



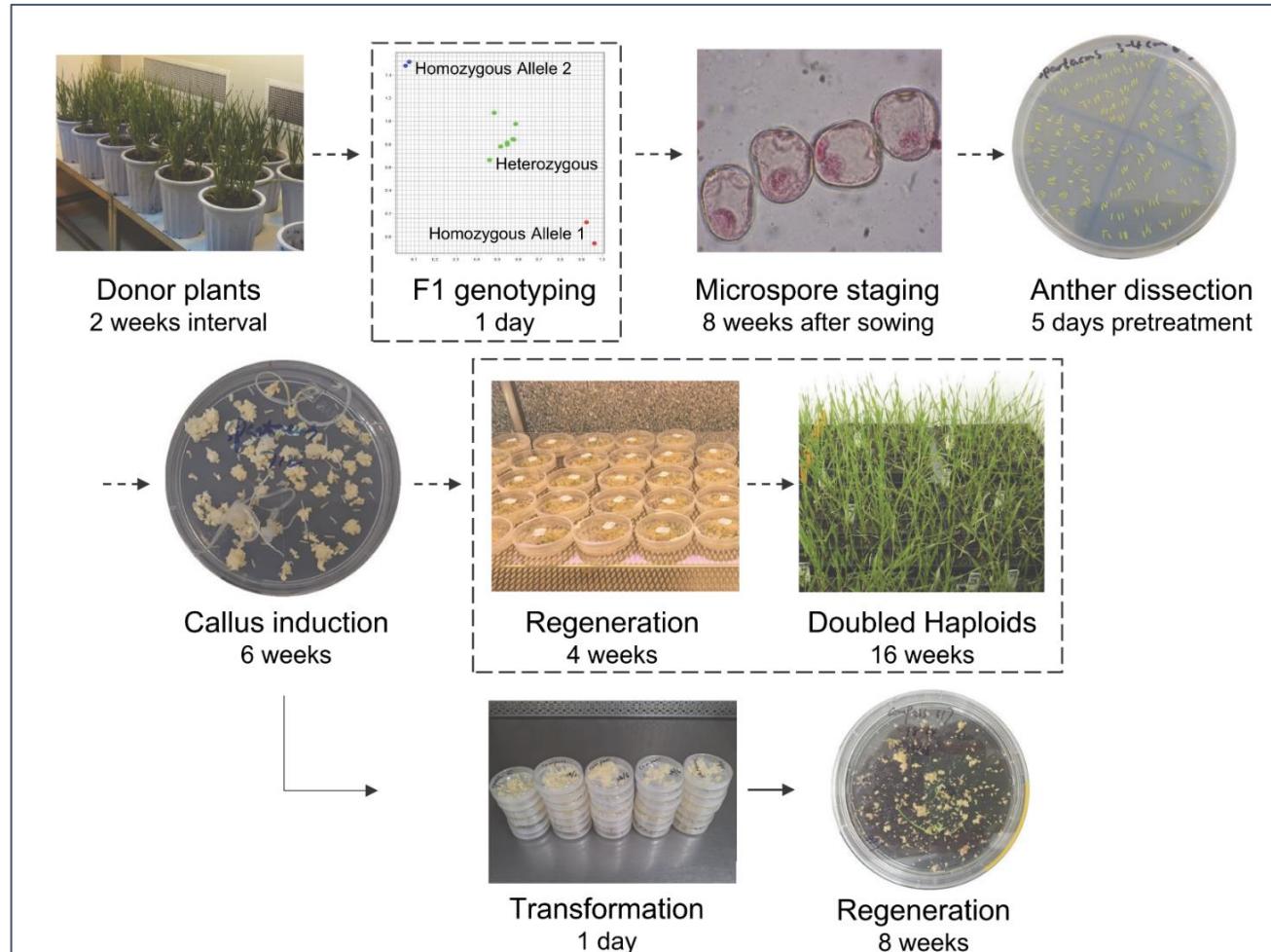
Frontiers in Barley Genetic Improvement

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Messages

- Efficient gene editing platforms have been established in barley.
- Advanced materials with increased nitrogen use efficiency, salinity tolerance and coleoptile length have been developed and can be transformed into new profitable varieties.
- New opportunities are emerging to adopt the technology for (complex) trait improvement in other crops.

Editing commercial barleys



- SDN-1 type mutation
- Commercial and model varieties
- 53% average mutation rate
- Over 70% small indels (< 3 bp)

(Han et al., Plant Communications, 2021)

Case studies

- Nitrogen use efficiency (NUE)
- Salinity tolerance at germination
- Novel “Green Revolution” alternatives



