NUMERICAL DATA

Table 1: Effects of competition between As and Pi on uptake by plants grown in soil. (2018)

Soil types	Plant species	Addition	Effect	Reference
Soil	Zea mays	Fe (1e4 g/kg)	At low goethite / low As/high P uptake. At high goethite / no As/Pi uptake	Vetterlein et al. (2007)
Silt loam/sand	Zea mays	Pi (50e300 mg/kg)	Pi had little effect on As toxicity to plants in silt loam, but enhanced As uptake and toxicity in sand at 80 mgAs/kg	Jacobs and Keeney (1970)
Soil	Pteris vittata	As (2.7e5.3 mM)	Low As increased Pi uptake, but high As decreased Pi uptake. Pi increased plant biomass and As uptake at high As supply	Tu and Ma (2003a), Kertulis et al. (2005)
Soil	Oryza sativa	Pi	Increasing shoot Pi for breeding rice with low grain As	Lu et al. (2010)
Soil	Oryza sativa	Pi (0e0.5 mM)	Suppressed As(V), but not As(III) uptake; little difference in As uptake between two P-deprived rice genotypes	Abedin et al. (2002), Geng et al. (2006)
Clay loam	T. durum	Pi (75 kg/ha)	Prevented As uptake and translocation in plants	Pigna et al. (2010)
Soil	H. vulgare	Pi/As	Pi strongly inhibited As(V) uptake. As weakly inhibited Pi uptake	Asher and Reay (1979)
Soil-sand, soil	H. vulgare	Pi (20e120 mg/kg)	Increased As uptake; decreased As(V) toxicity not by lowering As uptake, but by enhancing Pi nutrition. No competition between As and Pi.	Christophersen et al. (2009a), Tao et al. (2006)
Soil	C. arietinum	Pi (50e400)	Pi increased As uptake, but partially protected membranes from damage	Gunes et al. (2009)
Soil	L. cinereus	As/Pi	High level of As and low Pi supply decreased plant growth	Knudson et al. (2003)
Loam soil	P. armeniaca	Pi	Increased shoot and root As in soil contaminated with Pb-arsenate pesticide residue.	Creger and Peryea (1994)
Soil	Arabidopsis thaliana	Pi (10e40 mg/kg)	Low Pi supply increased As uptake and plant growth. High Pi supply decreased As uptake due to competition on surface of soil particles and plant roots.	Geng et al. (2005)
Soil	Solanum lycopersicum	Pi (6 mM), As (4 mg/L)	Pi was more strongly adsorbed to soil than As(V), Pi desorbed As and increased As uptake by plants depending on soil charge properties	Pigna et al. (2012), Bolan et al. (2013)
Soil	H. lanatus	Pi (0.2 g/kg)	Increased As uptake by plant because of increased As desorption by competition	Lewinska and Karczewska (2013)
Soil	Plants	Pi	Enhanced As(V) and As(III) desorption from soil and thus leaching or uptake by plants	Fitz and Wenzel, 2002
As-Soil	Vegetable	Pi (3867)	Increased As uptake- 4.6e9.3 times for carrot, 2.5e10for lettuce	Cao and Ma (2004)
Soil	No plants	Pi/As	At As:Pi ratio equal to 1, more Pi was sorbed than As. At As:Pi ratios >1, Pi was desorbed due to a mass action effect	Woolson, (1973)
Fe-soil/mine soil	No plants	Pi	Reduced As(V) sorption to low Fe oxide soils and increased As mobility by competitive adsorption	Zupancic et al. (2012), Smith et al. (2002)

Table 2: Effect of competition between As and Pi on uptake by plants in hydroponics (2018)

Plant species	Addition	Effect	References
Pteris vittata	Pi (0.1e2 mM)	High Pi decreased As(V) but not As(III) accumulation in roots/shoot; it enhanced As(V) reduction; high As(V) decreased Pi uptake	Lou et al. (2010), Tu et al. (2004), Wang et al. (2002)
Oryza sativa	Pi, 0.1 mM	High Pi concentration decreased As uptake; high As concentration slightly decreased Pi uptake	Lihong and Guilan (2009)
Holcus lanatus	Pi	Decreased As(V) uptake in nonresistant, but less in resistant plants	Meharg and MacNair (1992)
Lemna gibba	Pi, 40 mg/L	High Pi reduced As(V, III) uptake; high As reduced Pi uptake	Mkandawire et al. (2004)
M.sativa	Pi	Strongly suppressed As uptake	Khattak et al. (1991)
Silene vulgaris	Pi, 0.3e3 mg/L	As supply did not influence root growth at high Pi, but did at low Pi supply	Sneller et al. (1999)
Avena sativa	Pi	Decreased As(V) uptake, but little effect on As(III) uptake.	Rumberg et al. (1960)
Glycine max	As, 32e96 mM	Decreased Pi content in soybean organs	Milivojevic et al. (2006)
T. aestivum	Pi	High-affinity uptake system switched on at 25 mM Pi.	Zhu et al. (2006)

