B.A.T.A. BACTERIAL-ASSISTED ADSORPTION TECHNOLOGY FOR ARSENIC REMOVAL FROM WATER

Con il contributo di Fondazione CARIPLO

MILANO
23 MARZO 2018
FACOLTÀ DI SCIENZE AGRARIE E ALIMENTARI
AULA MAGGIORE, VIA CELORIA 2

CONVEGNO
ARSENICO NELL'AMBIENTE
AZIONI DI MITIGAZIONE PER LA PROTEZIONE DELLA SALUTE UMANA

Traslocazione di arsenico in piante agrarie e mitigazione del rischio

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Variabilità dell'accumulo di As nelle specie vegetali

[As] nei suoli: 5 mg kg^{-1} < 10 mg kg^{-1} non contaminato > 10^2-10^3 mg kg^{-1} fortemente inquinato

Wolffia globosa

Oryza sativa

Hordeum vulgare

<1 mg kg^{-1}

>1.0000 mg kg^{-1}

20.000 mg kg^{-1}

Alberi da frutto

Triticum aestivum

Isatis cappadocica

Equisetum

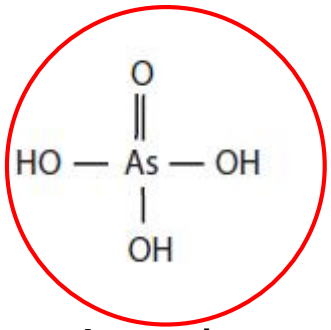
Pteris vittata

Transfer factor (TF)

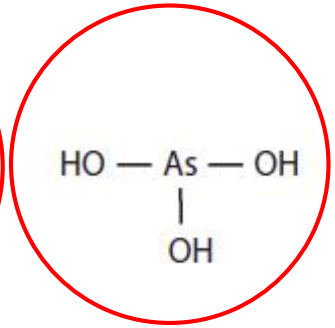
< 0,1 1,0 >> 1,0

UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI SCIENZE AGRARIE
E AMBIENTALI - PRODUZIONE,
TERRITORIO, AGROENERGIA

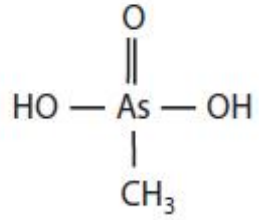
Forme principali di As nei suoli e nelle piante



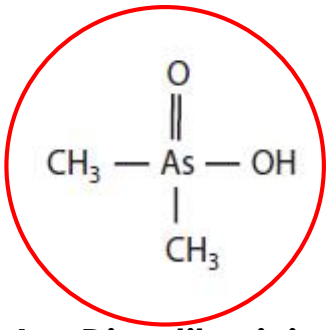
Arsenato



Arsenito

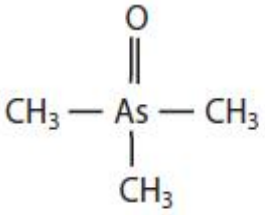


Ac. monometilarsonico (MMA)

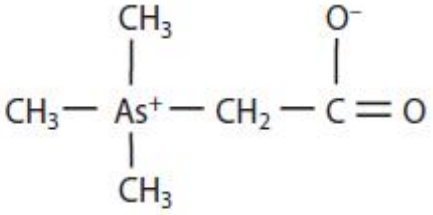


Ac. Dimetilarsinico (DMA)

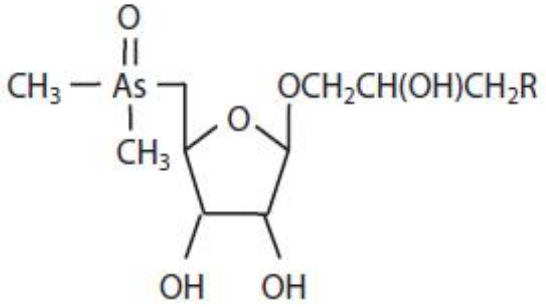
As_i



Ossido di trimetil arsina



Arsenobetaina



Arsenozuccheri

Livelli di As nella granella del riso

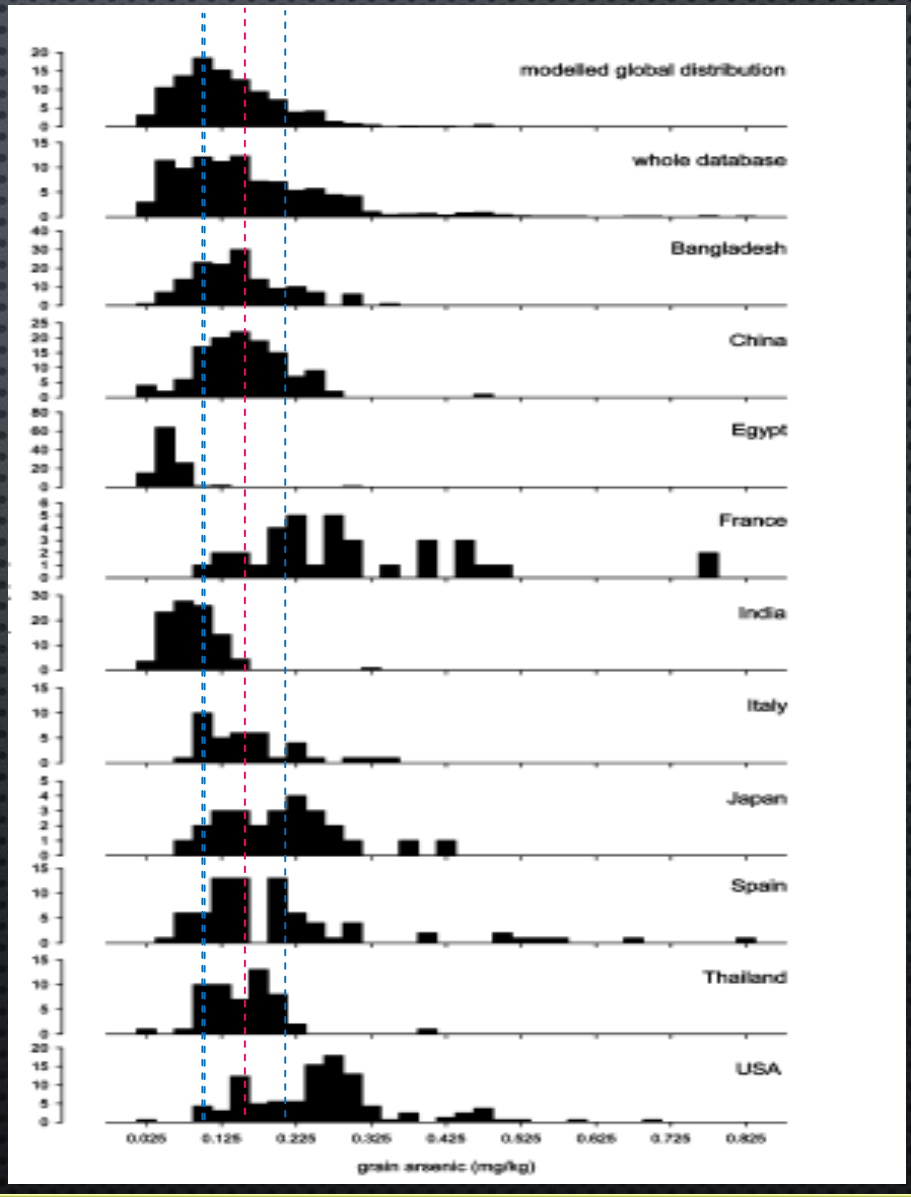
901 campioni a livello globale

Range: 10-820 µg kg^{-1}

Media: 150 µg kg^{-1}

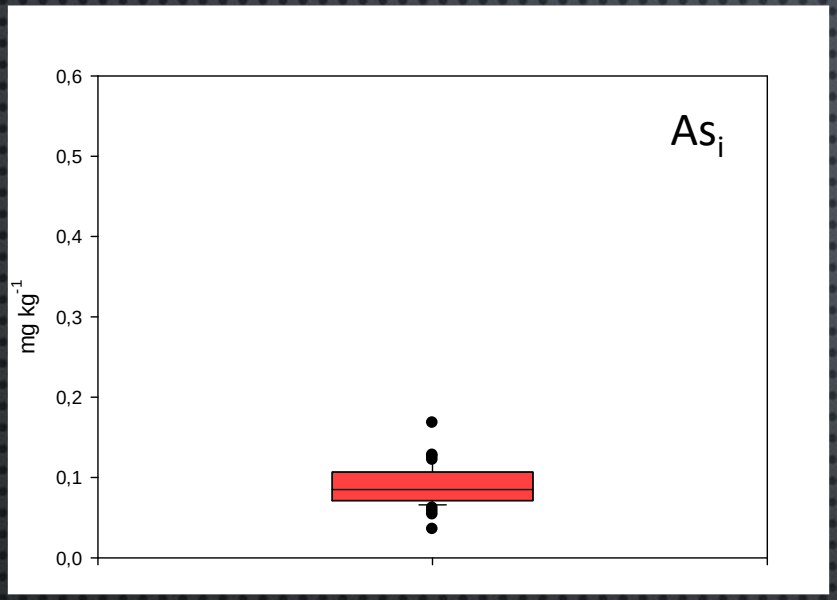
«Range di normalità»: 80-200 µg kg^{-1}

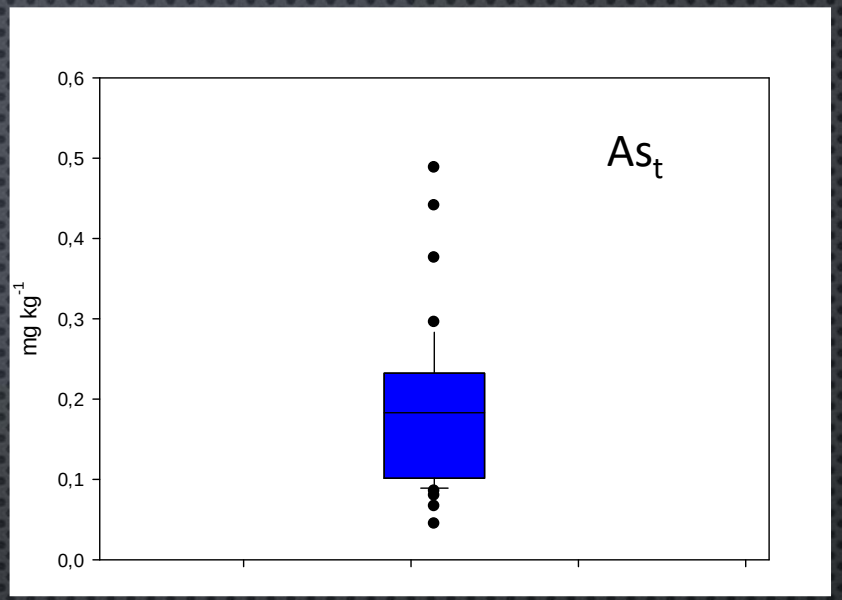
Frumento:
≤ 50 µg kg^{-1}; valore medio ≈ 9 µg kg^{-1}