Long coleoptile



Enhanced yield potential

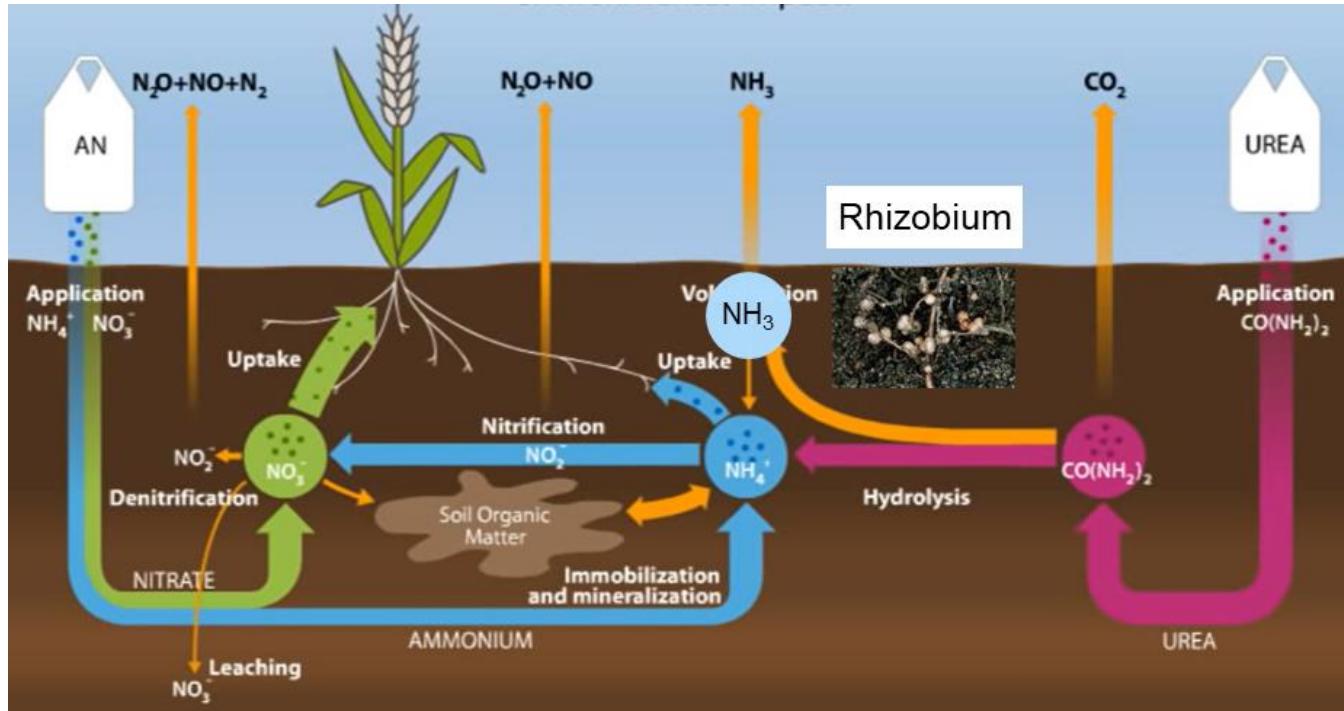


Nitrogen use efficiency



Early flowering time

The N flow



Ammonium nitrate

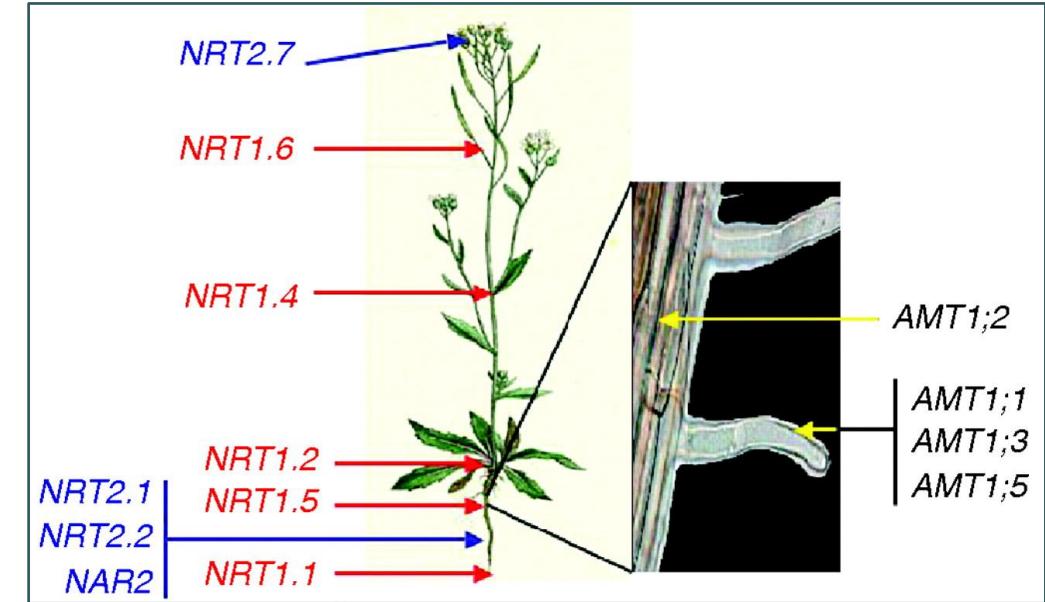
1:1 $\text{NH}_4^+:\text{NO}_3^-$

Urea

$\text{NH}_4^+ \rightarrow \text{NO}_3^-$

BFN

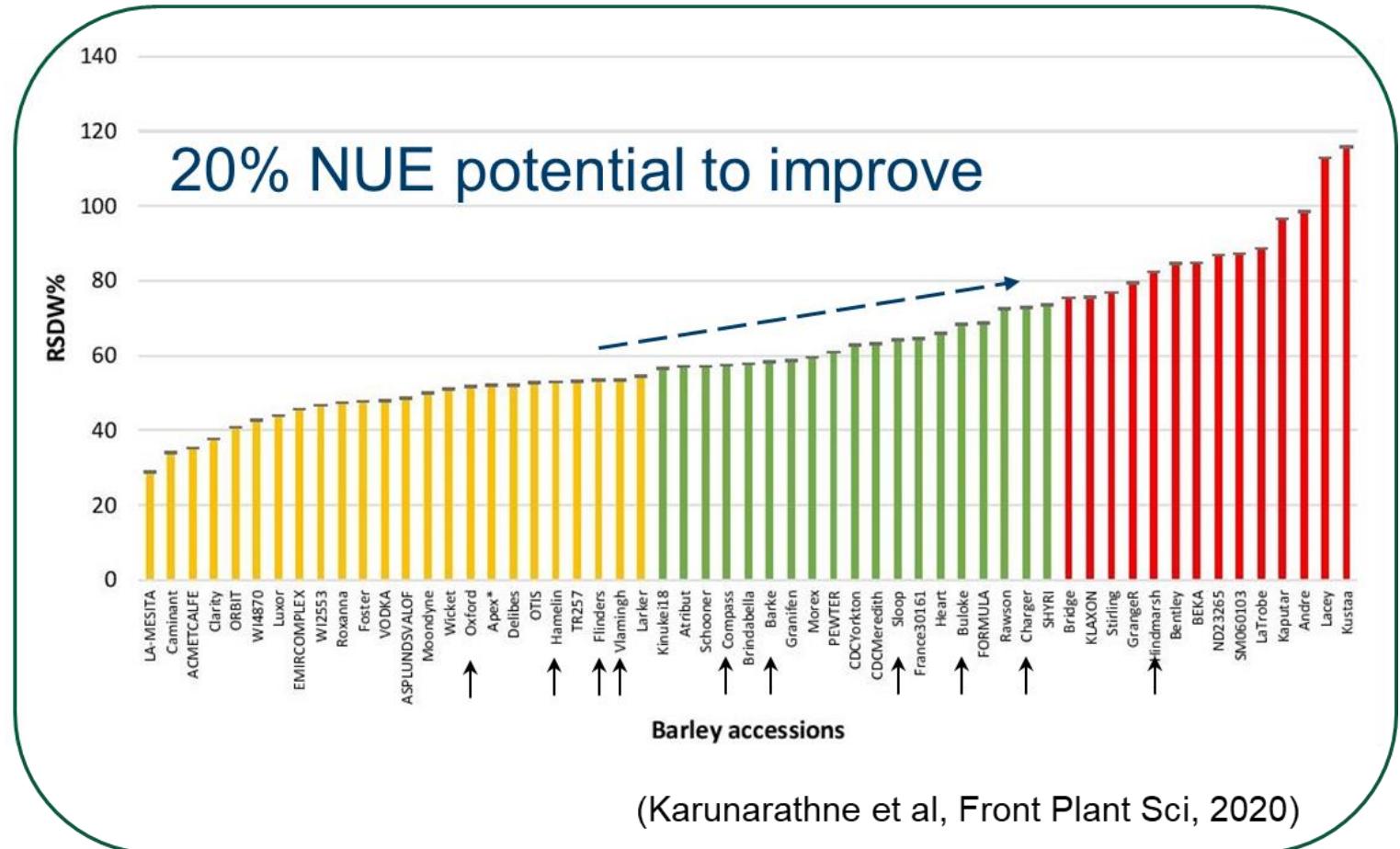
$\text{NH}_4^+ \rightarrow \text{NO}_3^-$



