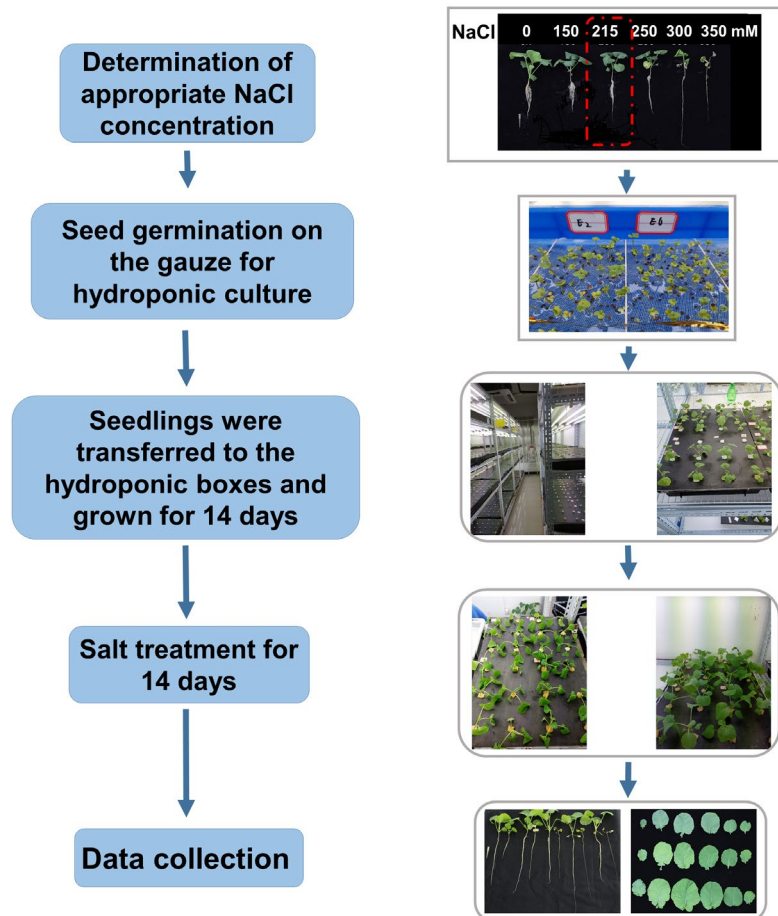


Traits and treatments types at germination stage in 505 accessions

Treatment (NaCl)	Treatment type	Traits description	Traits abbreviation
0 mM	CK	Germination potential	FYS_CK
150 mM	T1		FYS_T1
215 mM	T2		FYS_T2
0 mM	CK	Germination rate	FYL_CK
150 mM	T1		FYL_T1
215 mM	T2		FYL_T2
0 mM	CK	shoot length	GSL_CK
150 mM	T1		GSL_T1
215 mM	T2		GSL_T2
0 mM	CK	Root length	GRL_CK
150 mM	T1		GRL_T1
215 mM	T2		GRL_T2