Source: https://www.sciencedirect.com/science/article/pii/S0269749117340757

Critical gene families and representative genes from different species involved in As uptake, transport and metabolism. (2017)

Gene category	Gene name	Source	Manipulation	Consequence	Reference
Phosphate transporter (AsV transport)	AtPht1;1/4	A. thaliana	Knockout	Increased AsV tolerance	Shin et al., 2004
	OsPht1;8 (OsPT8)	O. sativa	Knockout	Decreased AsV uptake; Increased AsV tolerance	Wang et al., 2016
Aquaporins (AsIII transport)	Lsi1 (OsNIP2;1)	O. sativa	Knockout	Decreased As accumulation in straw of field-grown rice	Ma et al., 2008
	AtNIP1;1	A. thaliana	Knockout	Increased AsIII tolerance; Decreased As accumulation	Kamiya et al., 2009
	AtNIP3;1	A. thaliana	Knockout	Increased shoot As tolerance; Decreased shoot As	Xu et al., 2015
	PvTIP4;1	P. vittata	Overexpression (Arabidopsis)	AsIII sensitivity; Increased As accumulation	He et al., 2016
Arsenate reductase	AtACR2	A. thaliana	Knockout or overexpression	No effect on As accumulation	Liu et al., 2012
	AtHAC1	A. thaliana	Knockout	AsV sensitivity; Decreased As efflux from roots; Increased As accumulation in the shoots	Chao et al., 2014; Sanchez-Bermejo et al., 2014
	OsHAC1;1 & OsHAC1;2	O. sativa	Overexpression (rice)	Increased AsIII efflux into the external medium; Decrease As accumulation in rice grain	Shi et al., 2016
Glutaredoxin	PvGrx5	P. vittata	Overexpression (Arabidopsis)	Increased As tolerance; Decreased As in leaves	Sundaram et al., 2009
	OsGrx_C7 & OsGrx_C2.1	O. sativa	Overexpression (Arabidopsis)	Increased As tolerance; Decreased As accumulation	Verma et al., 2016
Phytochelatin synthase	CdPCS1	C. demersum	Overexpression (rice)	Decreased As accumulation in grain	Shri et al., 2014
NRAMP transporter (Fe/Mn/Cd/As transport)	OsNRAMP1	O. sativa	Overexpression (rice)	Increased As tolerance and accumulation	Tiwari et al., 2014
ABC transporter (Cd/Pb/As transport)	YCF1	S. cerevisiae	Overexpression (Arabidopsis)	Increased As tolerance and accumulation	Song et al., 2003; Guo et al., 2012
	AtABCC1/2	A. thaliana	Overexpression (Arabidopsis)	Increased As tolerance	Song et al., 2010
	OsABCC1	O. sativa	Overexpression (Arabidopsis)	Increased As tolerance	Song et al., 2014
ACR3 transporter (AsIII efflux)	ScACR3	S. cerevisiae	Overexpression (rice)	Increased As efflux; Decreased As in grain	Duan et al., 2012
	PvACR3	P. vittata	Overexpression (Arabidopsis)	Increased As efflux; Decreased As accumulation under AsIII in short-term exposure; Increased shoot As accumulation in soil in long-term cultivation	Chen Y. et al., 2013
ArsB/NhaD permease (AsIII efflux)	ArsB	E. coli	Knockout	As sensitivity and As accumulation	Meng et al., 2004
	Lsi2	O. sativa	Knockout	Decreased As accumulation	Ma et al., 2008
ArsM/AS3MT family (As methylation)	RpArsM	R. palustris	Overexpression (rice)	Produced methylated volatile arsenic	Qin et al., 2006; Meng et al., 2011
	CmArsM7/8	C. merolae	Expression (E. coli)	Conferred resistance to AsIII	Qin et al., 2009
	CrarsM	C. reinhardtii	Overexpression (Arabidopsis)	As methylation to DMA^V and As sensitivity	Tang et al., 2016
Inositol transporters (As transport)	AtINT2/4	A. thaliana	Knockout	Lower shoot As accumulation	Duan et al., 2015
CRT-like transporter (Glutathione homeostasis)	OsCLT1	O. sativa	Knockout	Lower As accumulation in roots but higher or similar As accumulation in shoots	Yang et al., 2016