Complex N uptake and assimilation

(Daubresse et al, 2010)

Barleys are different in NUE



- Variations and low to medium NUE
- Struggling for desirable protein for export markets
- Variety for exploration

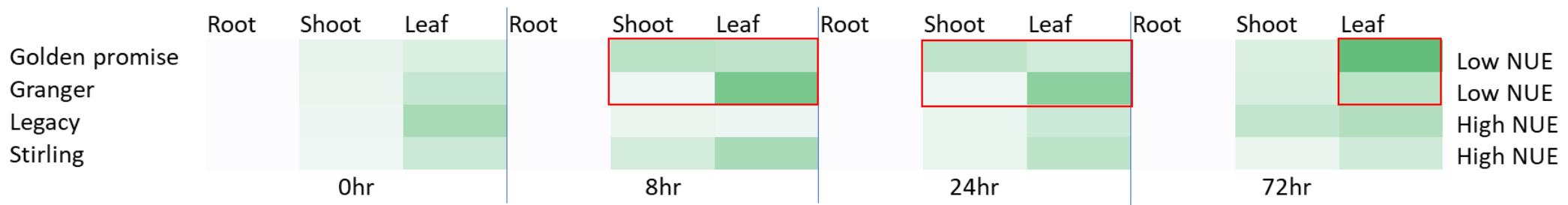
HvARE1 gene mapped under low-N

Marker	Trait	-log10 (p)	
L7H314872268	RSL	2.8	
L7H314872470	Leaves-treat	2.3	
D7H310311917	RRDW	2.7	
	RSDW	2.5	
	RSL	2.2	

overlap within a 0.4Mb region

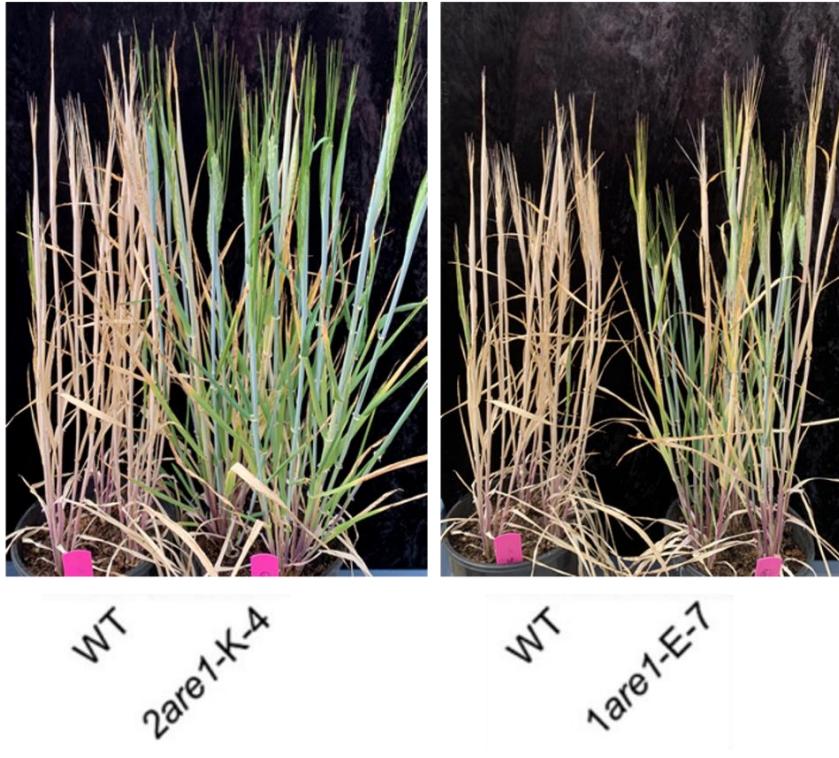
overlap within a 4Mb region

- It is a chloroplast envelope membrane protein



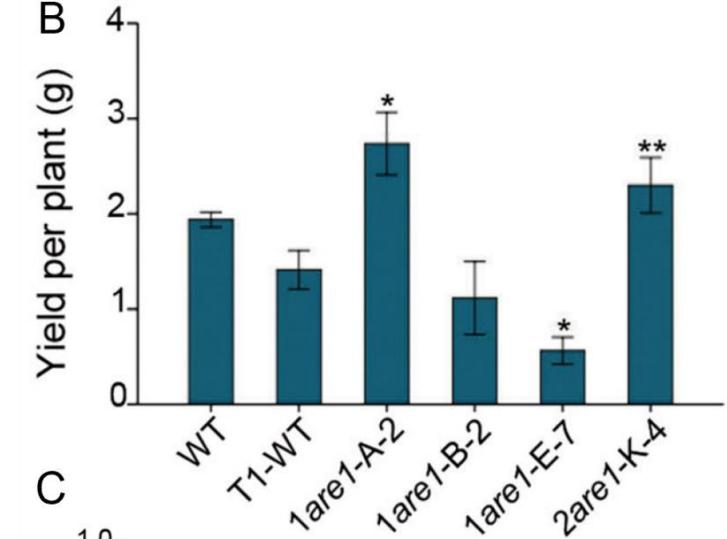
Improving barley NUE

A

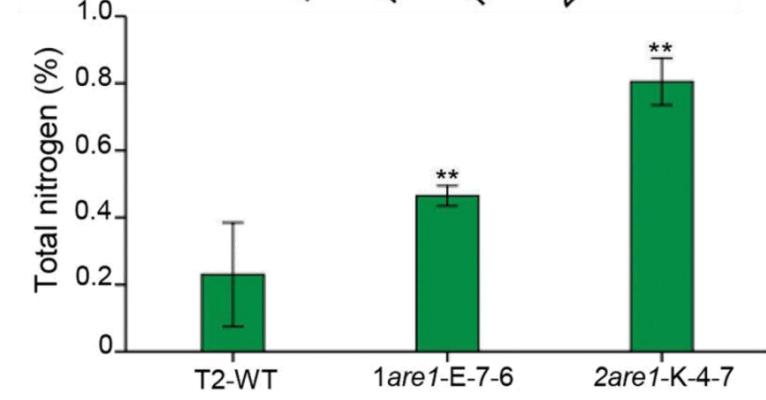


(Karunaratne et al, J Integr Plant Biol, 2022)