Screening germplasm for salt resistance at seedling stage

Flow chart of salt treatment at seedling stage



Traits and treatments types at seedling stage in 505 accessions

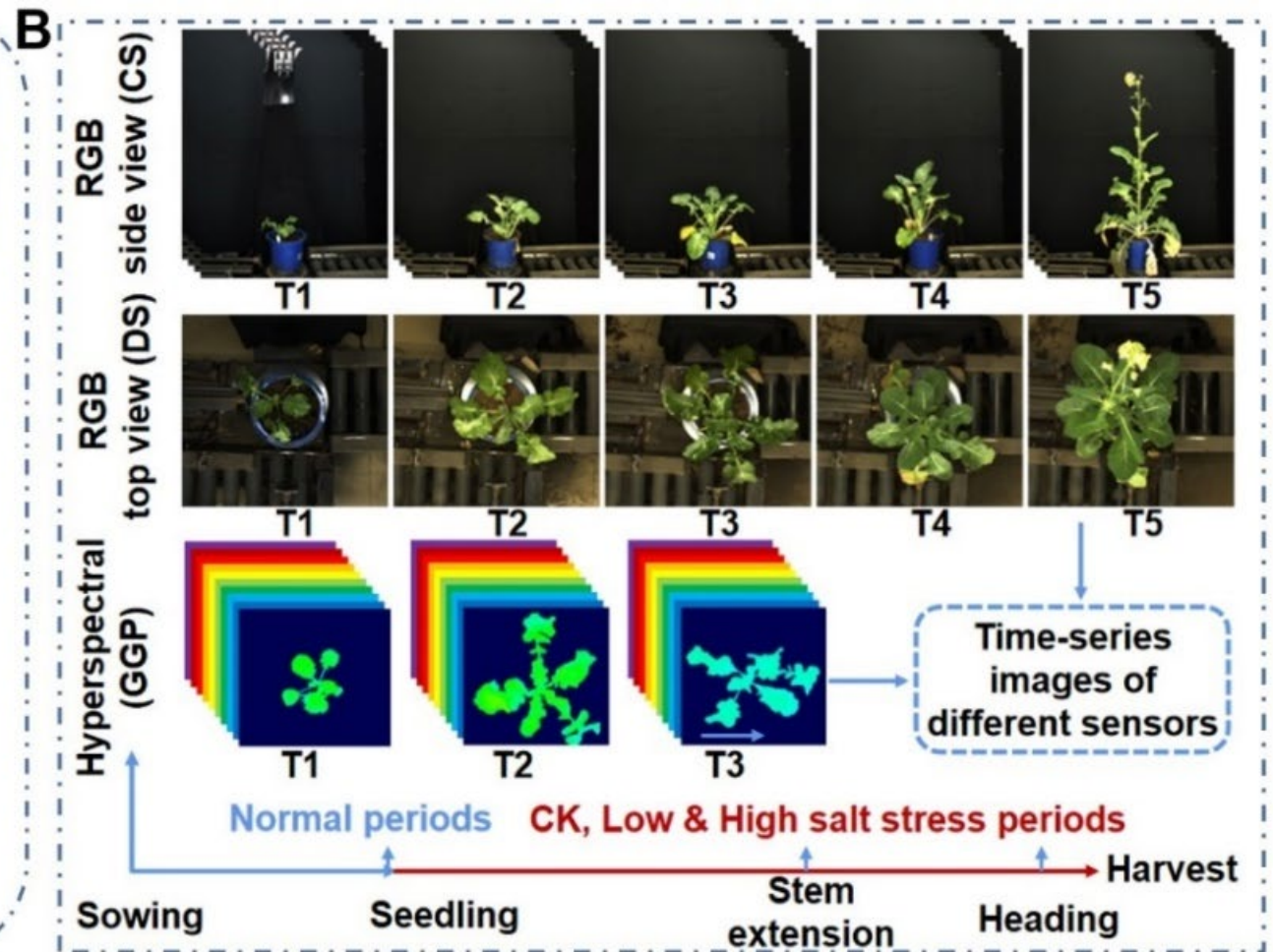
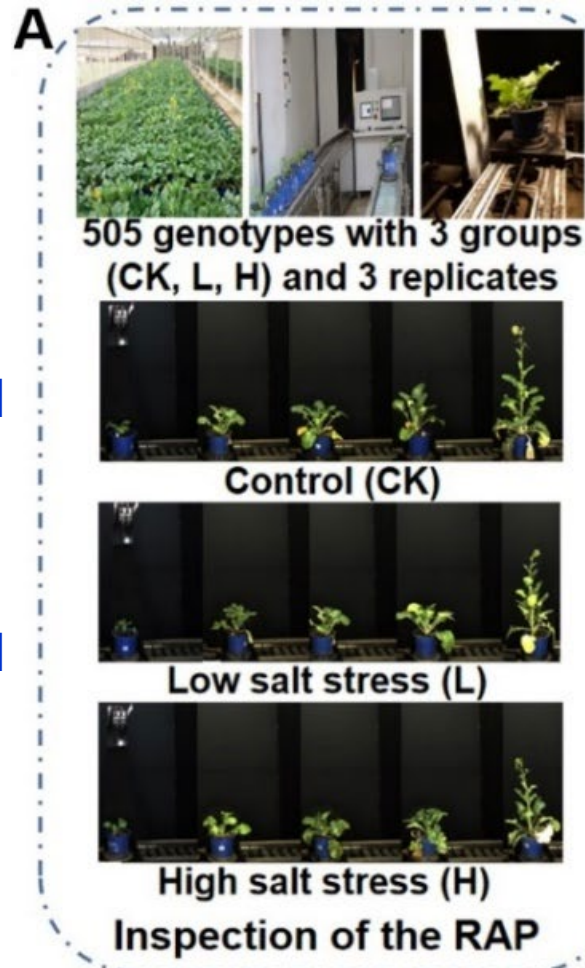
Treatment (NaCl)	Treatment type	Traits description	Traits abbreviation
0 mM	CK	Plant height	PH_CK
215 mM	T2		PH_T2
0 mM	CK	Root length	RL_CK
215 mM	T2		RL_T2
0 mM	CK	Above dry weight	ADW_CK
215 mM	T2		ADW_T2
0 mM	CK	Root dry weight	RDW_CK
215 mM	T2		RDW_T2
0 mM	CK	Total dry weight	TDW_CK
215 mM	T2		TDW_T2
0 mM	CK	Leaf area	LA_CK
215 mM	T2		LA_T2
0 mM	CK	Proline	Proline_CK
215 mM	T2		Proline_T2
0 mM	CK	Malondialdehyde	MDA_CK
215 mM	T2		MDA_T2
0 mM	CK	Chlorophyll content	SPAD_CK
215 mM	T2		SPAD_T2
0 mM	CK	Relative electrical conductivity	REC_CK
215 mM	T2		REC_T2

Screening germplasm for salt resistance using high-throughput phenotypic platform

CK: control

L: low salt
0.15-0.25% NaCl

H: high salt
0.35-0.45% NaCl



Screening germplasm for salt resistance

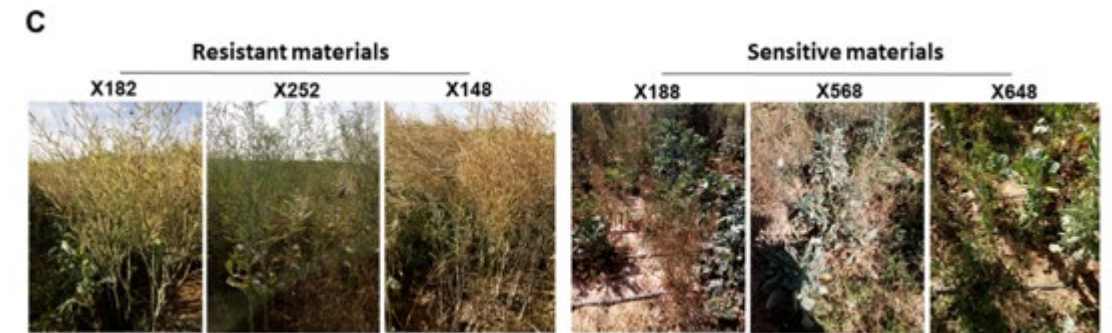
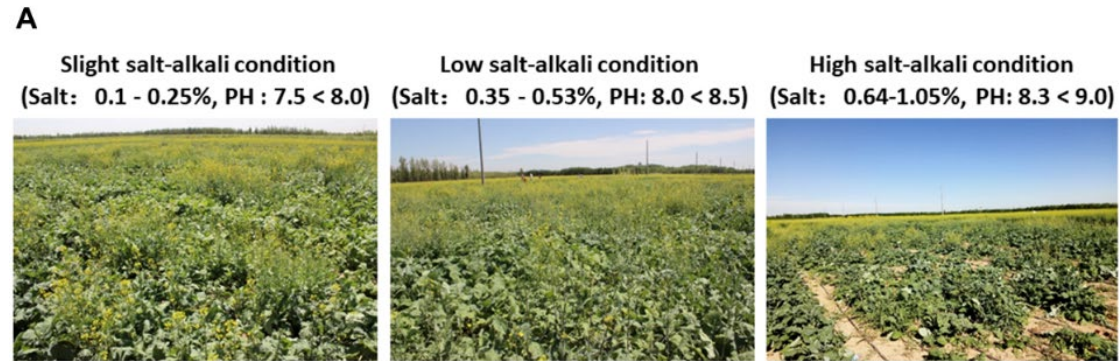
Salt resistant materials