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5331031/

Table 1. Selected references of arsenic (As) concentration in soil and groundwater in different parts of the world. (2016)

Arsenic in soil				Arsenic in ground water		
Country/Region	**Location**	**As concentration (mg kg^{-1})**	**Reference**	**Location**	**As concentration (μg L^{-1})**	**Reference**
Bangladesh	Tala Upazilla	3.2–51.8	Ahmed et al., 2011a, Ahmed et al., 2011b	Bengal Delta Plain	22–1000	Jiang et al. (2013)
India	Central India	16–417	Das et al. (2013)	Uttar Pradesh	43.75–620.75	Srivastava and Sharma (2013)
Pakistan	Punjab	7–35	Farooqi et al. (2009)	Punjab Mailsi	11–828	Rasool et al. (2016)
Taiwan	Taipei	4.71–513 dry weight	Lin et al. (2013)	Chianan Plain	10–1800	Chen and Liu (2007)
China	Inner Mongolia	154–238	Neidhardt et al. (2012)	Huhhot Basin Inner Mongolia	up to 1860	Guo et al. (2014); He et al. (2010)
USA	Hawaii	15–950	Hue (2010)	Tulare Lake	2600	Cutler et al. (2013)
Brazil	Minas Gerais	200–860	Bundschuh et al. (2012)	Minas Gerais	0.4–350	Mukherjee et al. (2006)
Chile	Chiu-Chiu	41.12–65.72	Díaz et al. (2011)	Northern Chile	60–80	Sancha and O'Ryan (2008)
Mexico	Durango	55–221.1	Morales et al. (2015)	Zimapan (Salamanca aquifer system)	190–650	Armienta and Segovia (2008)
Spain	Salamanca	70–5330	Otones et al. (2011)	Duero Cenozoic Basin	40.8 (mean)	Gómez et al. (20

Table 2. Arsenic (As) transporters recently found in different plant species. (2016)

Transporter name	Group	Plant species	Transport processes	As species	Reference
AtINT2; AtINT4	Inositol transporters	*Arabidopsis*	Phloem translocation, a possible arsenic translocation to the seeds	As^{III}	Duan et al. (2016)
AtNIP3;1	Aquaporin	*Arabidopsis*	Uptake; translocation root to shoot	As^{III}	Xu et al. (2015)
AtPHT1;4; AtPHT1;7	Phosphate transporter	*Arabidopsis*	Uptake	As(V)	LeBlanc et al. (2013)
AtABCC1 and AtABCC2	ABC transporter	*Arabidopsis*	As^{III}-PC complex transport	As^{III}-PC	Song et al. (2010)
OsPHT1;1	Phosphate transporter	Rice	Uptake and translocation root to shoot	As(V)	Kamiya et al. (2013)
OsNIP3;3; OsNIP3;2	NIP aquaporin	Rice	Transport	As^{III}	Katsuhara et al. (2014)
OsNRAMP1	NRAMP transporter	Rice	Mediated xylem loading	As^{III}	Tiwari et al. (2014)
OsABCC1	ABC transporter	Rice	Vacuole transporter	As^{III}-PC	Song et al. (2014b)
HvNIP1;2	NIP aquaporin	Barley	Transport	As^{III}	Katsuhara et al. (2014)
PvPht1;3	Phosphate transporter	*Pteris vittata*	Transport	As^{V}	DiTusa et al. (2016)
PvTIP4;1	TIP aquaporin	*Pteris vittata*	Uptake	As^{III}	He et al. (2016)

Source: https://www.sciencedirect.com/science/article/pii/S0098847216301629#tbl0010

Table 5. As concentrations (mg kg^{-1} dry wt.) in shoot and root tissues and As, Fe and Mn concentrations (mg kg^{-1} dry wt.) on root surfaces, As translocation factors (%) and tolerance indices (%) for 9 species of wetland plants grown in soils without and with 60 mg As kg^{-1} for 3 months (mean ± S.E., n = 4). (2012)