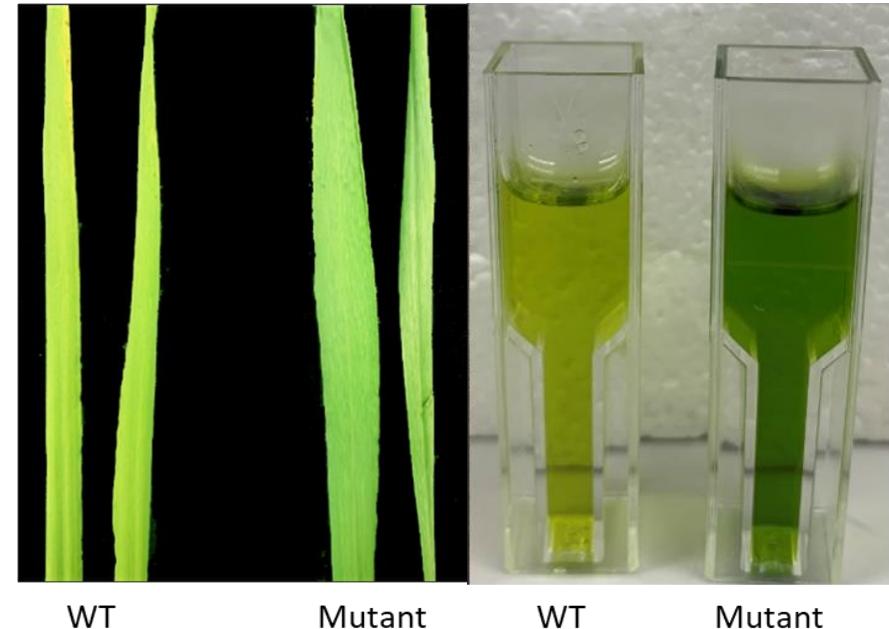
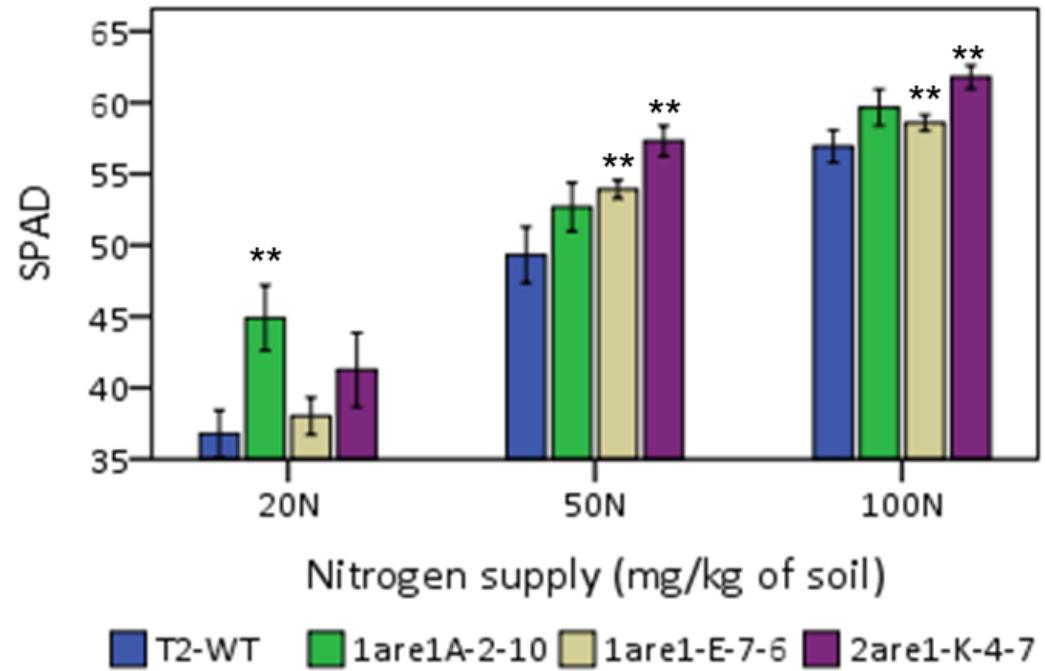
B



C



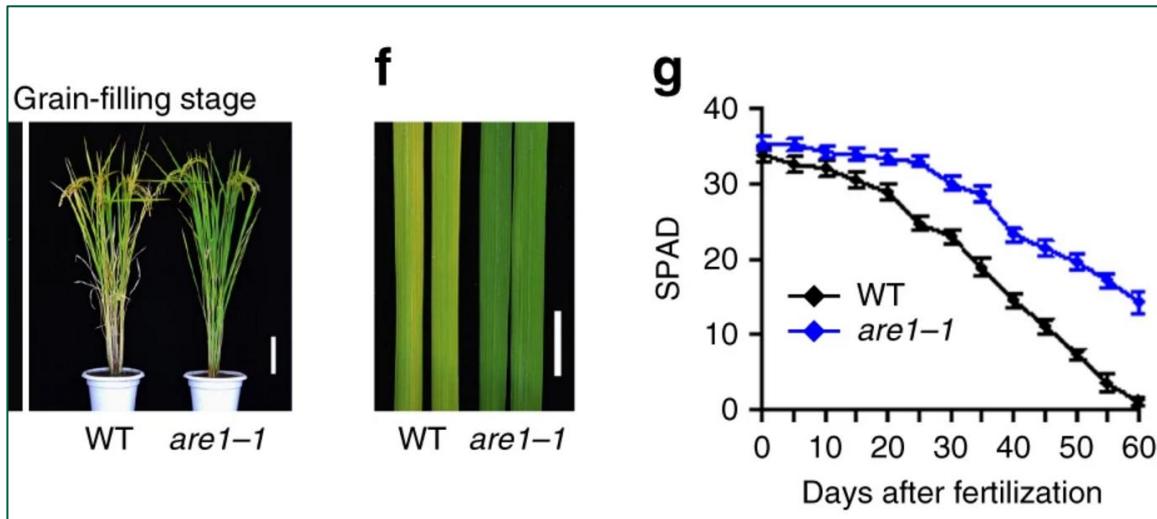
Improving barley NUE



(Karunaratne et al, J Integr Plant Biol, 2022)