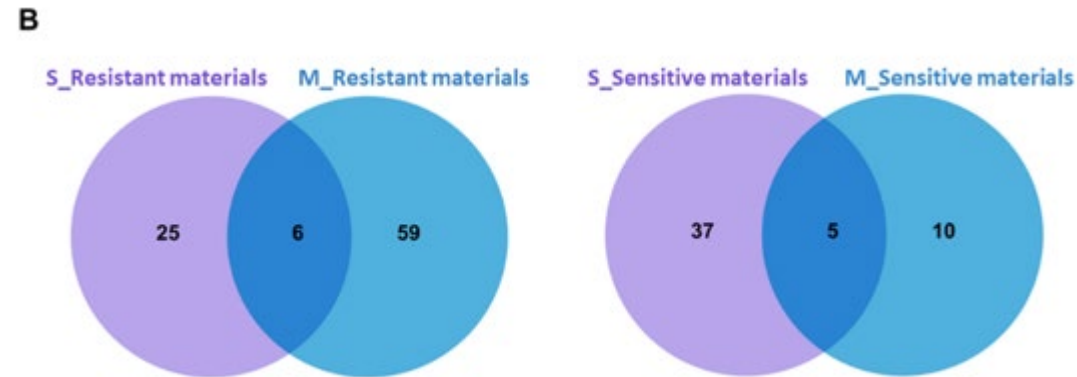
Salt sensitive materials



Screening germplasm for salt-alkali resistance in field



Germplasm identified in Inner Mongolia



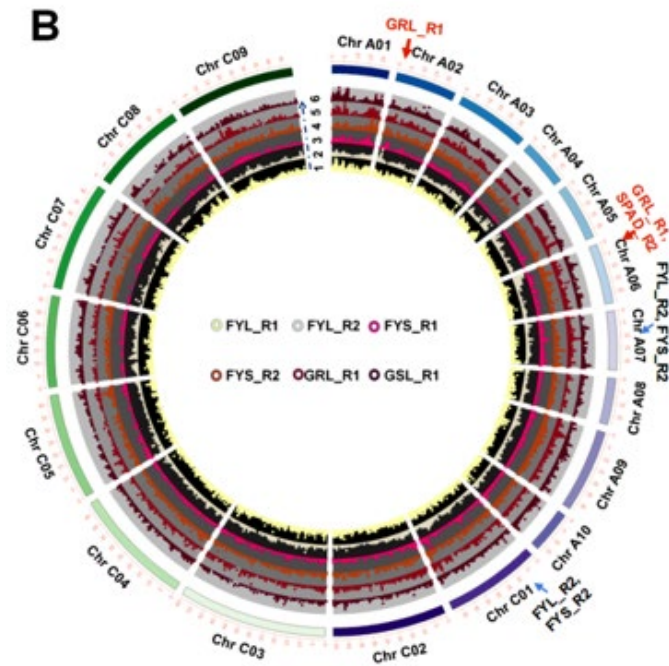
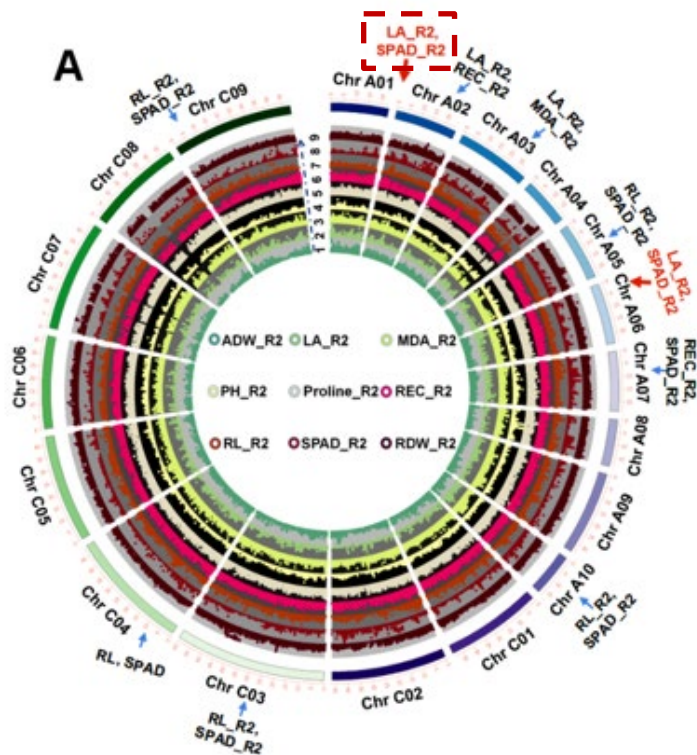
Germplasm identified in Xinjiang Uygur Autonomous Region