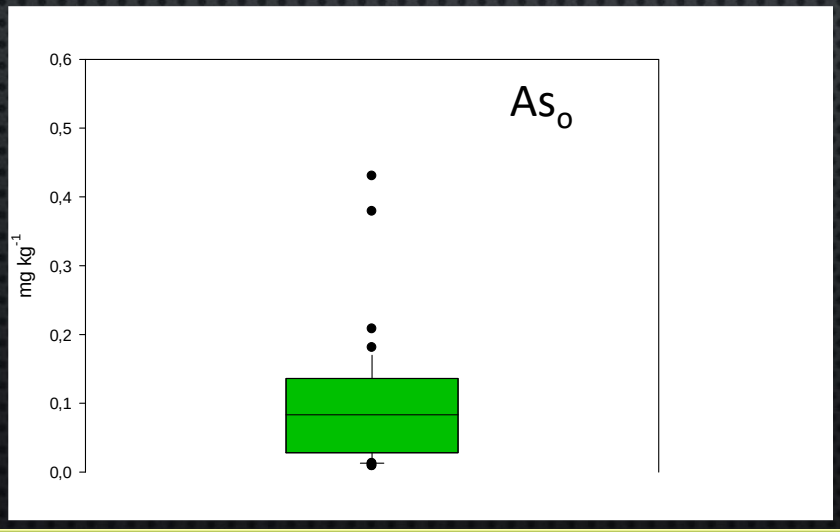


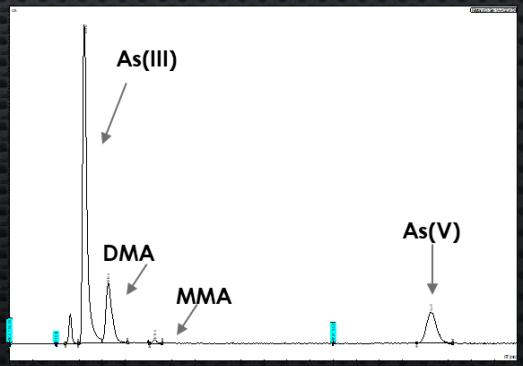
Meharg et al. (2009) *Env Sci Tech*, 43:1612.1627
Cubadda et al. (2010) J. Agr. Food. Chem., 58: 10176-10183

Analisi dei livelli di As in campioni commerciali di riso









Perchè il riso e possibili interventi per la mitigazione del rischio

Perchè il riso tra i cereali e quello maggior rischi di accumulo di As in granella?:

- Nei suoli anaerobici la forma AsIII, la più facilmente assorbita, è predominante
- Il riso è una specie che accumula Si, e l'AsIII è assorbtio e traslocato con i trasportatori del Si
- Nei suoli anaerobici sono attivi microrganismi che riducono l'As ad arsina (AsH_3), monometilarsina (MMA), dimetilarsina (DMA) e trimetil arsina (TMA)

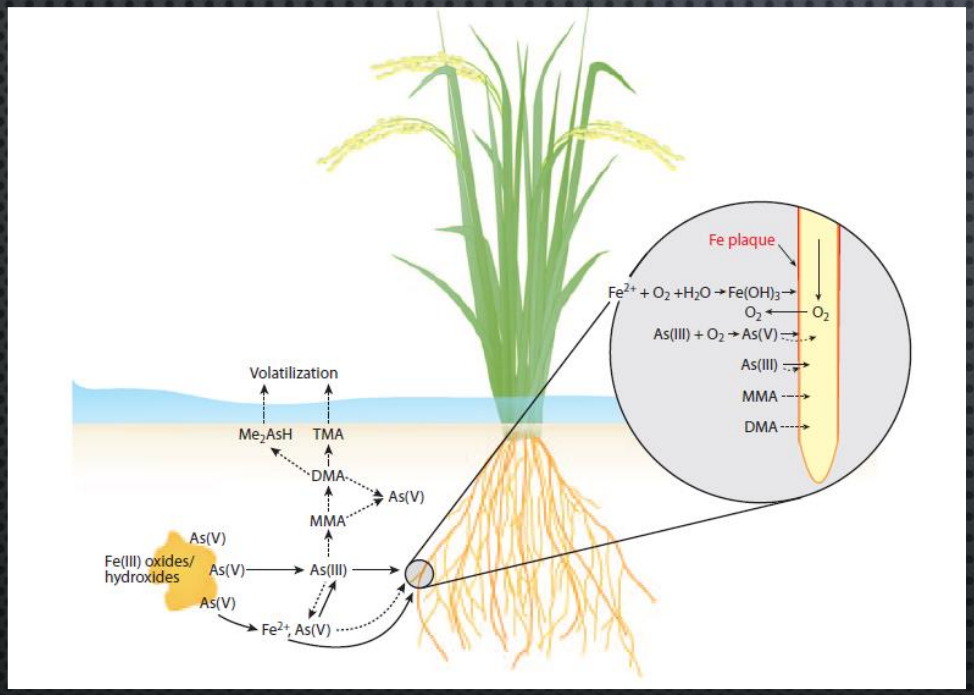
Definizione di limiti normativi per la commercializzazione (As_i):

- Riso lavorato non parboiled (riso brillato o bianco) < 0,20mg kg^{-1}
- Riso parboiled e riso semigreggio < 0,25mg kg^{-1}
- Cialde di riso, cialdine di riso, cracker di riso e dolci di riso < 0,30 mg kg^{-1}
- Riso destinato alla produzione di alimenti per lattanti e i bambini < 0,10 mg kg^{-1}

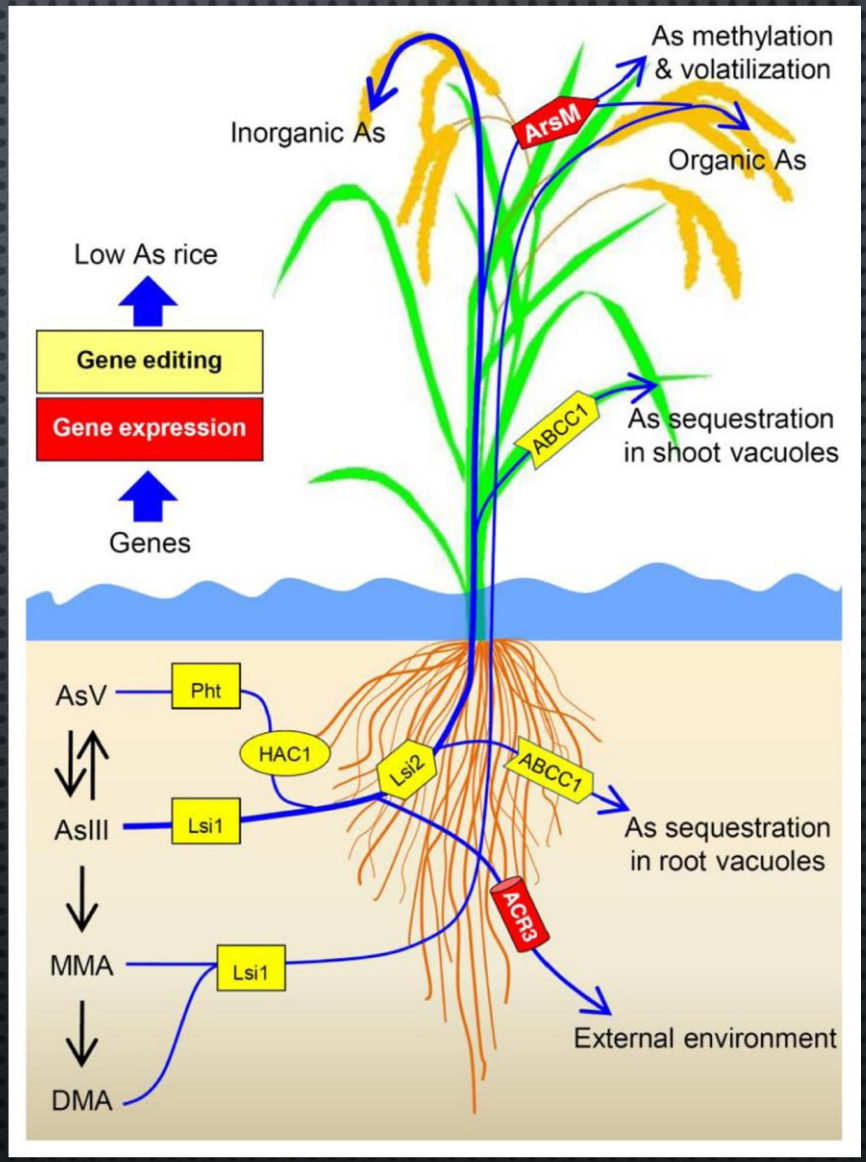
Stategie di intervento sistemiche:

- Identificazione delle cause di contaminazione di suoli e/o acque (fertilizzanti, concimi, ammendanti, antiparassitari, geopedologia e idrologia……) e loro rimozione/contenimento
- Bonifiche dei suoli contaminati (uso di iperaccumulatrici, piante per biomassa o fibre)
- Agrotecniche adeguate (gestione dell'acqua, ammendanti, fertilizzazioni…)
- Variabilità naturale (genotipi produttivi con tendenza ad escludere l'As dalle parti eduli)
- Miglioramento genetico per il/i tratto/i di esclusione dell'As dalle parti eduli
- Interventi biotecnologici (OGM, non-OGM, Genome Editing)

Mobilizzazione e flussi di As nel Sistema suolo-pianta



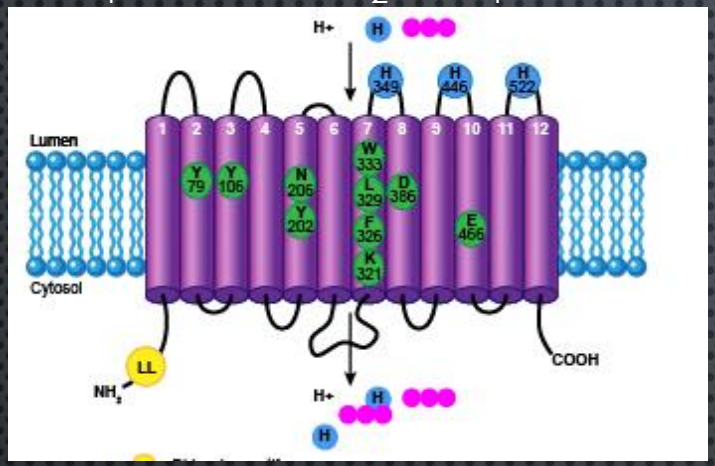
Zhao et al. (2010) Annu. Rev. Plant Biol., 61: 535-559