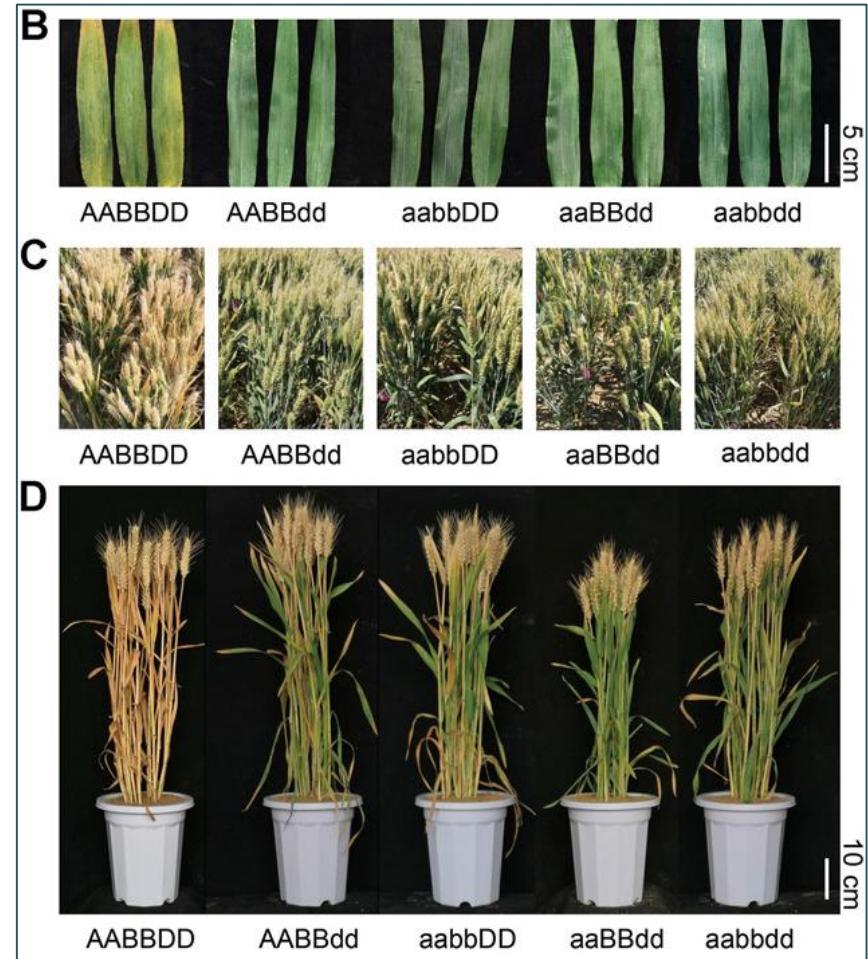
Same gene, similar function

Rice



(Wang et al., Nat. Commun., 2018)

Wheat

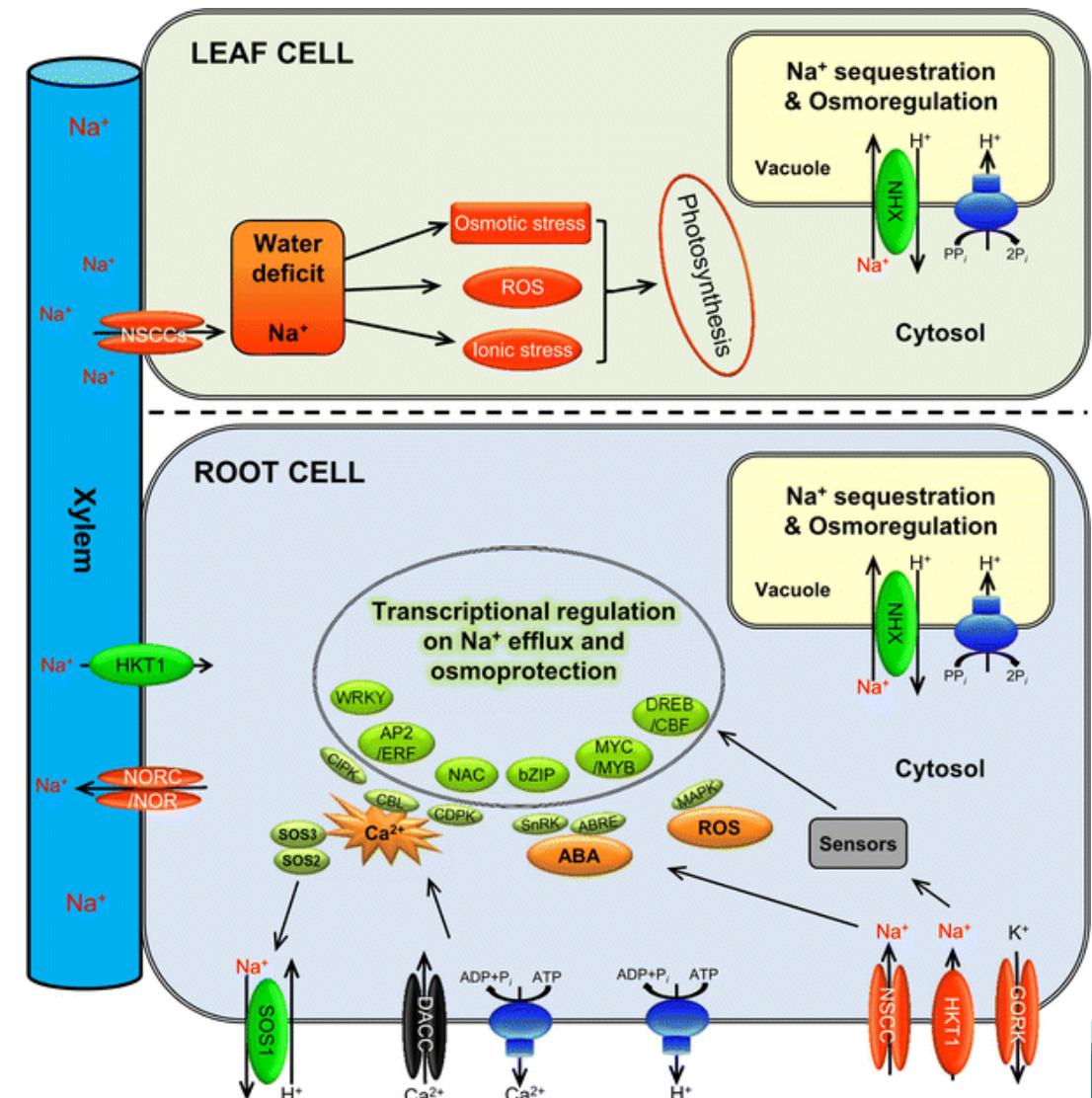


(Zhang et al., J. Integr. Plant Biol., 2021)