3

Genome-wide association studies of salt resistance using hydroponic system

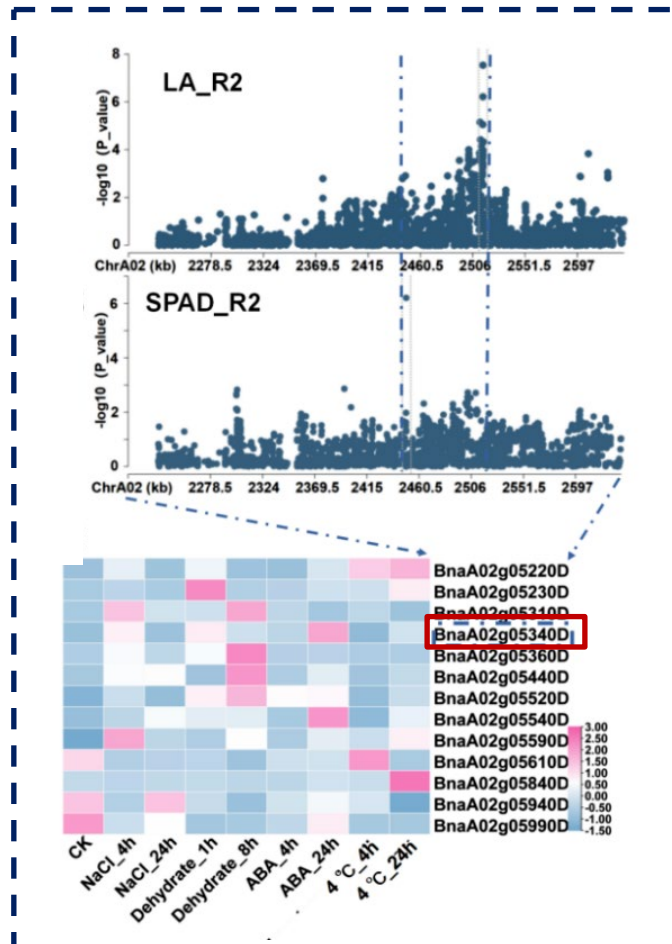
Genome-wide association studies of salt resistance at germination and seedling stages

- Six main-effect QTLs were located in chromosomes A02, A03, A06, A07, A10 and C01
- Co-located QTLs: LA_R2, SPAD_R2, REC_R2, MDA_R2, SPAD_R2, RL_R2, LA_R2, REC_R2, FYL_R2 and FYS_R2