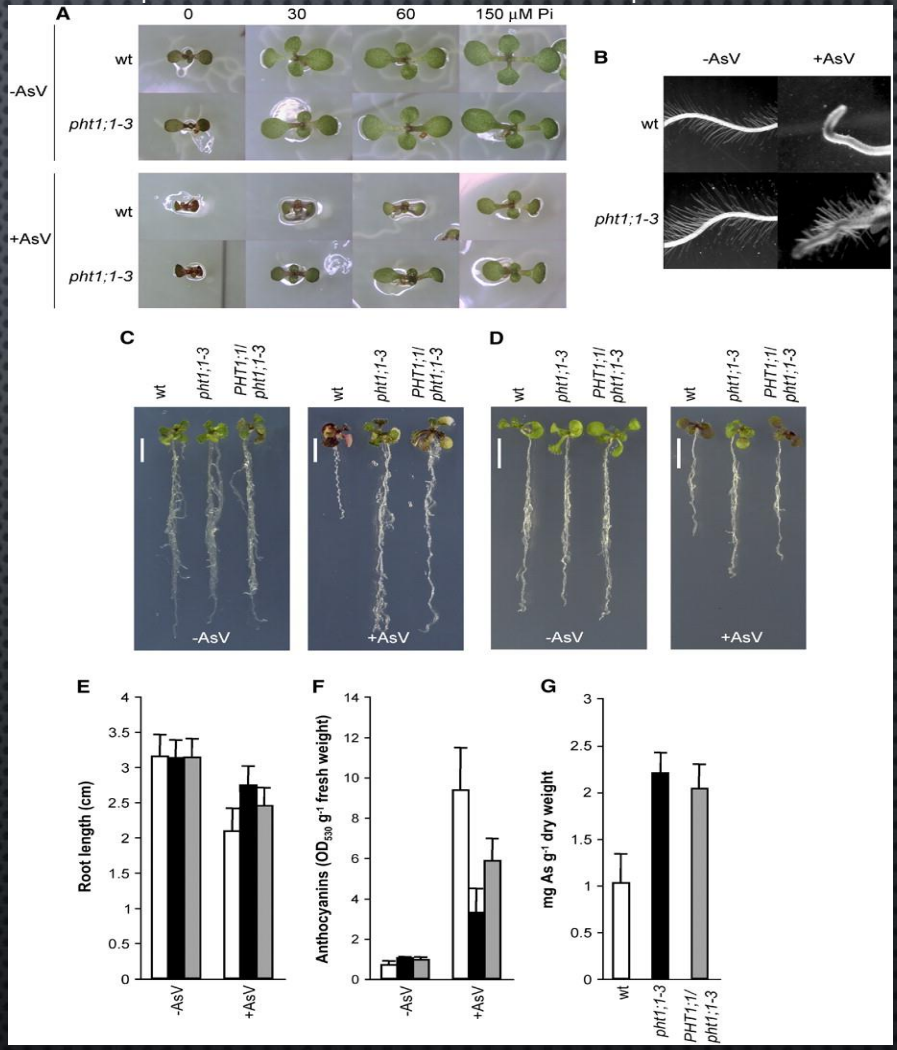


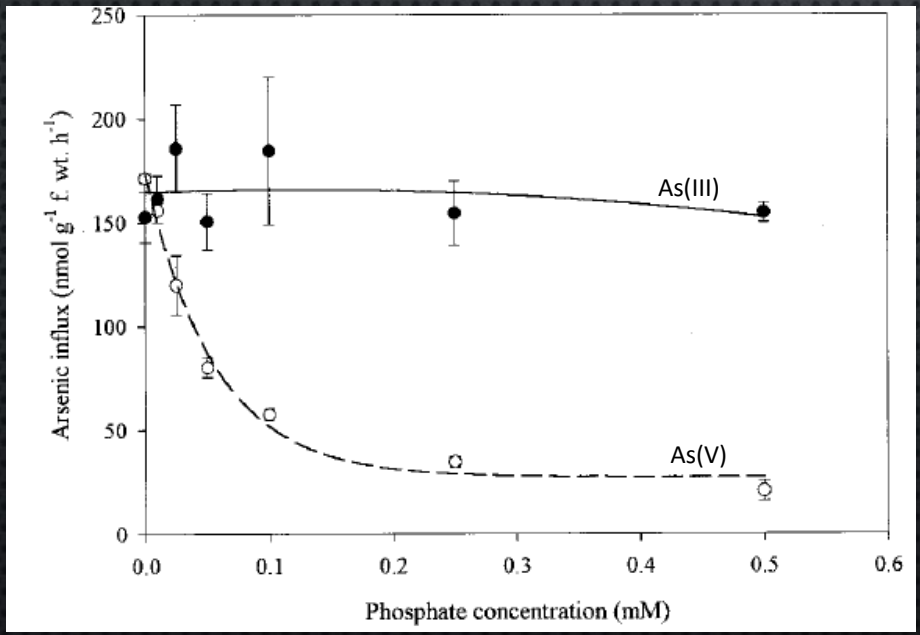
Chen et al. (2017) Frontiers in Plant Sciences, 8:268

L'As(V) è assorbito attraverso i trasportatori del fosfato (OsPT8)

$H_3AsO_4 \xrightarrow{pK_a = 2,2} H_2AsO_4^- + H^+ \xrightarrow{pK_a = 6,7} HAsO_4^{2-} + H^+ \xrightarrow{pK_a = 11,5} AsO_4^{3-} + H^+$



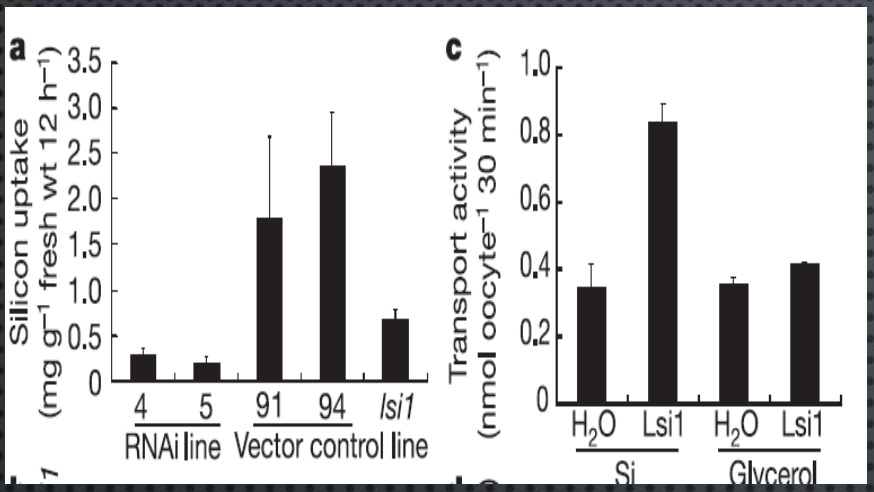




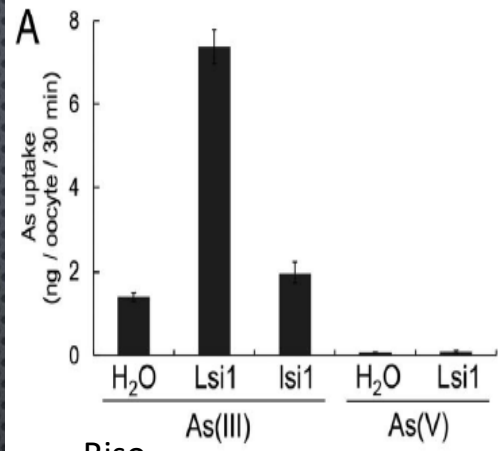
Catarecha et al. (2007) *Plant Cell*, 9:1123-1133
Wang et al. (2016) *J. Exp. Bot.*, 67: 6051-6059

L'As(III) è assorbito dal trasportatore LSi1 del silicio

$H_3AsO_3 \xrightarrow{pK_a = 9,2} H_2AsO_3 + H^+ \xrightarrow{pK_a = 12,1} HAsO_3^{2-} + H^+ \xrightarrow{pK_a = 13,4} AsO_3^{3-} + H^+$

