***New Phytologist* Supporting Information**

Article title: Dynamics in plant roots and shoots to minimise stress, save energy and maintain water and nutrient uptake

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Supporting Information Table S1. Details of ion (Na^+, K^+, Cl^-, NO_3^{-2}, NH_4^+) and water transporters positioned in roots and shown in Figure 2, main text. Complete set of publications presented. [1]Label used in Figure 2, main text; *Protein function not fully understood or not characterized in cited study, ** protein localization as a result of promotor::GUS/LUC fusion.

Transp. Type	Fig. 2[1]	Species	Ion	Transporter	Location in plant root and inside the cell	*In planta* Transcript (t), protein (p) localization in publication	Publication
HKT	1a	Barley	Na^+, K^+	HvHKT1;1	Cell plasma membrane in root stele and epidermis radial root Na+ transport	t, p	Han et al. (2018)
	1b	Wheat	Na^+	TmHKT1;5-A	Xylem, plasma membrane	t	Munns et al. (2012)
		Barley	Na^+	HvHKT1;5	Root epidermis and root stele (transcript data)	t	Zhu et al. (2017)
		Barley	Na^+ *	*HKT1;5 and HKT2.4* (rice ortholog)	Seminal roots (maturation zone)	t	Hill et al. (2016)
		Barley	Na^+ ,K^+*	*HKT2.1* (rice ortholog)	Seminal roots (elongation and maturation zone)	t	Hill et al. (2016) (Mian et al., 2011)
		Barley	Na^+ ,K^+*	*HKT2.3* (rice ortholog)	Seminal roots (elongation zone and maturation zone)	t	Hill et al. (2016)
SOS1	1c	Arabidopsis	Na^+	SOS 1	Young root cells, root tip	p	Shi, (2002)
		Barley	Na/H	SOS1	Root epidermis and root stele (transcript data) Seminal roots (apex, elongation maturation zone)	t	Zhu et al. (2017), Hill et al. (2016)
NHX		Arabidopsis	Na/H	NHX6	Root apical region (meristem) Lateral root development	p	Dragwidge et al. (2018)

NPL	2a	Maize	Cl^-/NO_3^-	NPL6.4 & 6.6	Also selective for NO_3^{-2}, Plasma membrane localization.	p	Wen et al. (2017)
NPF		Arabidopsis	Cl^-	AtNPF2.4	Root stele, plasma membrane	t	Reviewed in Li et al. (2017)
	2b	Arabidopsis	Cl^-	AtNPF2.5	Plasma membrane, along the root length of 2week old Arabidopsis and in root-to –shoot junction. In cortical cells.	p	Li et al. (2016)
		Arabidopsis	Cl^-/NO_3^-	AtNRT1.5/ AtNPF7.3 AtNRT1.8/ AtNPF7.2	Stele specific, root xylem	t	Reviewed in Li et al. (2017)
SLAH		Arabidopsis	Cl^-	AtSLAH1	Root perycycle	t, p	Reviewed in Li et al. (2017)
		Arabidopsis	Cl^-/NO_3^-	AtSLAH3	Root perycycle (and stomatal guard cells)	t, p	Reviewed in Li et al. (2017)
CCC		Arabidopsis	Cl^-, Na_+, K_+	AtCCC	root vasculature, golgi and trans-golgi network	t, p	Reviewed in Li et al. (2017)
CLC		Arabidopsis	Cl^-/NO_3^-	AtCLC	Vacuolar tonoplast, root cells	p	Reviewed in Li et al. (2017)
KT-HAK-KUPs	3a	Arabidopsis	K^+	AtKUP7	Plasma membrane, ubiquitously expressed in mature root and stele of root tip.	p	Han et al. (2016)
	3b	Arabidopsis	K^+	AtHAK5	Strongly induced by K^+ starvation, expression strongest in epidermis and steele of primary root and epidermis of lateral roots.	t, p	Gierth et al. (2005)
		Rice	K	HAK5	root epidermis, parenchyma of stele tissue and primordial of the lateral root	t ,p	Yang et al. (2014)
Shaker like channel s		Barley	K^+	SKOR	Root stele	t	Zhu et al. (2017)
		Arabidopsis	K^+	SKOR	Root Stele, xylem parenchyma, epidermis	t, p**	Gaymard (1998)
		Arabidopsis	K	AKT2	Root Phloem	t, p**	Lacombe et al. (2000)
		Arabidopsis	K	GORK	Root hairs	t, p	Ivashikina et al. (2001)