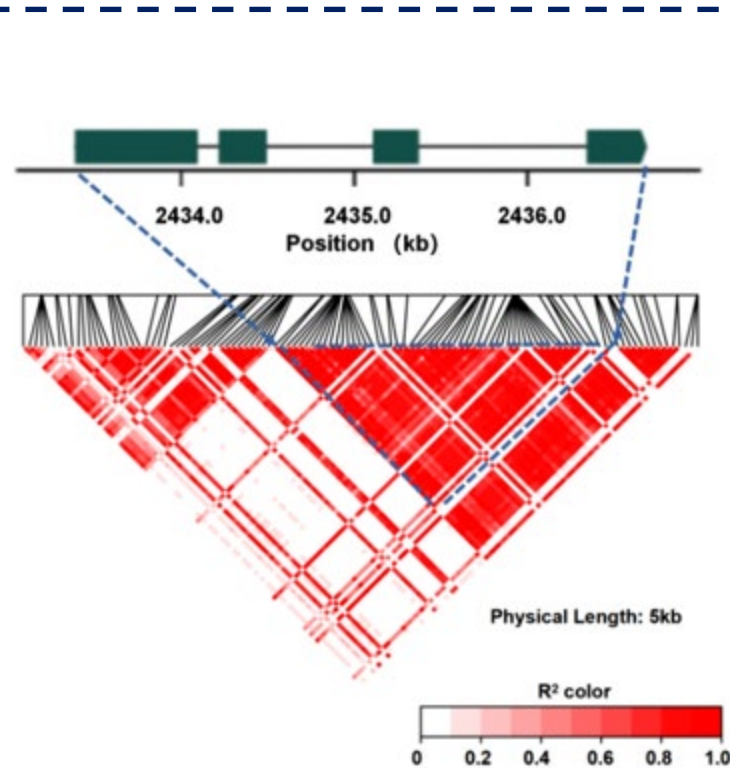


Identification of co-located QTLs and candidate genes on ChrA02

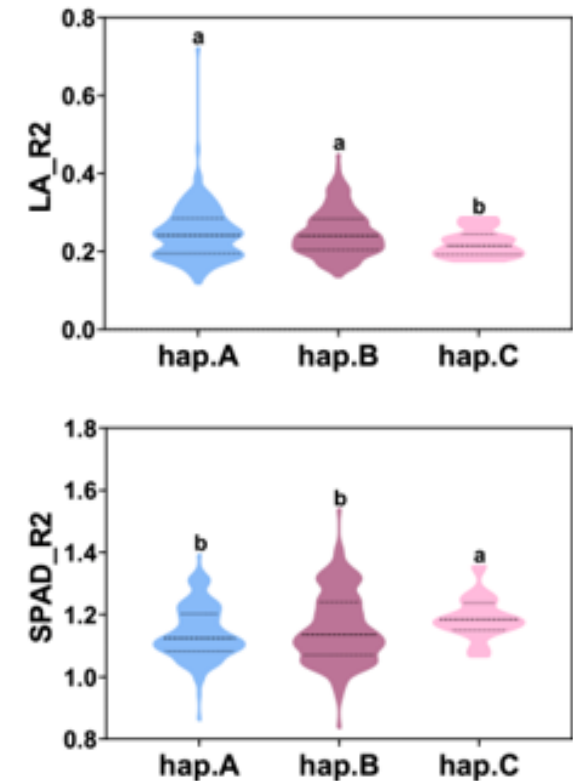
Prediction of candidate genes



LD heatmap

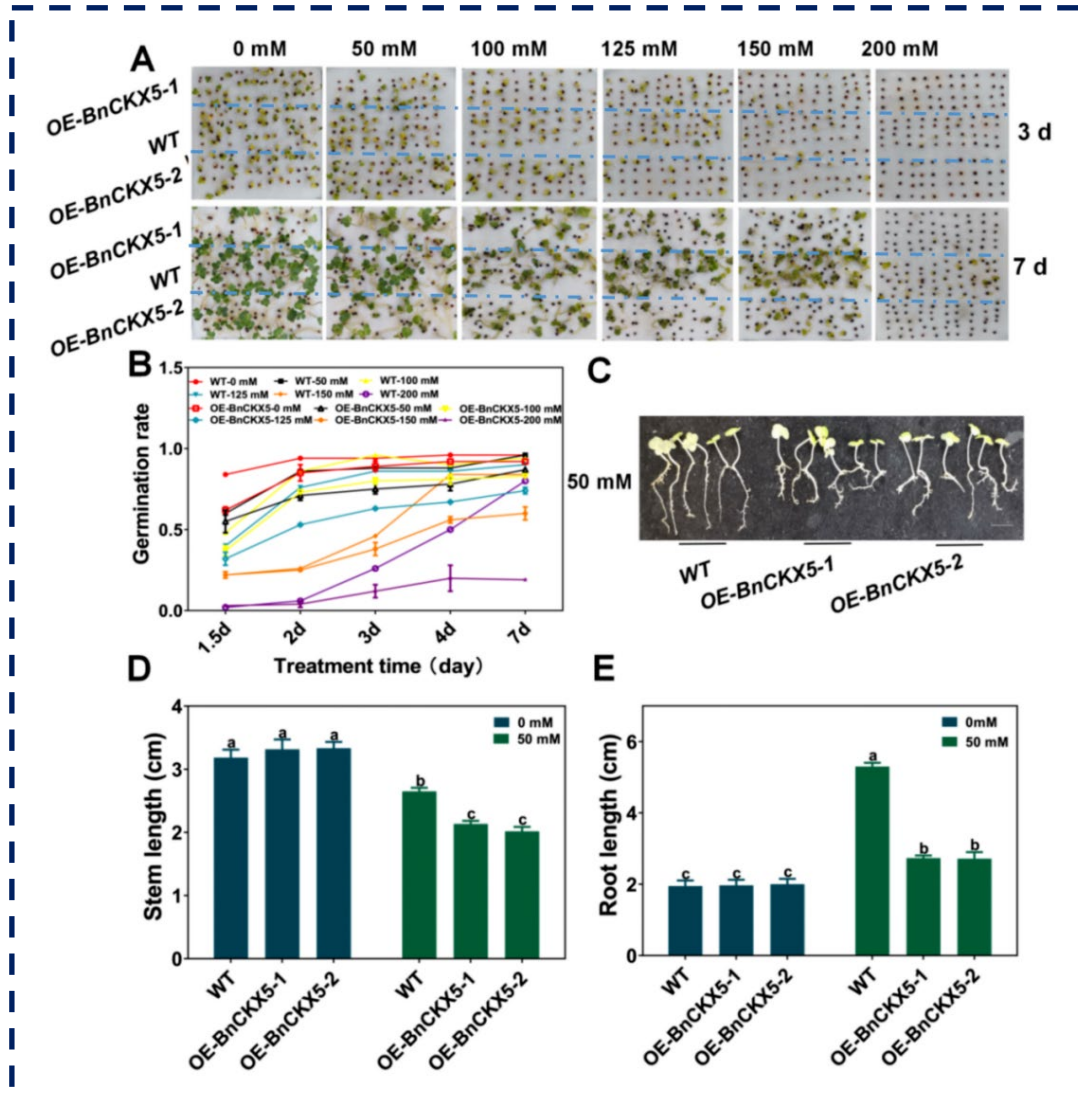


Haplotype analysis



BnaCKX5 (BnaA02g05340D) encodes a cytokinin dehydrogenase

Overexpression of *BnaCKX5* enhances sensitivity to salt stress at germination stage