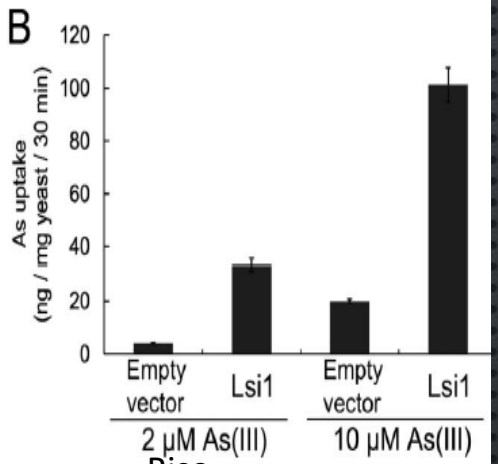


Oocita di *Xenopus*

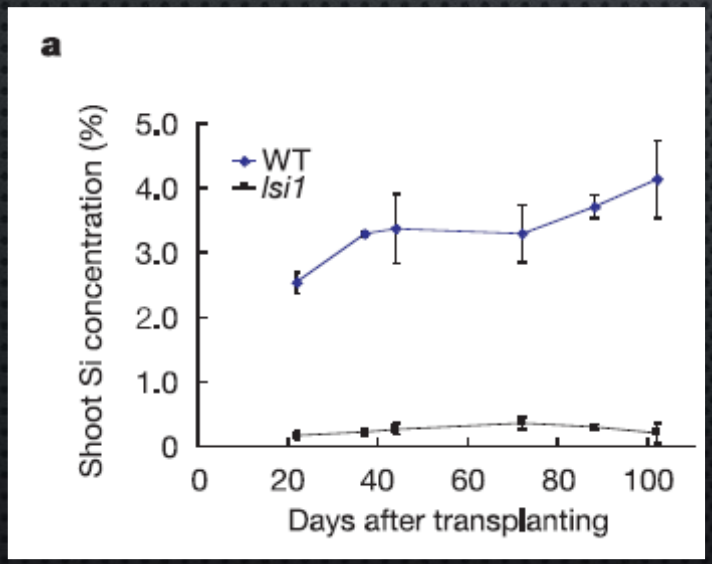


Riso

Saccaromyces cerevisiae

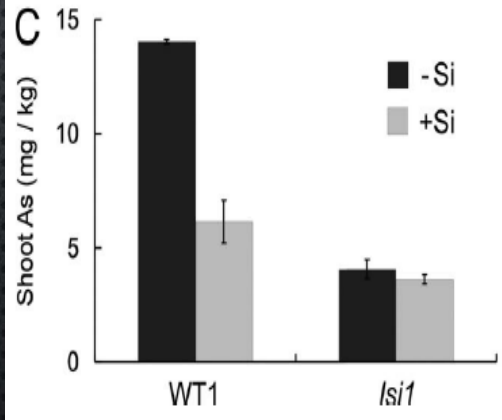


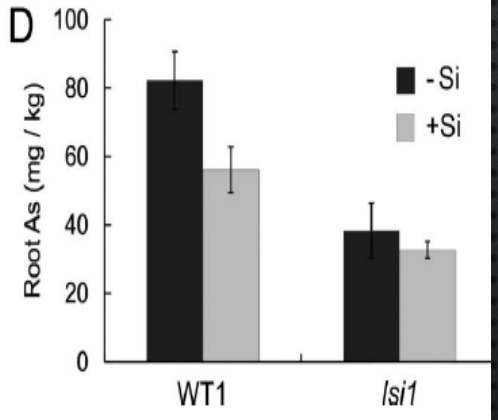
Riso



LSi1

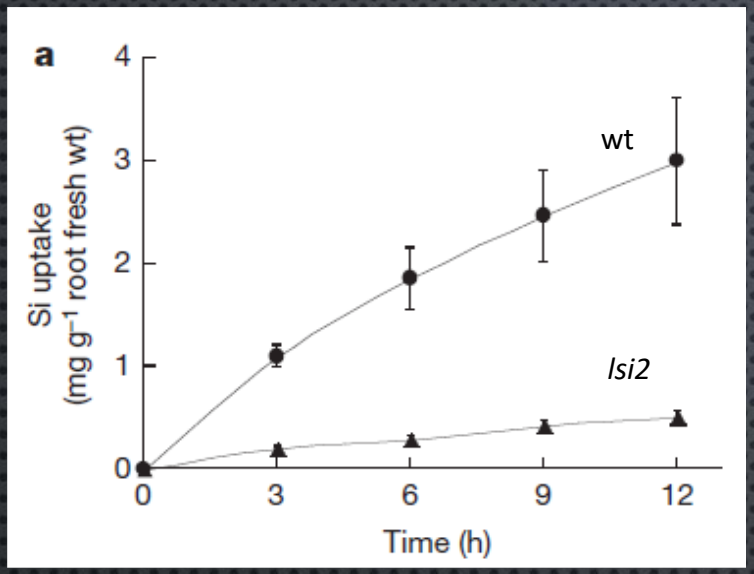
Ma et al. (2006), Nature 440: 688-691

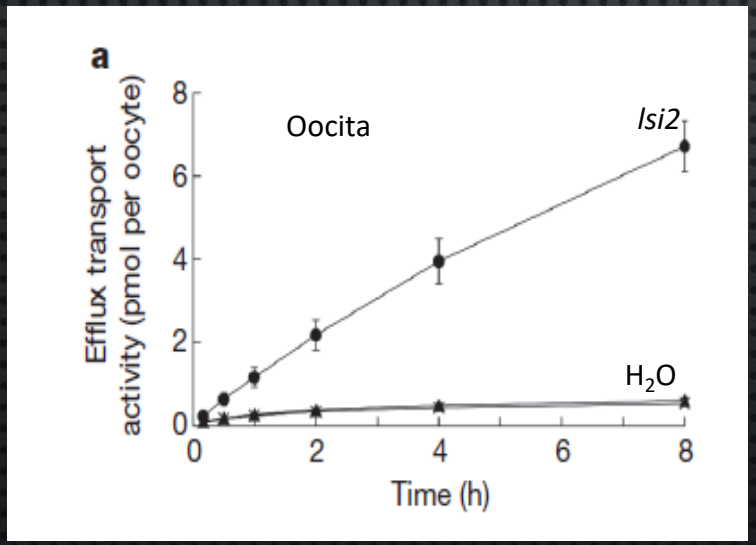




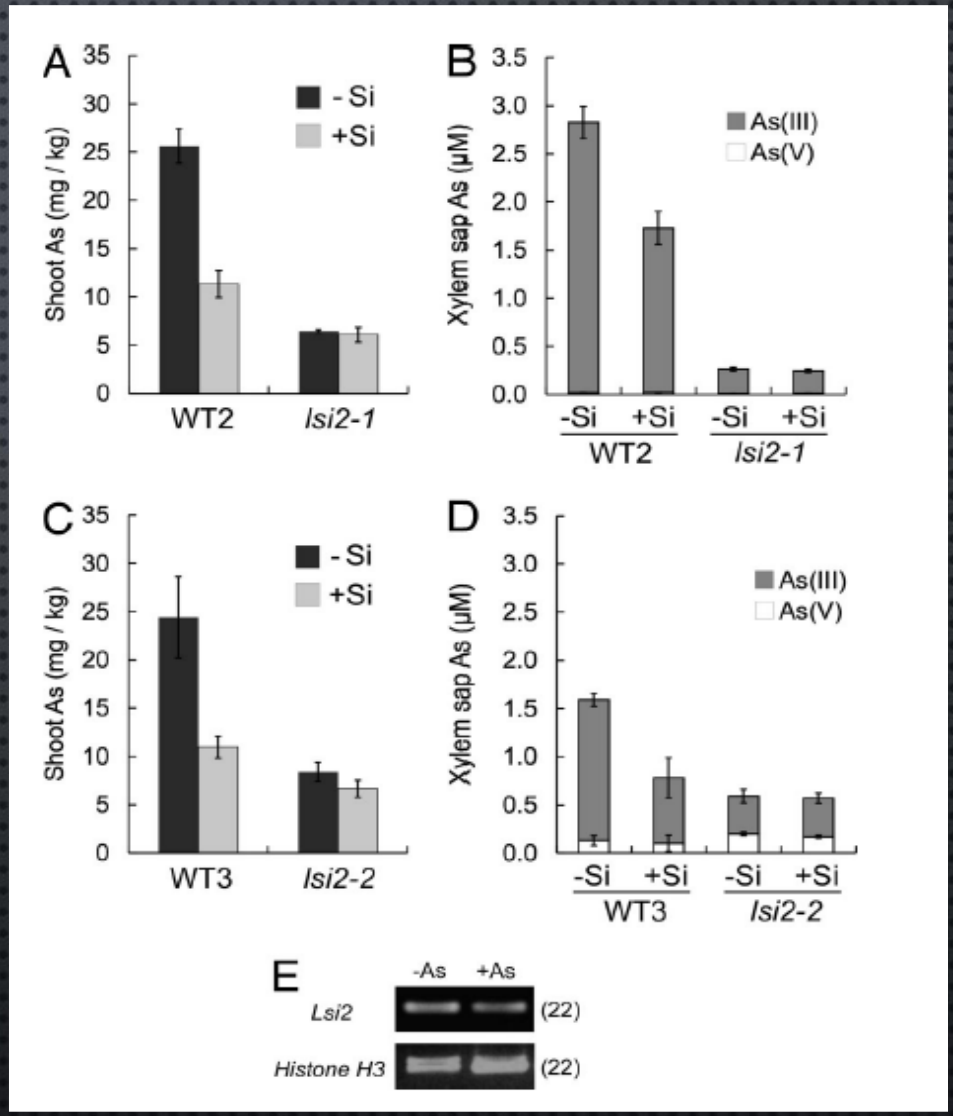
Ma et al. (2008), PNAS 105: 9931-9935

Forme dell'As in rizosfera e loro assorbimento nelle radici





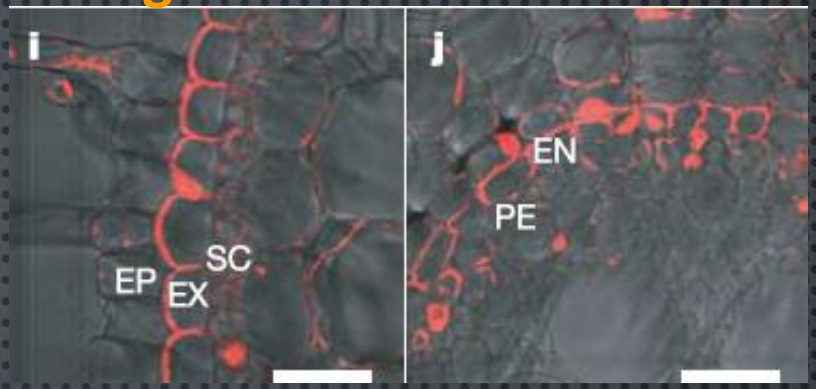
LSi2



Ma et al. (2007), Nature 448: 209-212

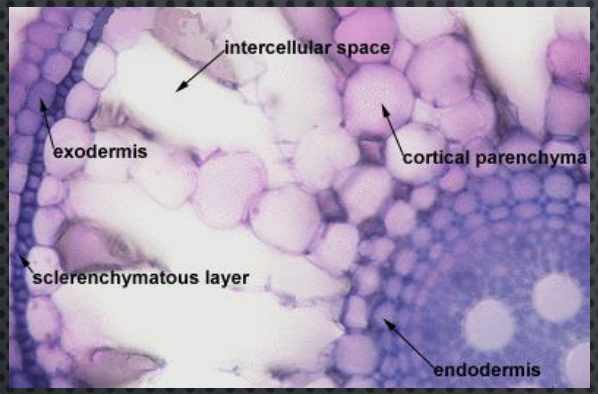
Ma et al. (2008), PNAS 105: 9931-9935