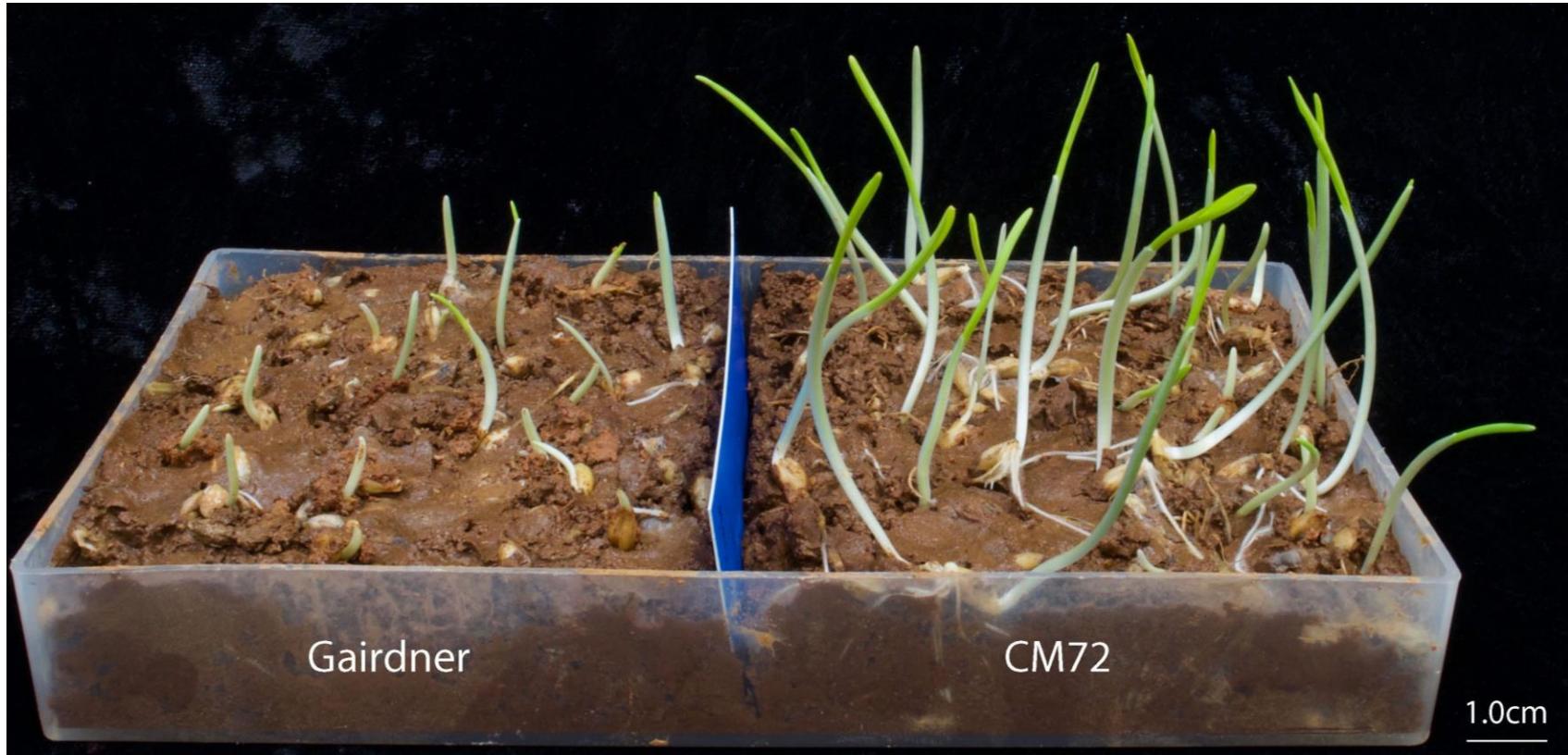
Salinity is complex

(Han et al. Plant Growth Regul., 2015)

- Multi-stress factors
- Tolerance varied in G/T/S
- Transfer tolerance to yield?