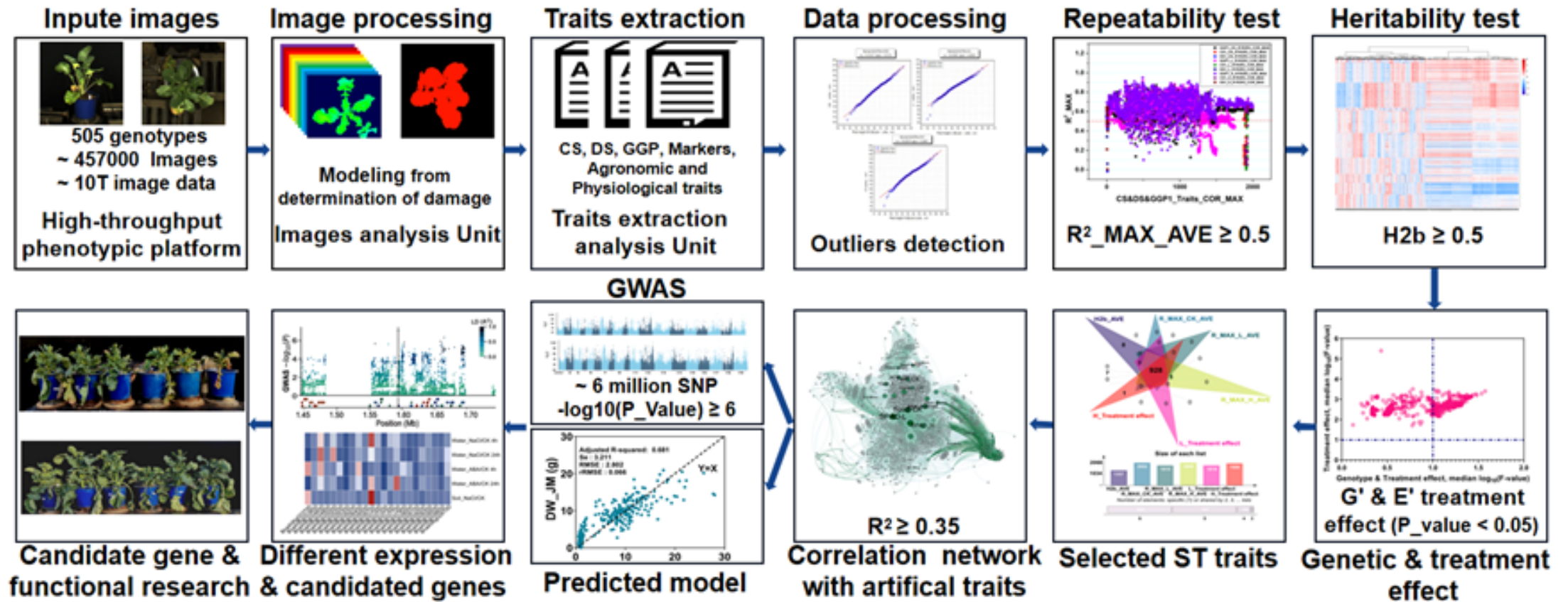




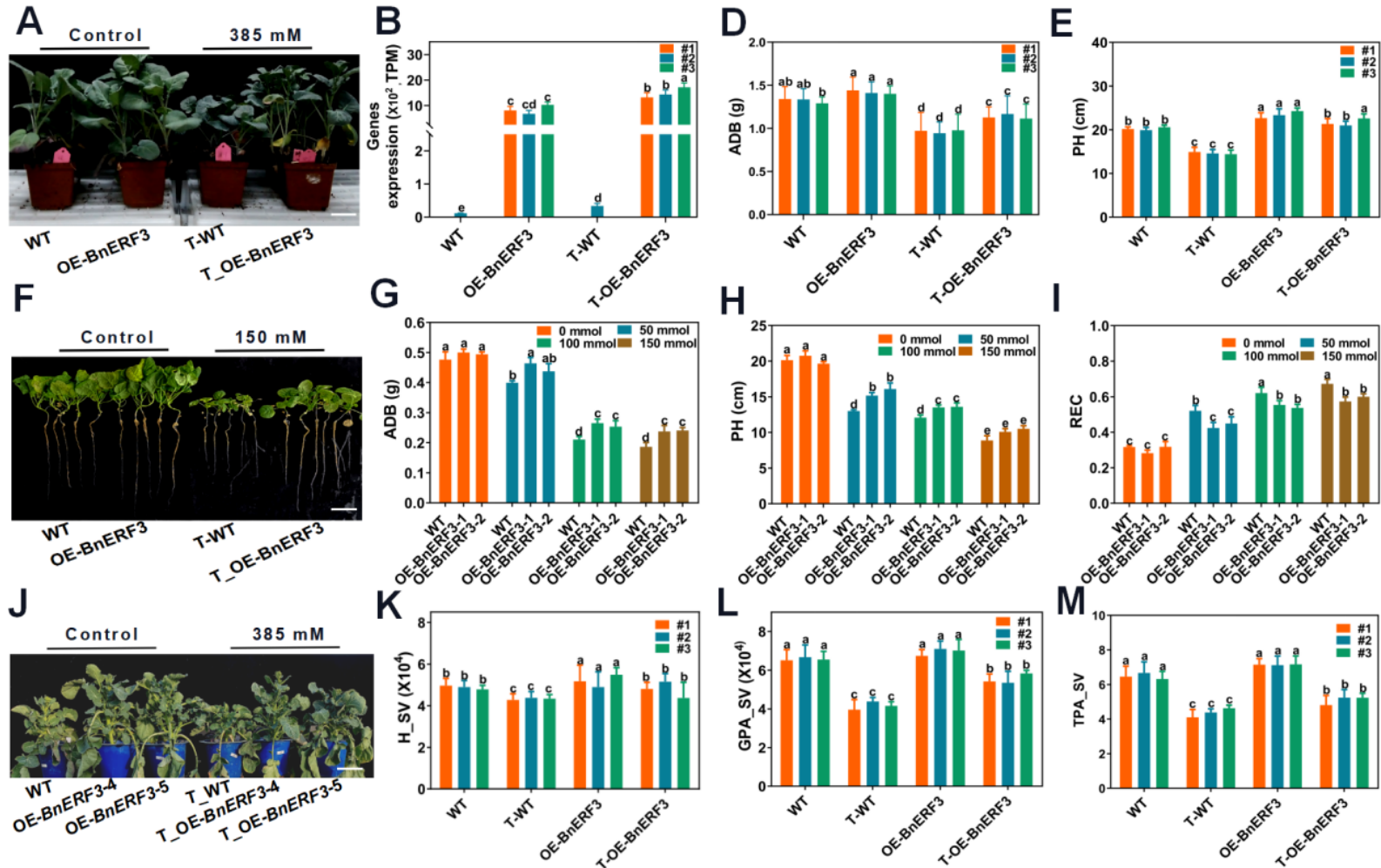
4

**Genome-wide association studies of salt resistance using
high-throughput phenotypic platform**

Flow chart of trait data collection using high-throughput phenotypic platform



Overexpression of *BnaERF3* enhances resistance to salt stress at seedling stage

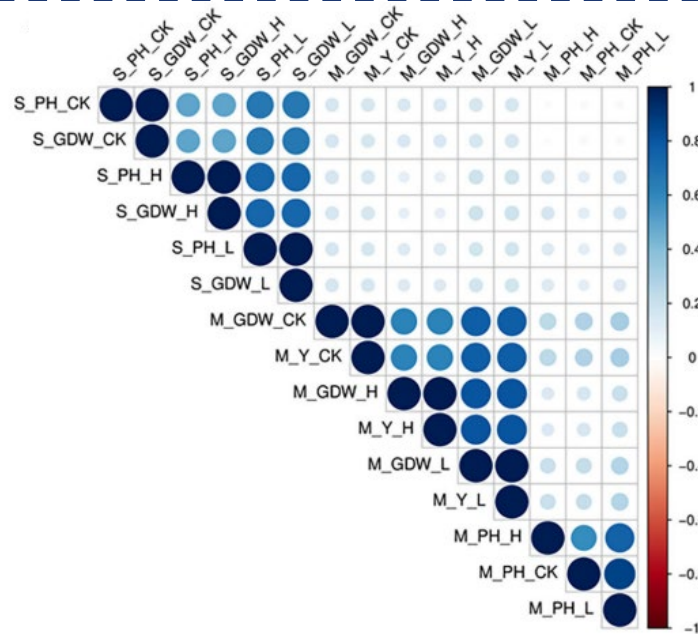


BnaERF3 (BnaA06g02670D) encodes a member of the ERF (ethylene response factor) subfamily of ERF/AP2 transcription factor family