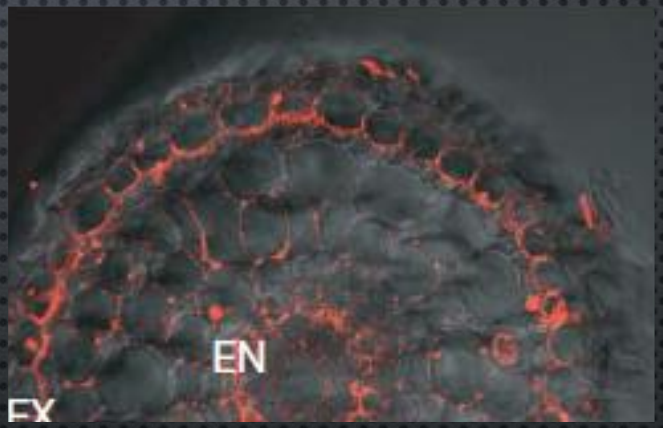
Localizzazione istologica LSi1 e LSi2



LSi1

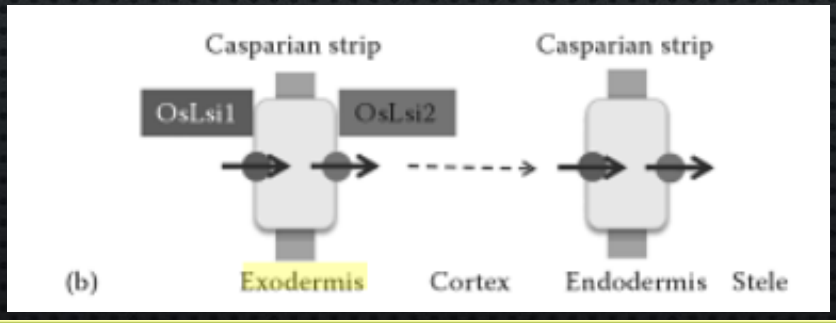
Ma et al. (2006), Nature 440: 688-691





LSi2

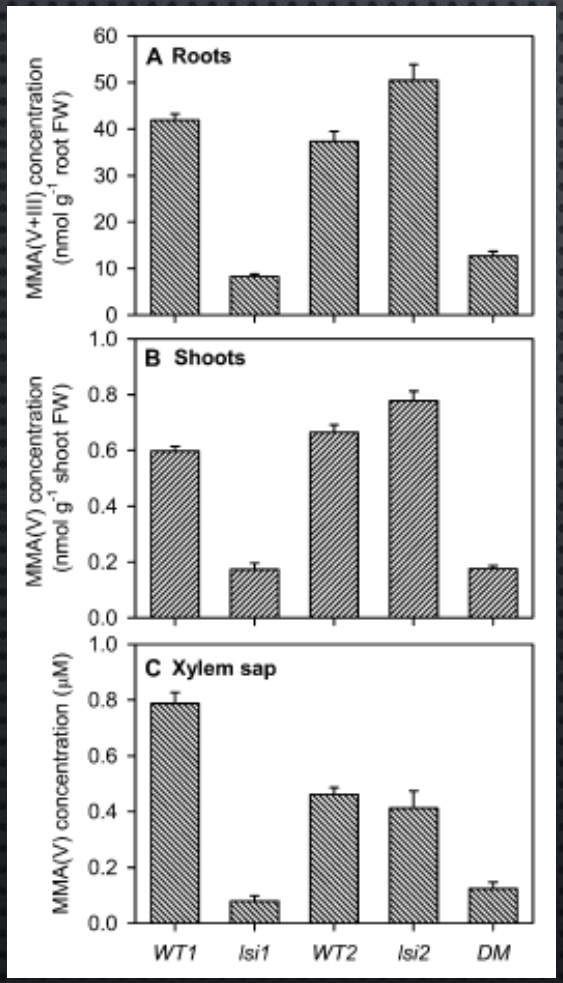
Ma et al. (2007), Nature 448: 209-212

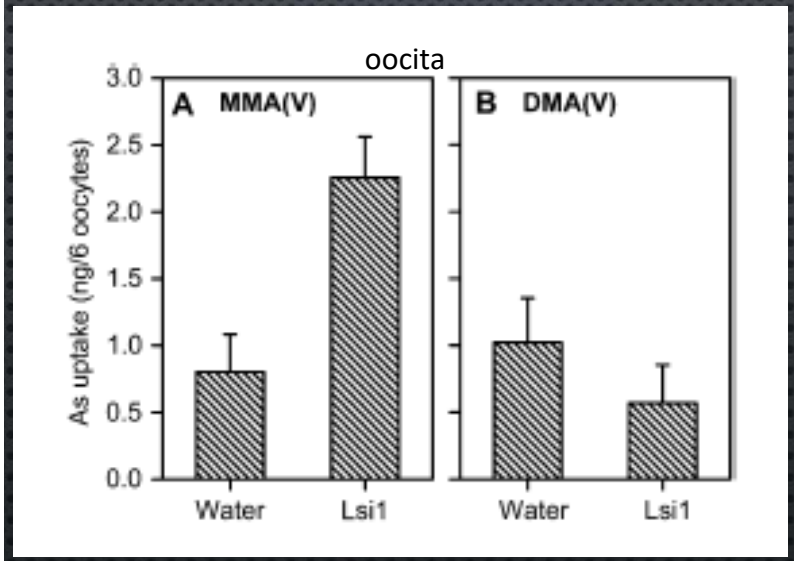


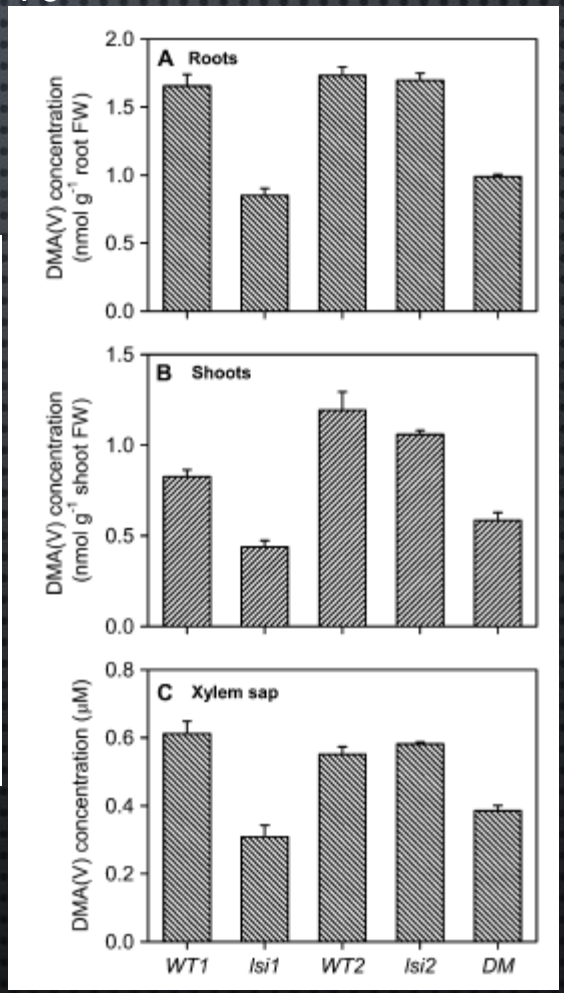
LSi1 media l'assorbimento anche delle forme metilate dell'As in riso

[3H]MMA
P = 1,4 x 10^{-13}

[3H]DMA
P = 4,5 x 10^{-11}

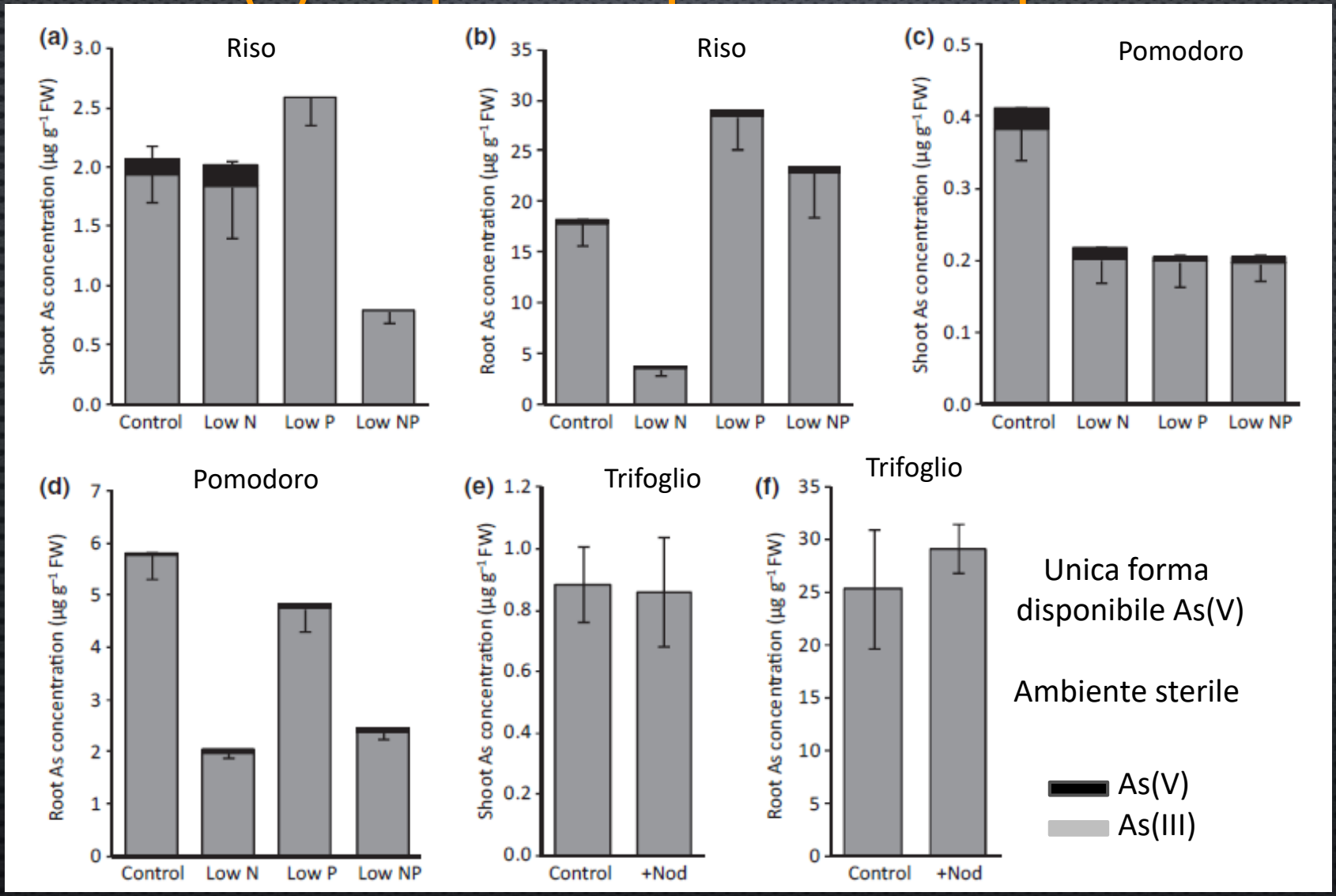






Li at al., (2009) *Plant Physiol*, 150: 2071-2080

L'As(III) è la specie di As prevalente nelle piante



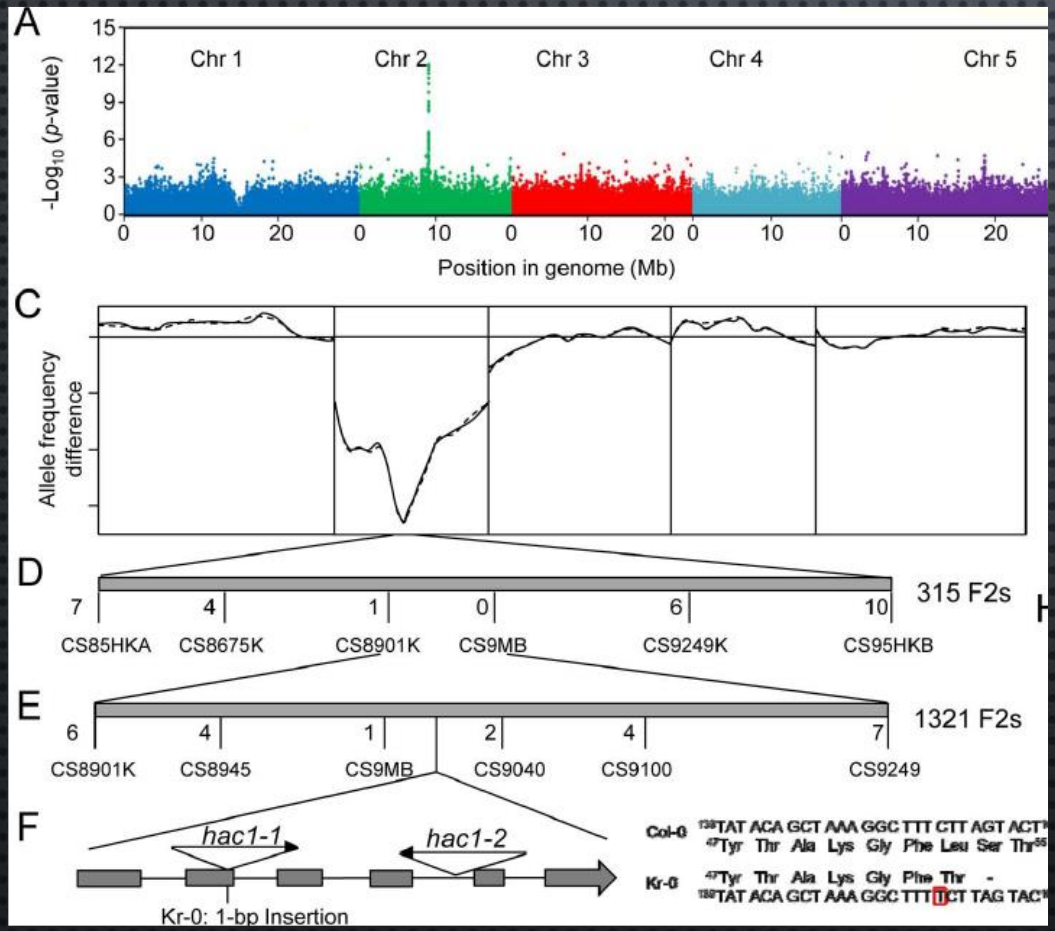
Lomax et al. (2012) New Phytologist, 193: 665-672