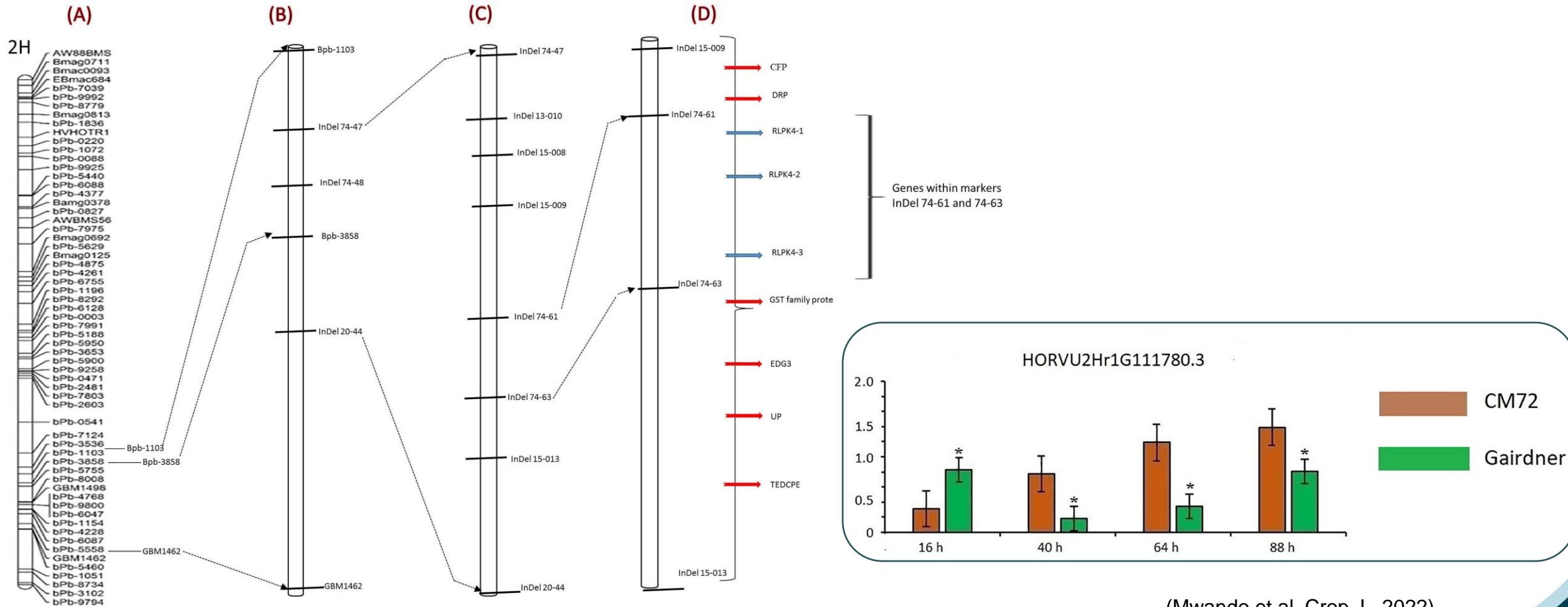


Salinity tolerance at germination



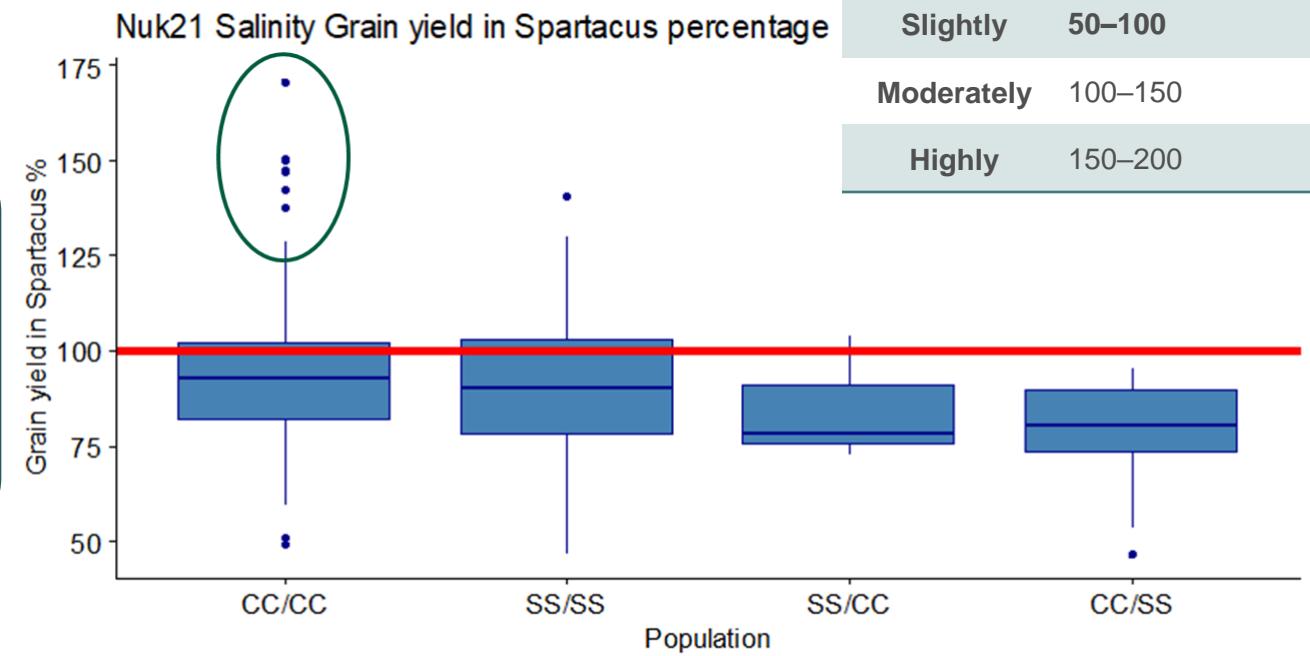
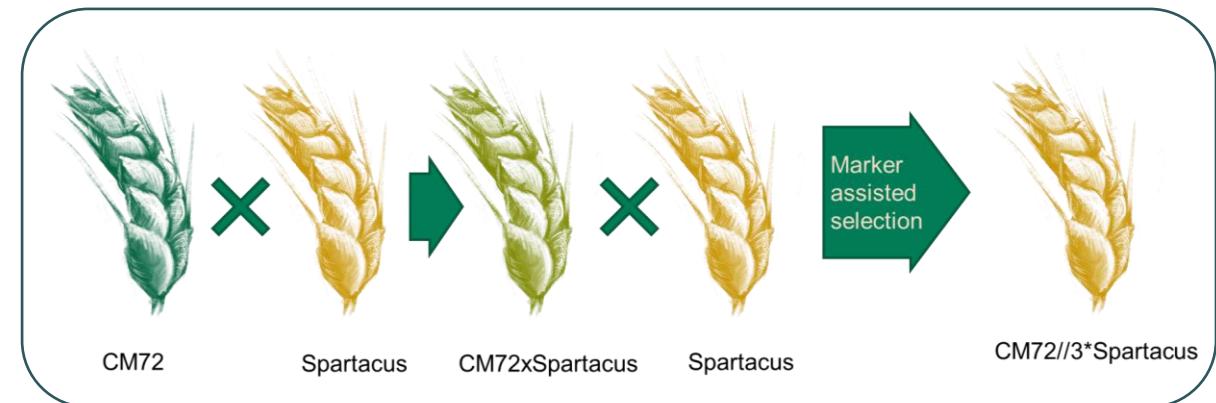
(Mwando et al, Crop J., 2022)

Mapping the gene



(Mwando et al, Crop J., 2022)

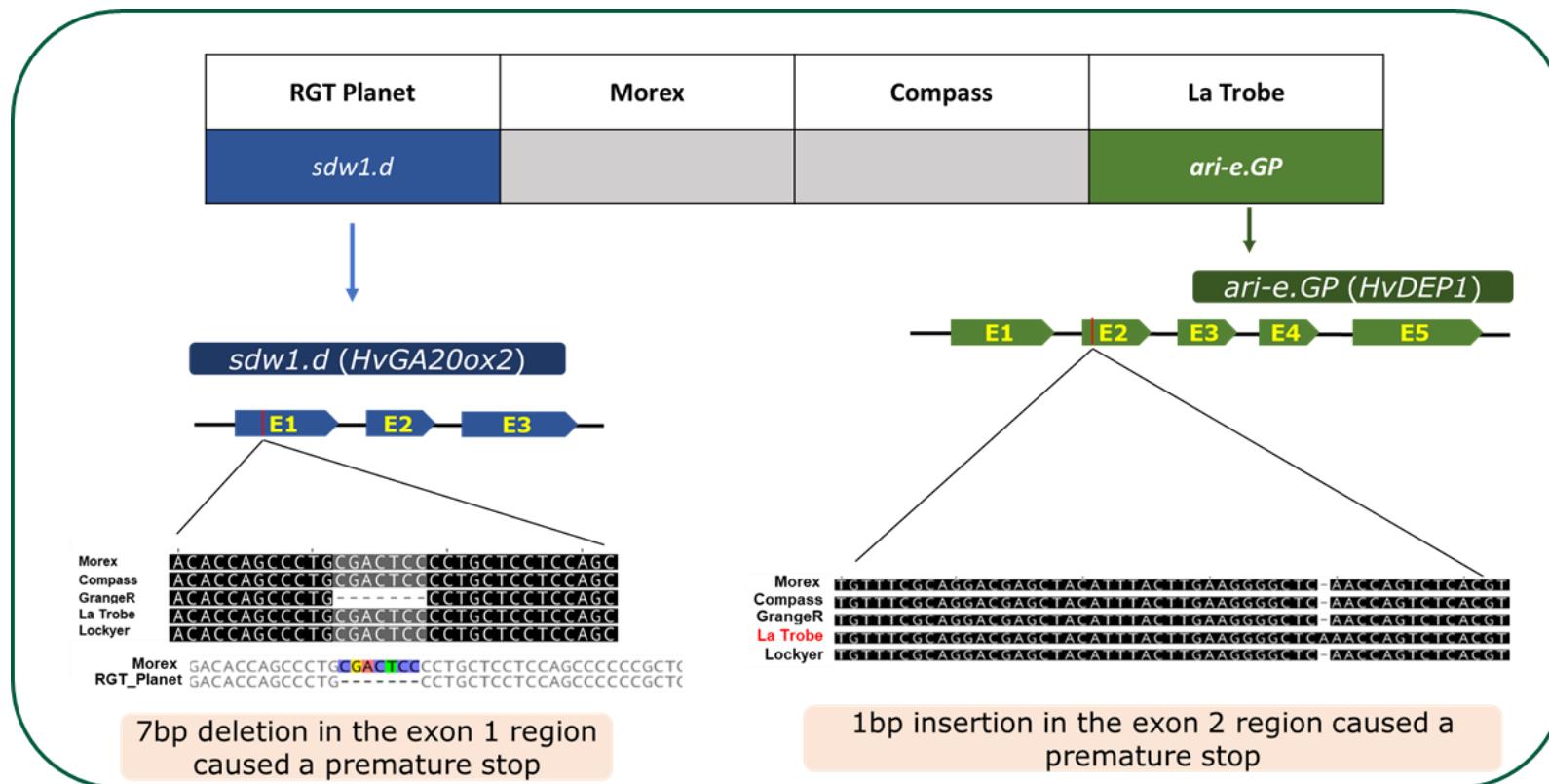
Introducing the gene to elite variety



(Price et al, unpublished)