5

**Genome-wide association studies of
salt-alkali resistance in field**

Evaluation of correlation coefficient and heritability under salt-alkali stress



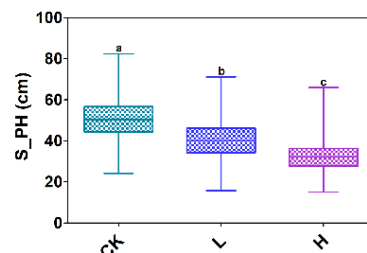
	G_effect (Pr)	E_effect (Pr)	G&E_effect (Pr)	H ² b
S_GDW	1.82E-239***	0***	0.023*	0.828
S_PH	0***	0***	7.85E-48***	0.873
M_PH	0***	0***	0***	0.889
M_GDW	0***	0***	3.819E-270***	0.770
M_Y	1.38E-28***	0***	1	0.759

S: at seedling stage **M:** at mature stage

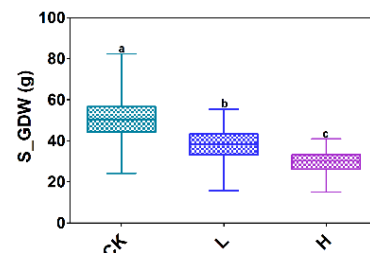
GDW: ground dry weight **PH:** plant height

Y: yield

Seedling stage

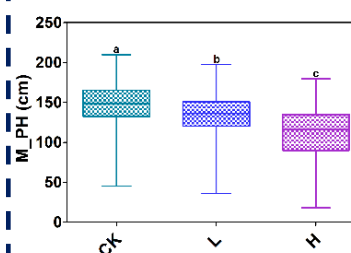


Box plot of plant height at seedling stage under different salt-alkali stress conditions

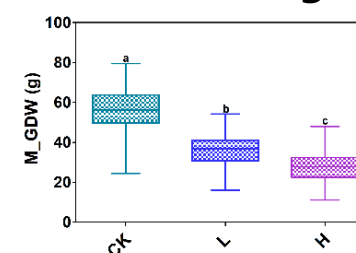


Box plot of ground dry weight at seedling stage under different salt-alkali stress conditions

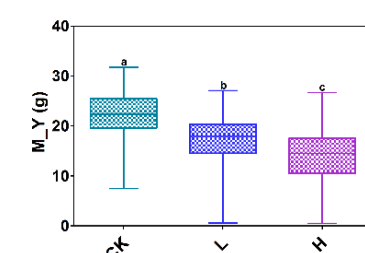
Mature stage



Box plot of plant height at mature stage under different salt-alkali stress conditions

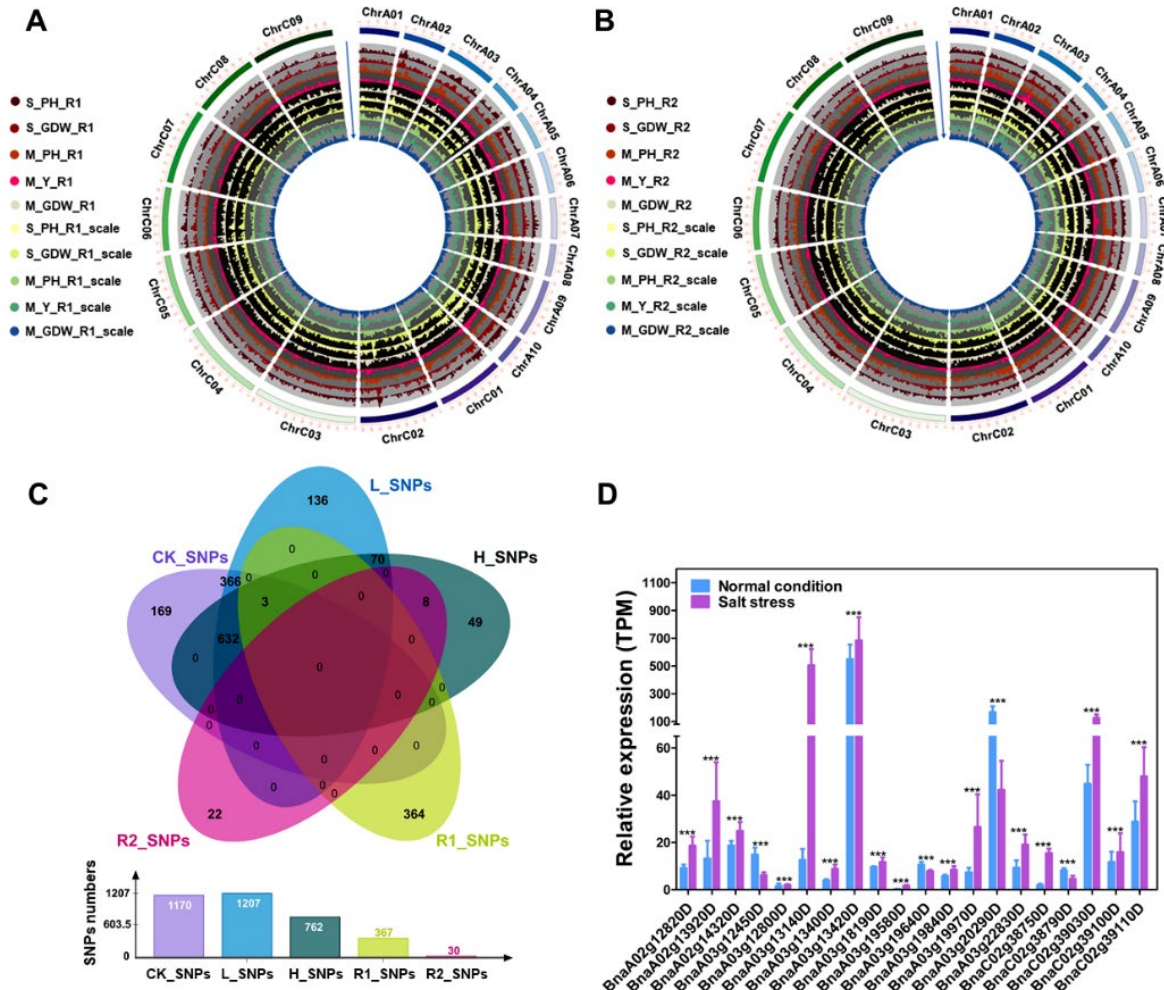


Box plot of ground dry weight at mature stage under different salt-alkali stress conditions