NRT	4a	Arabidopsis	NO_3^-	AtNRT1.1 (CHL1)	Root tip, elongation zone in primary and lateral roots. It seems at the tip uniform distribution , in mature roots epidermal plasma membrane and central lamella	t, p	Guo et al. (2001), Guo, (2002)
	4b	Arabidopsis	NO_3^-	AtNRT1.9	phloem	t, p	Wang and Tsay (2011)
	4c	Arabidopsis	NO_3^-	AtNRT2.1	Periphery of epidermal cells (?!) Along the length of the primary root and at older regions of lateral roots	p t, p**	Chopin et al. (2007) (Remans et al., 2006)
CLC		Arabidopsis	NO_3^-	AtCLC-b	Vacuolar tonoplast, young roots, lateral roots	t, p	von der Fecht-Bartenbach et al. (2010)
AMT	5a	Arabidopsis	NH_4^+	AtAMT1;1	Epidermis, root hairs	t, p	Yuan et al. (2007)
	5b	Arabidopsis	NH_4^+	AtAMT1;2	Endodermis, Plasma membrane (root hair zone), Endodermis and cortex in mature region; Cortex in basal region of the root	t, p	Yuan et al. (2007)
	5c	Arabidopsis	NH_4^+	AtAMT1;5	Root tips; Root hair zone	t, p	Yuan et al. (2007)
	5d	Arabidopsis	NH_4^+	AtAMT1;3	Outer cortex (?!)	t, p	Yuan et al. (2007)
PIP	6a	Barley	Water	HvPIP2;1*	All cells near the tip, but epidermis and vascular bundles in maturing region.	t, p	Bramley et al. (2007)
		Arabidopsis	Water	PIP2;1	Epidermis, elongation zone (1 cm from apex). Located on PM but internalized to vacuoles upon NaCl treatment. Water permeability further increases when co-expressed with AtPIP1;2 or AtPIP1;5	p	Ueda et al. (2016), Prak et al. (2008), Byrt et al. (2017)

		Rice	Water*	OsPIP2;4, OsPIP2;5	Exodermis, cortex, endodermis PiP2s also in stelar tissue of Lateral root > crown root > primary root, Located on plasma membrane but become internalised upon NaCl or PEG treatment	p	Chu et al. (2018)
	6b	Maize	Water*	ZmPIP1;2	Highest in mature compared to elongating tissue, xylem parenchyma	t	Reviewed in Bramley et al. (2007)
		Maize	Water*	ZmPIP2;4 ZmPIP1;5 ZmPIP2;5 ZmPIP1;1, ZmPIP2;1,ZmPIP2;5, ZmPIP1;5			Reviewed in Bramley et al. (2007)
		Maize	Urea/ Water	ZmPIP1;5	Preferentially expressed in roots. Stele and cortex		Reviewed in Bramley et al. (2007)
		Rice	Water*	OsPIP1;1	Exodermis, cortex, endodermis	p	Chu et al. (2018)
		Barley	Water*	HvPIP1;2, HvPIP2;2, HvPIP2;5	Ubiquitous in all major root tissues (epidermis, cortex, endodermis, stele – but images show not in epidermis and HvPIP2;2 low expression in transition zone)	t	Knipfer et al. (2011)
		Barley	Water*	HvPIP2;7	Epidermis	t	Knipfer et al. (2011)
TIP	6c	Maize	Water	ZmTIP1	Meristems of primary and lateral roots. Epidermis, endodermis, xylem parenchyma of elongation zone. In mature roots highest in xylem parenchyma.	t	Reviewed in Bramley et al. (2007)
		Barley	Water*	HvTIP1;1,	Ubiquitous in all major root tissues (epidermis, cortex, endodermis, stele – but images show not in epidermis and HvPIP2;2 low expression in transition zone)	t	Knipfer et al. (2011)

		Barley	Water*	HvTIP2;3,	Epidermis	t	Knipfer et al. (2011)
		Bamboo	Water*	PeTIP4;1, PeTIP4;2	Epidermis, pith and vasculature, Expression correlated with root pressure	t	Sun et al. (2018)
		Arabidopsis	Water*	AtTIP1;2	Root cap	p	Gattolin et al. (2009)
		Arabidopsis	Water*	AtTIP1;1	Throughout root axis (especially endodermis and pericycle), but not root cap	p	Gattolin et al. (2009)
		Arabidopsis	Water*	AtTIP2;1	Lateral root primordium, Primary and lateral roots	p	Gattolin et al. (2009)
		Arabidopsis	Water*	AtTIP2;2	Cortex and epidermis, extends to pericycle as root matures	p	Gattolin et al. (2009)
		Arabidopsis	Water*	AtTIP2;3	Similar to TIP2;2 but initiates in pericycle; Primary and lateral roots	p	Gattolin et al. (2009)
		Arabidopsis	Water*	AtTIP4;1	Pericyle, especially xylem poles, absent from endodermis	p	Gattolin et al. (2009)
NIP		Arabidopsis	Water	AtNIP2;1	Most root cells, Most of young root, but higher expression in root elongation zone and stele. Mainly located in the ER membrane under ambient conditions. Low water channel activity – most likely functions as aquaglyceroporin	t, p	Mizutani et al. (2006)
		Arabidopsis	Lactic acid		Root cap and vascular cylinder. Zone of cell specialization in primary root, not in zone of cell division or elongation or in lateral roots	t, p	Choi and Roberts (2007)
		Rice	Boron	OsNIP3;1	Exodermis and stele. Root tip, elongation and root hair zones in B-deficient plants. Found in primary and lateral roots (but not root hairs) and especially regions of lateral root emergence	t, p**	Hanaoka et al. (2014)

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Supporting Information Table S2. Wheat root geometry used for model simulations in Figure 3, based on the micrographs shown in Figure 1.

Tissue Type	Seminal Root		Branch Root	
	Cells per tissue type	Tissue thickness (μm)	Cells per tissue type	Tissue thickness (μm)
Epidermis	43	6.2	38	2.5
Cortex layer 1	36	7.7	17	6.4
Cortex layer 2	29	7.0	9	7.0
Cortex layer 3	19	7.5	9	6.8
Cortex layer 4	19	5.2	-	-
Cortex layer 5	8	3.1	-	-
Endodermis	30	1.7	10	2.9
Stele	142	4.7	15	1.2

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