In sterilità non si evidenziano tracce di forme metilate

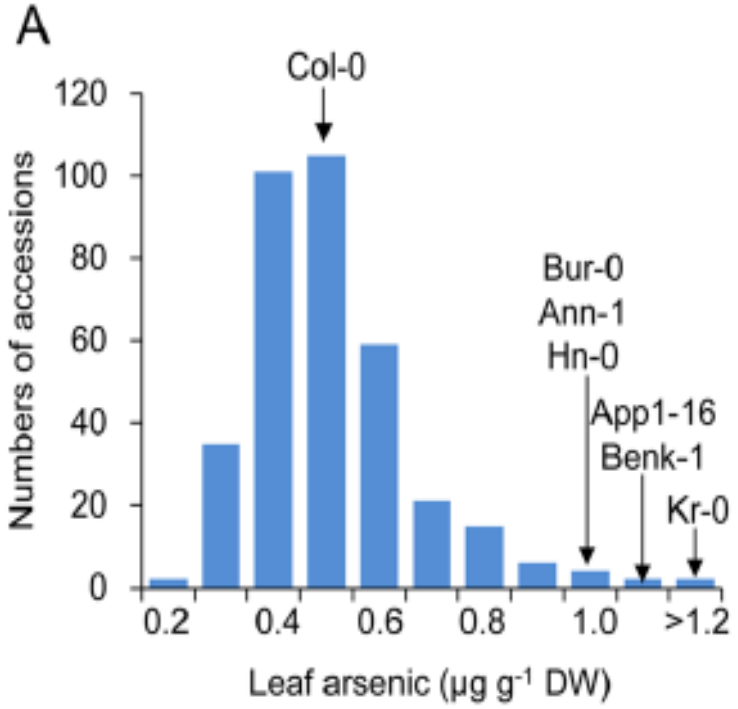
Una volta assorbito l'As(V) è ridotto ad As(III)

In *A. thaliana* ACR2 proteins: CD25-like (cell division cycle) tyrosine phosphatase

$$H_3AsO_4 + 2GSH \xrightarrow{\text{ACR2s or HAC1}} H_3AsO_3 + GSSG + H_2O$$



349 accessioni; 248584 diallelic SNPs

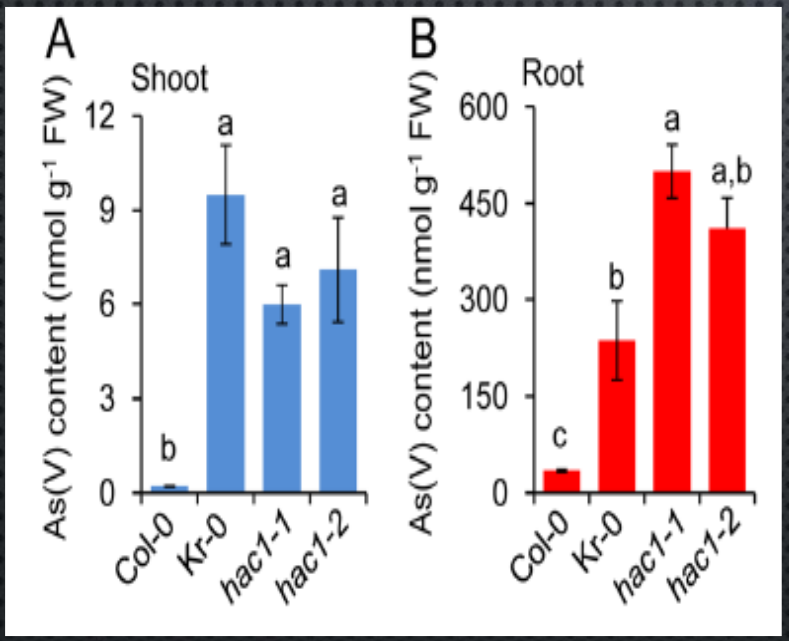


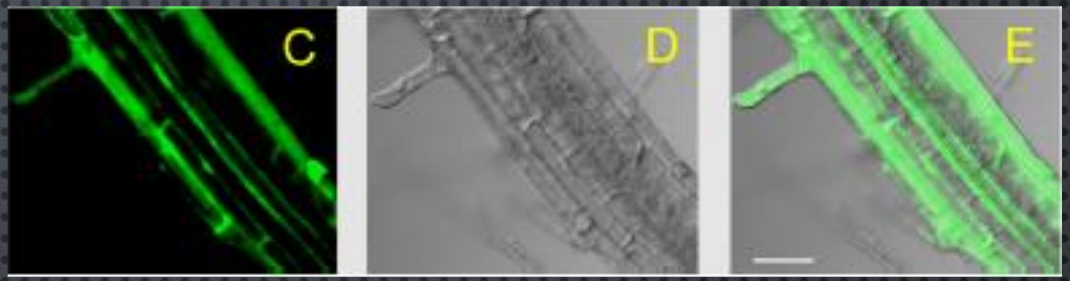
Chao et al. (2014) *PLOS Biology*, 12: e1002009

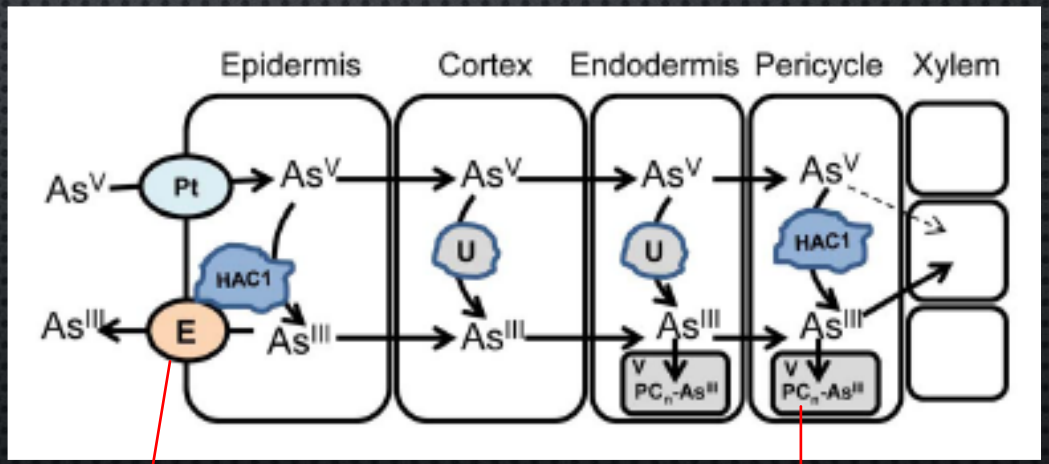
GWAS: As(V) reduttasi HAC1 (Hig Arsenic Content 1)

Ruolo di HAC1 nel metabolismo radicale dell'As

Chr2:9008060 — Kr-0 (C) X Col-0 (T) : F1 ↓ F2 25% ↑





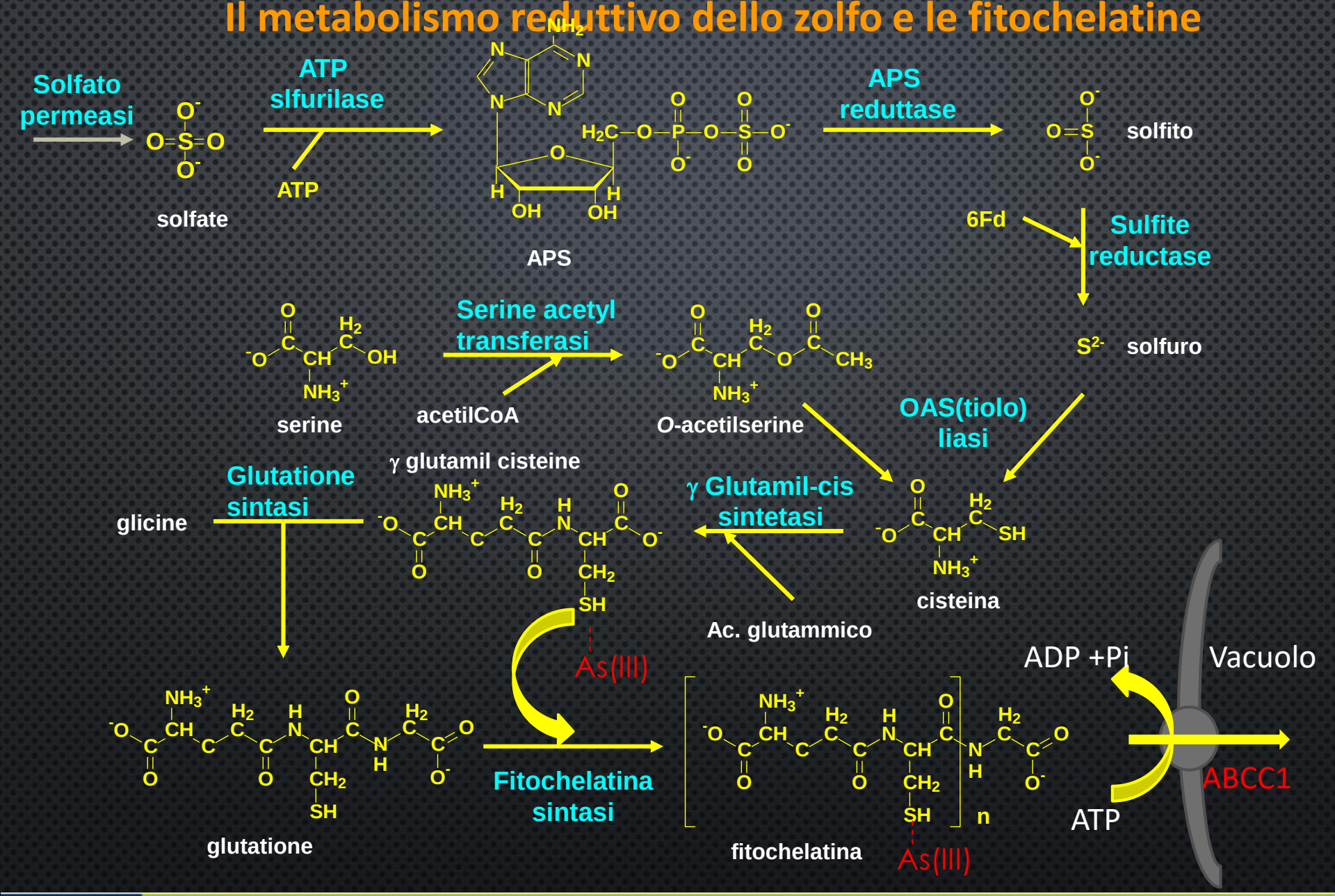


Chao et al. (2014) *PLOS Biology*, 12: e1002009

Efflusso di AsIII
Meno As nella pianta?