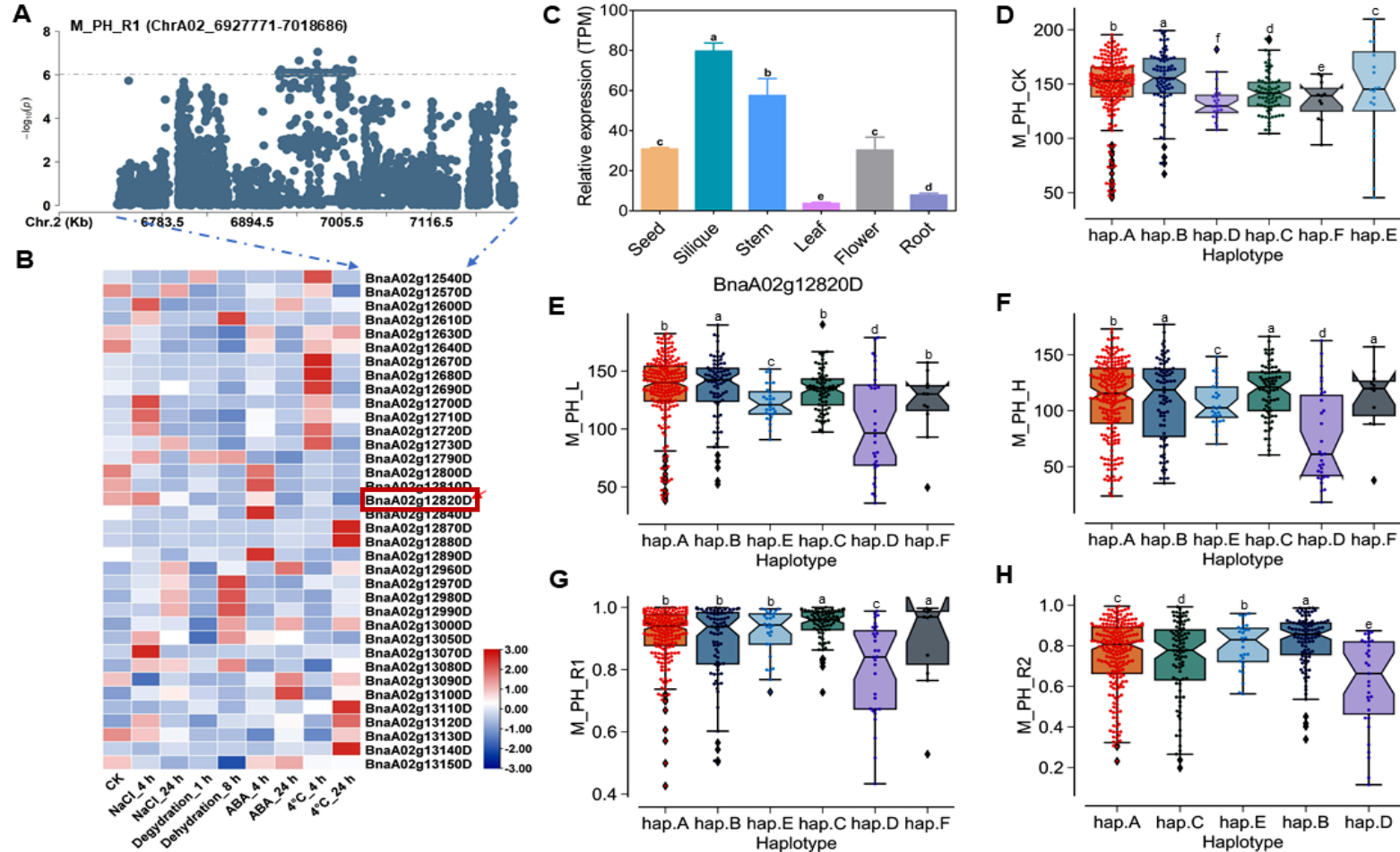
Box plot of yield at mature stage under different salt-alkali stress conditions

Genome-wide association studies of salt-alkali resistance at seedling and mature stages



- 15 absolute values and 10 tolerance coefficients (TCs) of growth and agronomic traits were investigated
- 9 significant QTLs related to salt-alkali stress response were mapped
- 20 candidate genes related to salt-alkali resistance were identified

Analysis of a candidate gene within the QTL qSAT.A02.1



***BnaABA4* (BnaA02g12820D) encodes a protein involved in the photoprotection of PSII and ABA biosynthesis**

Summary

- 8 resistant and 6 sensitive germplasms of *Brassica napus* have been identified at germination and seedling stages
- The genetic basis of salt resistance were dissected at germination and seedling stages in *Brassica napus*
- 6 resistant and 5 sensitive germplasms of *Brassica napus* have been identified from salt-alkali land in China
- The genetic basis of salt-alkali resistance were dissected at seedling and mature stages in *Brassica napus*

Acknowledgement

Huazhong Agricultural University

Dr. Guofang Zhang

Prof. Liang Guo

Prof. Tingdong Fu

Prof. Guangsheng Zhou

Rapeseed team



Guo Lab



勤 讀 力 耕
立 己 達 人