Species	**As in shoot tissue**		**As in root tissue**		**As on root surface**		**Fe on Root surface**	**Mn on Root surface**	**TF (%)**	**TI (%)**
	CK	60	CK	60	CK	60	60	60	60	60
Alternanthera philoxeroides	0.05±0.01	5.6 ±0.1	5.8± 0.2	1895±58	4.3 ±0.3	250 ±3.6	4371 ±39	61 ±4.5	0.26	91.6
Ammannia baccifera	0.25 ±0.01	11 ± 1.7	0.82 ±0.1	2497 ± 8	7.6 ±0.1	253 ±5.9	4277 ±81	70 ±2.4	0.39	74.8
Cuphea balsamona	1.7 ± 0.16	13 ± 0.7	1.1±0.03	2713 ±13	6.0 ±0.6	320 ±5.5	5683 ±23	63 ±2.5	0.44	85.1
Rotala rotundifolia	0.26 ±0.01	14 ± 4.1	2.8±0.1	3295 ±50	6.0 ±0.5	544 ± 15	7749 ±30	96 ±3.2	0.36	96
Polygonum lapathifolium	0.31 ±0.03	10 ± 0.4	6.4±0.2	1208 ±57	5.9 ±0.5	75 ± 0.7	4093 ±31	25 ±1.3	0.79	65.9
Eleocharis caribaea	1.2 ± 0.01	10 ± 2.1	1.8± 0.1	1827 ±24	1.0 ±0.1	243 ±9.4	4224 ±18	55 ±1.5	0.49	52.8
Eleocharis plantagineifor	1.8 ± 0.02	20 ± 1.5	1.5± 0.1	2211 ±22	4.5 ±0.3	129 ±1.9	2057 ±14	35 ±1.6	0.86	63.7
Fimbristylis nutans	2.4 ± 0.04	45 ± 7.9	3.3± 0.2	2901 ±21	4.5 ±0.3	134 ±2.3	1613 ±16	30 ±1.7	1.49	65.7
Echinochloa colonum	1.2 ± 0.04	6.7 ±0.3	6.3± 0.2	973 ± 30	2.7 ±0.2	171 ±2.9	3699 ±60	33 ±1.4	0.59	80.8

Source : Tripathi and Srivastava et al.2012

The rate of Rate of radial Oxygen Loss, shoot biomass, tolerance indices (% of control) for 18 species of wetland plants grown in 0.1% agar solution without As (CK) (2011)

Species	**Rate of ROL**	**Shoot biomass**			**Tolerance index (%)**	
	CK	CK	0.8	1.6	0.8	1.6
Alternanther a	697± 13	0.40 ± 0.05	0.27± 0.02	0.21± 0.02	69.0	52.1
Ammannia baccifera	673± 15	0.19 ± 0.04	0.17± 0.04	0.17± 0.02	93.7	93.9
Cuphea balsamona	887± 2	0.31± 0.03	0.32± 0.01	0.22± 0.03	104.6	72.1
Rotala rotundifolia	1750± 29	0.12± 0.02	0.12± 0.01	0.11± 0.01	106.4	97.6
Polygonum lapathifoliu	411± 8	0.31± 0.03	0.30± 0.02	0.28± 0.03	96.0	89.8
Veronica serpyllifolia	261± 1	0.17± 0.01	0.11± 0.01	0.12± 0.01	61.8	67.8
Hydrocotyle vulgaris	1663± 40	0.05± 0.01	0.05± 0.01	0.04± 0.01	92.1	75.0
Echinodorus amazonicus	164± 7	0.20± 0.03	0.08± 0.01	0.06± 0.01	39.9	27.0
Echinodorus osiris	705± 19	0.33± 0.03	0.21± 0.01	0.21± 0.06	64.6	64.8
Echinodorus tenellus	461± 18	0.74± 0.03	0.56± 0.03	0.53± 0.06	76.0	71.5
Cyperus alternifolius	648± 19	0.38± 0.03	0.31± 0.03	0.30± 0.02	80.9	78.7
Eleocharis caribaea	627± 8	0.14± 0.01	0.14± 0.02	0.10± 0.02	103.1	73.0
Eleocharis plantagineiformis	169± 8	0.14± 0.01	0.11± 0.01	0.06± 0.01	79.1	40.9
Fimbristylis nutans	63± 6	0.45± 0.08	0.18± 0.02	0.24± 0.02	41.2	52.7
Echinochloa colonum	425± 18	0.23± 0.04	0.21± 0.03	0.12± 0.01	93.1	54.5
Myriophyllum spicatum	662± 12	0.15± 0.03	0.19± 0.01	0.16± 0.02	121.4	105.5
Vallisneria natans	1065± 18	0.07± 0.01	0.03± 0.01	0.03± 0.01	48.4	42.3
Philydrum lanuginosum	55± 1	0.40± 0.08	0.11± 0.01	0.15± 0.01	28.7	36.6

Source : H. Li, Z.H. Ye et al.2011