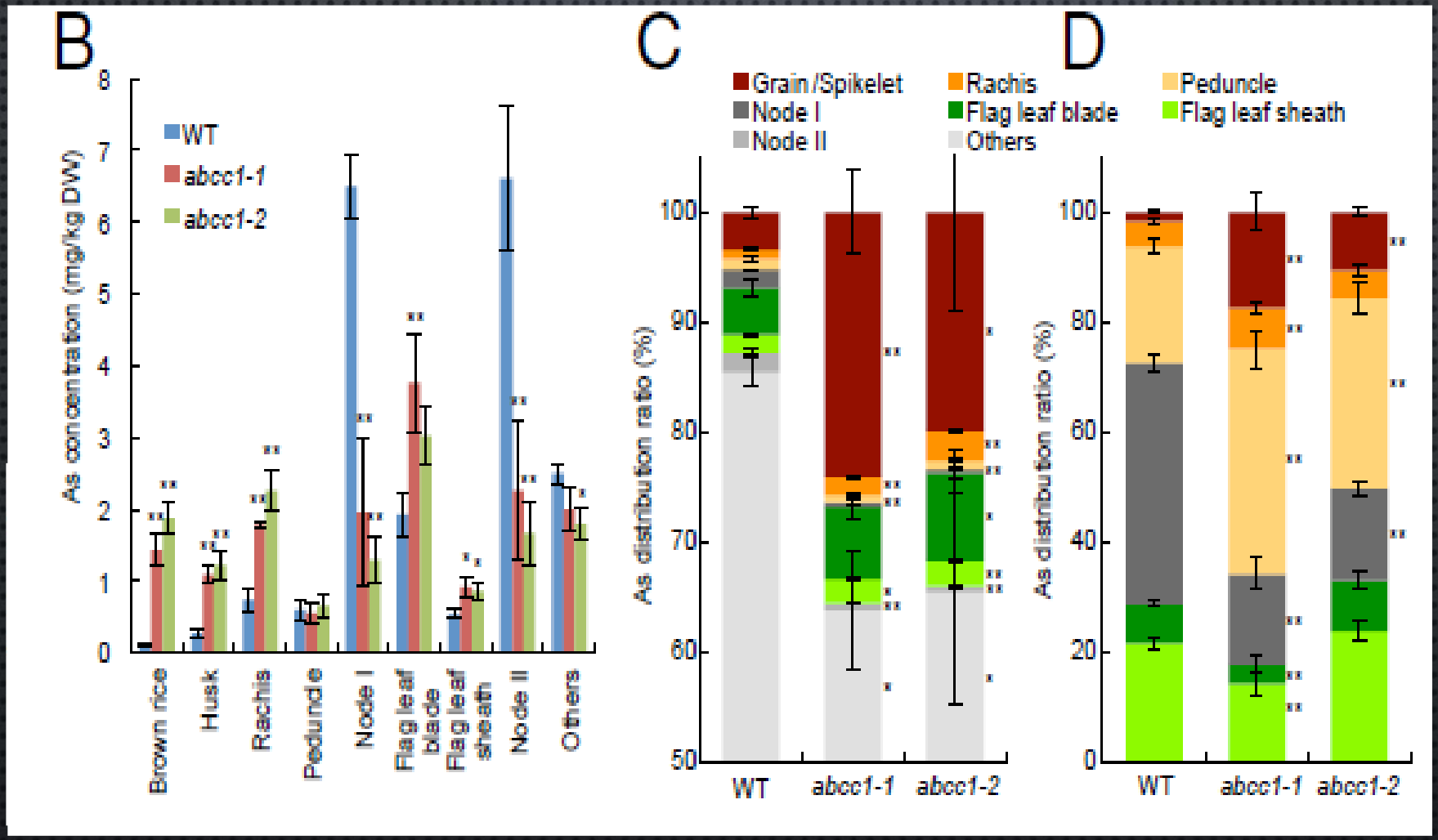
Fitochelatine

Il metabolismo reduttivo dello zolfo e le fitochelatine



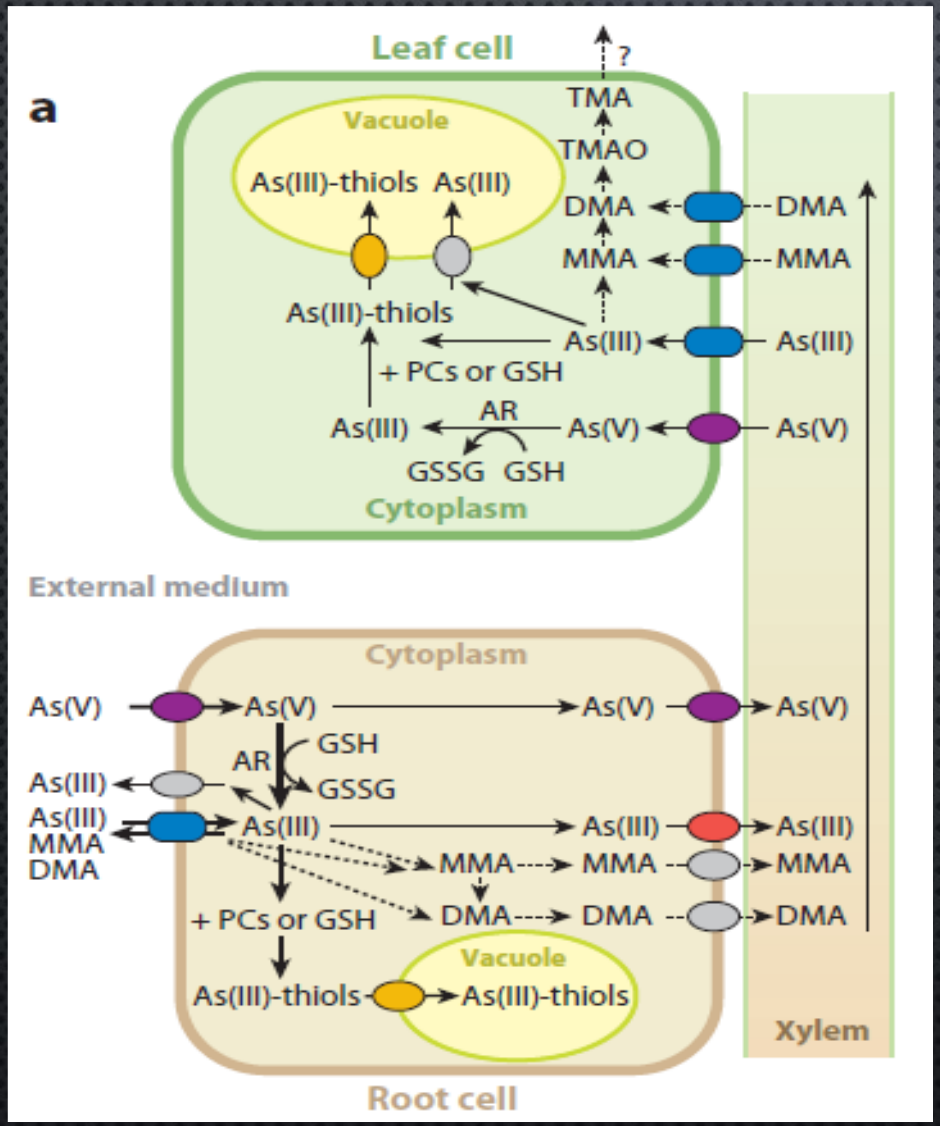
OsABCC1 e accumulo di As nella granella del riso