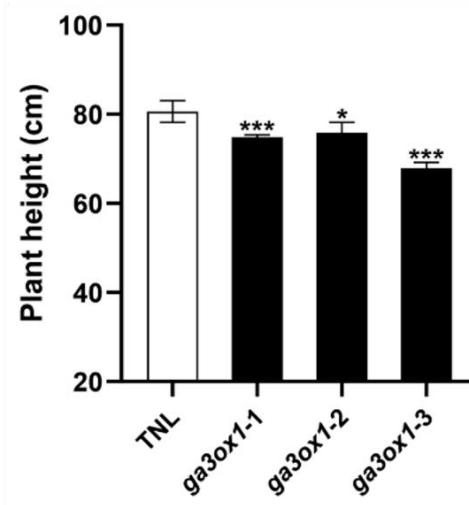
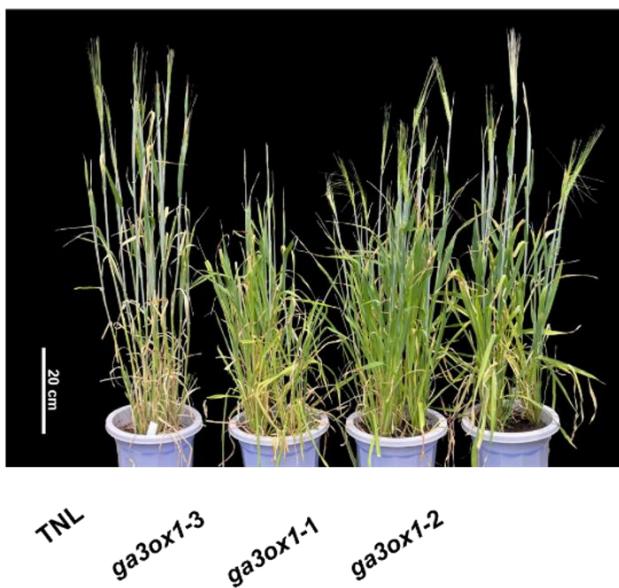
Key semi-dwarf genes in barley breeding

- “Green revolution” and grain yield
- Pleiotropic effects on maturity and coleoptile length

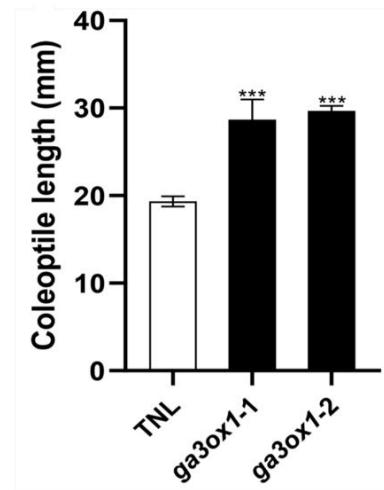


Semi-dwarf but longer coleoptile

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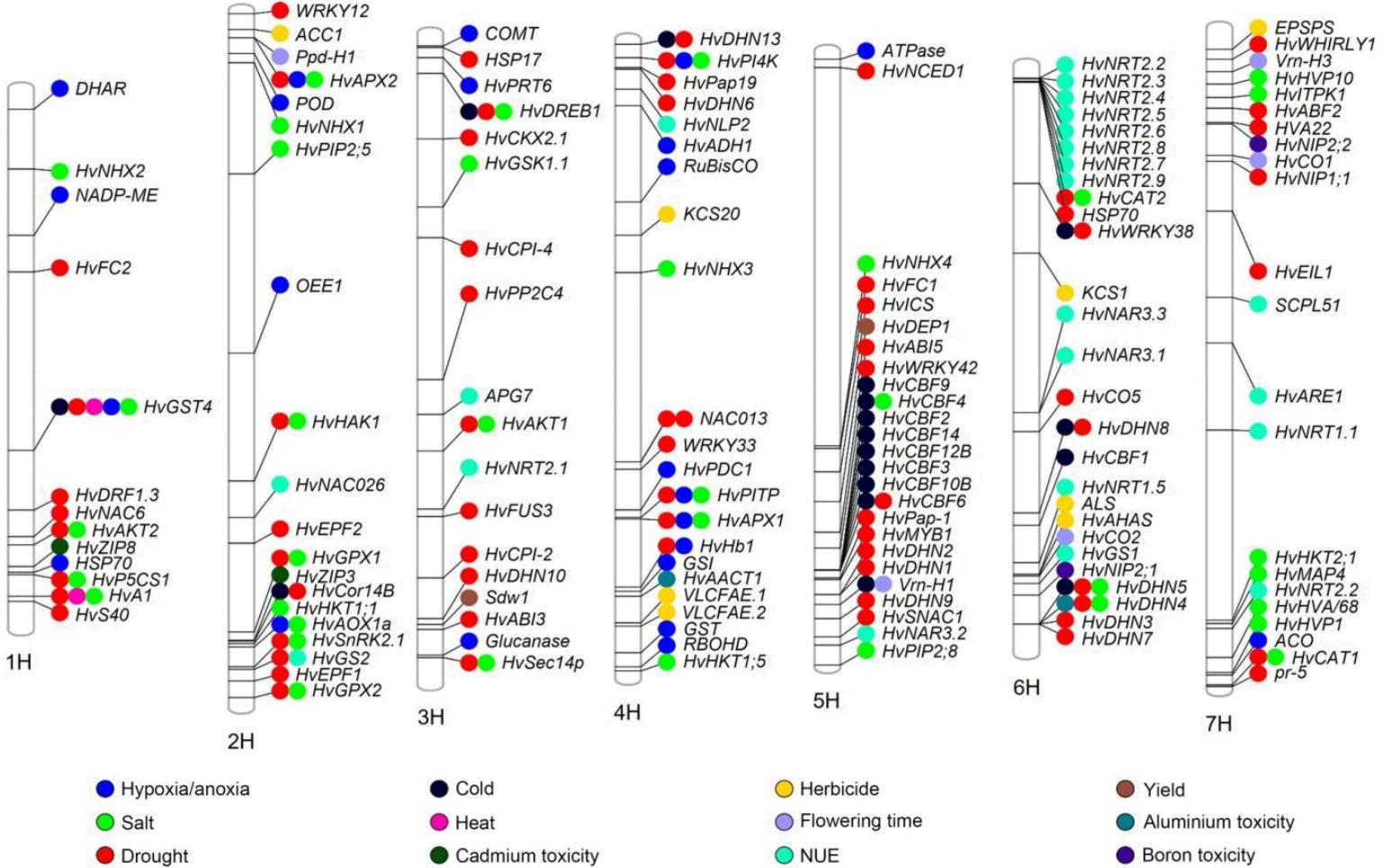
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(Cheng et al, Plant Biotech J, 2023)

Crop resilience map

(Karunaratne et al, J Zhejiang Univ Sci B, 2023)



Acknowledgements



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