OsABCC1 ortologo di AtABCC1 e AtABCC2: sono ABC-cassette box-transporter

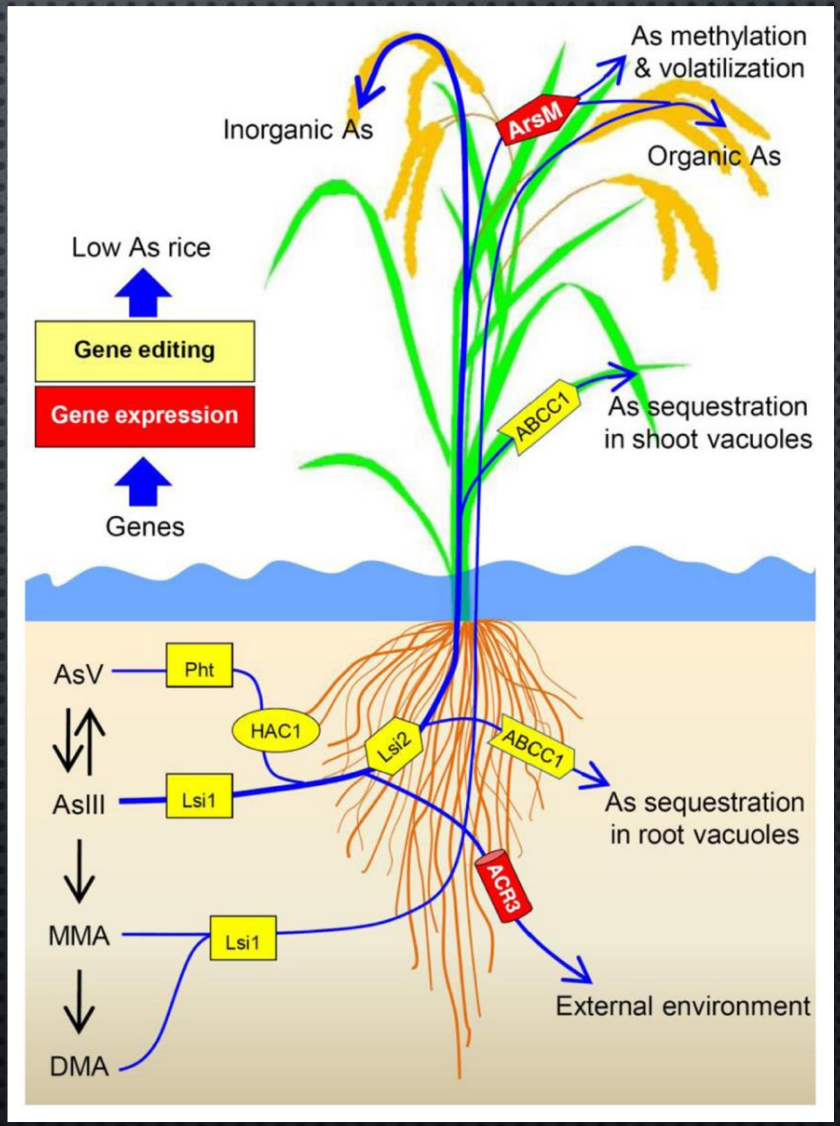


Song et al. (2014) PNAS, 44: 15699-15704

Flussi di As nella pianta di riso

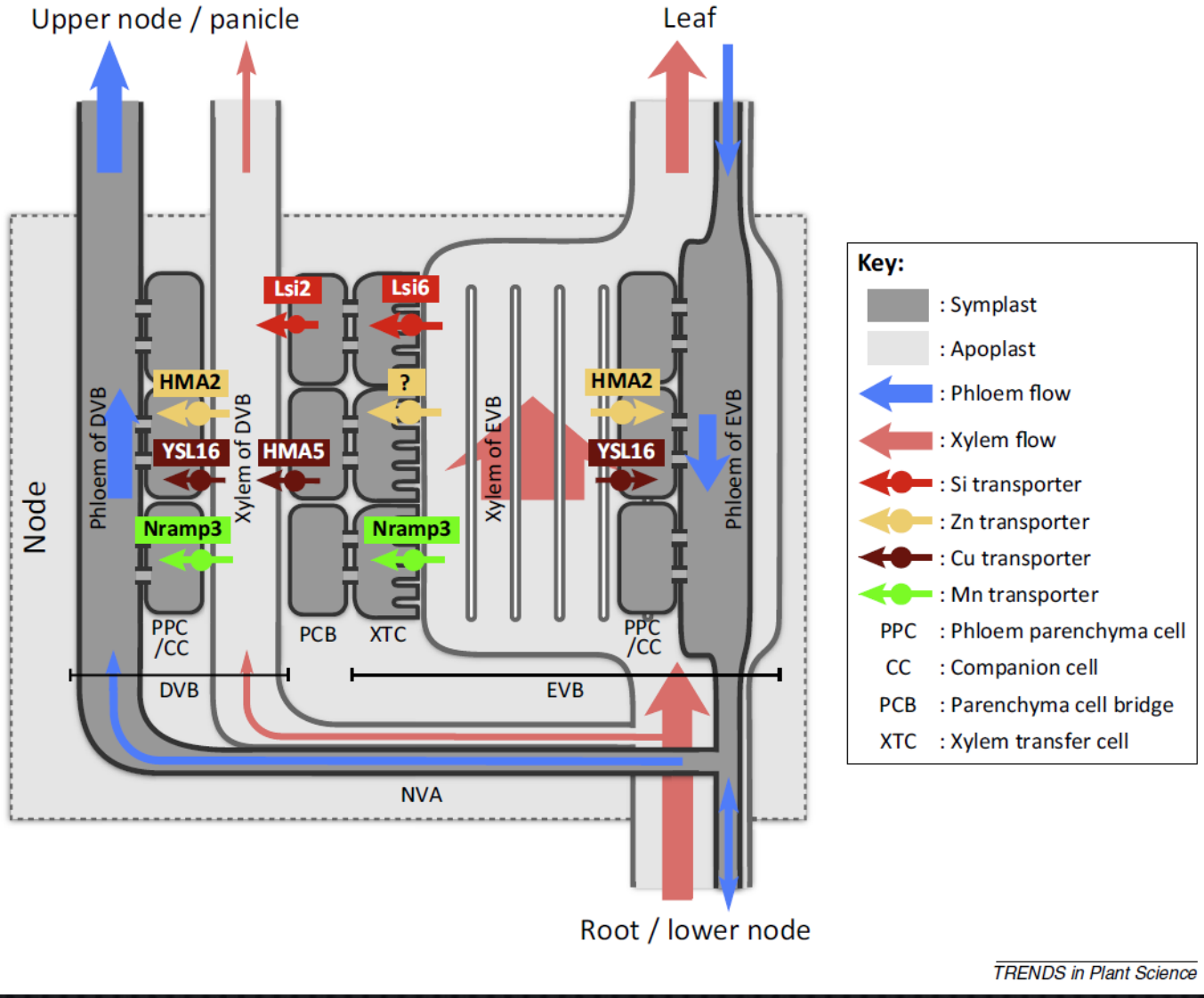


Zhao et al. (2010) Annu. Rev. Plant Biol., 61: 535-559



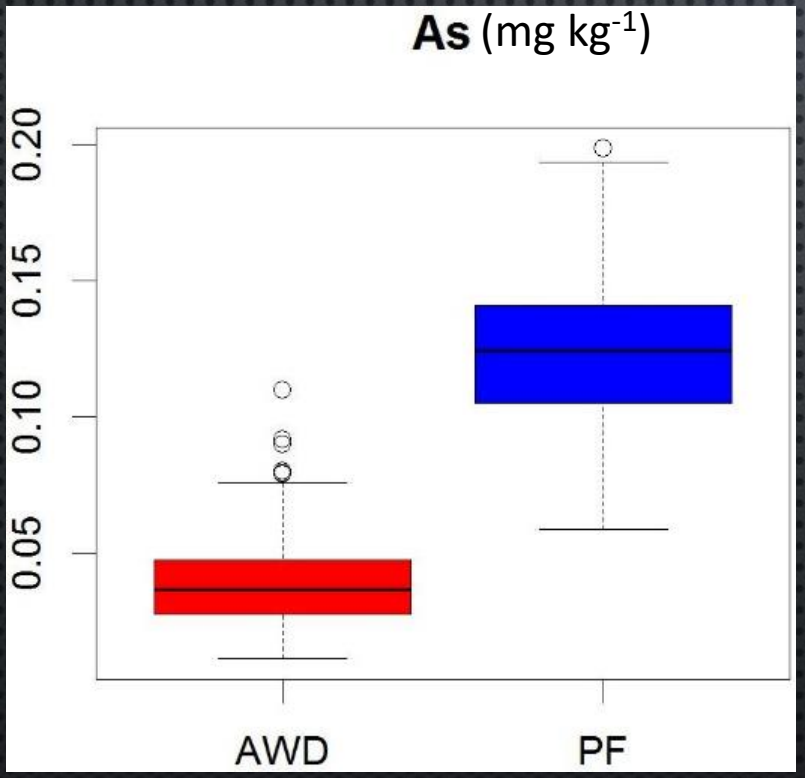
Chen et al. (2017) Frontiers in Plant Sciences, 8:268

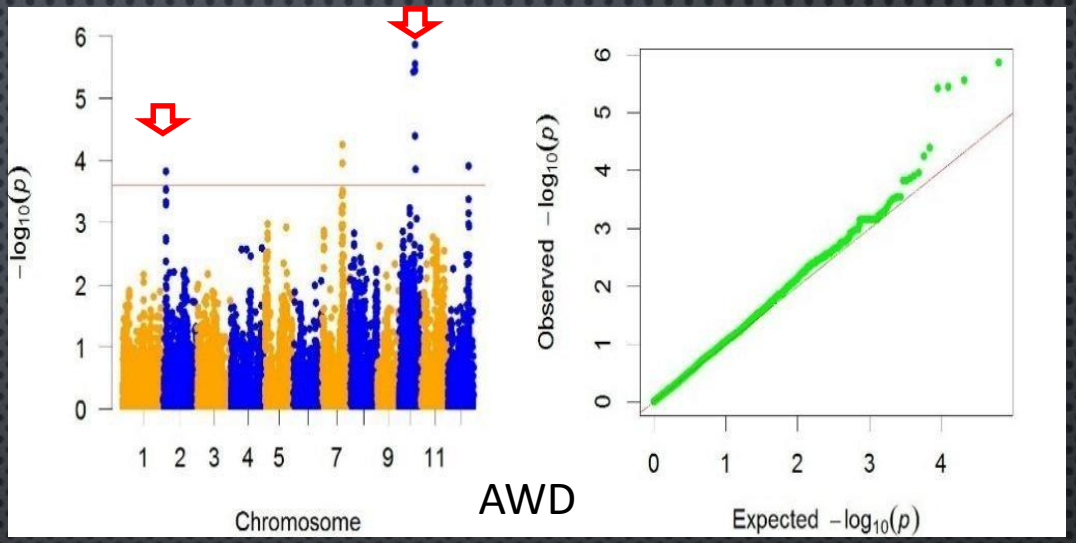
Ruolo dei nodi nell'accumulo e nella distribuzione dell' As in riso

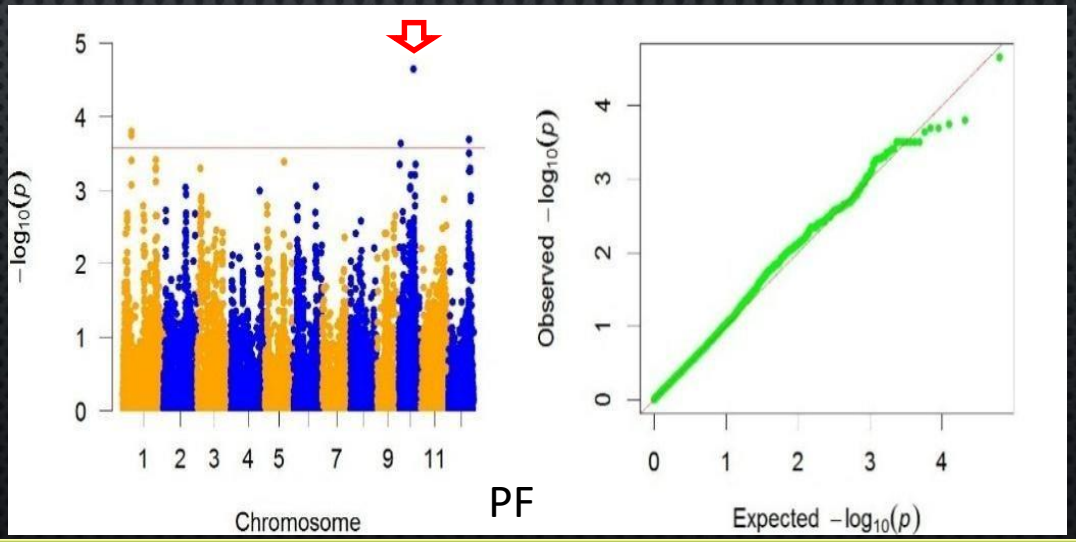


Yamaji and Ma (2014) Trends in Plant Sciences, 19:556-563

Effetto della gestione irrigua sui livelli di As in riso: uno studio di GWA 281 accessioni (+ 200 nuove accessioni per genomic selection)







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