



ARSENICO NELLE CATENE ALIMENTARI
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Meccanismi di assorbimento e accumulo dell'arsenico nelle parti eduli dei vegetali

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UNIVERSITÀ DEGLI STUDI DI MILANO
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TERRITORIO, AGROENERGIA

Variabilità dell'accumulo di As nelle specie vegetali

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



Hordeum vulgare



Oryza sativa



Wolffia globosa

< 1 mg kg^{-1}

> 1.000 mg kg^{-1}

$20.000 \text{ mg kg}^{-1}$



Alberi da frutto



Triticum aestivum



Isatis cappadocica



Equisetum



Pteris vittata

Transfer factor (TF)

< 0,1

1,0

>> 1,0



Livelli di As nella granella del riso

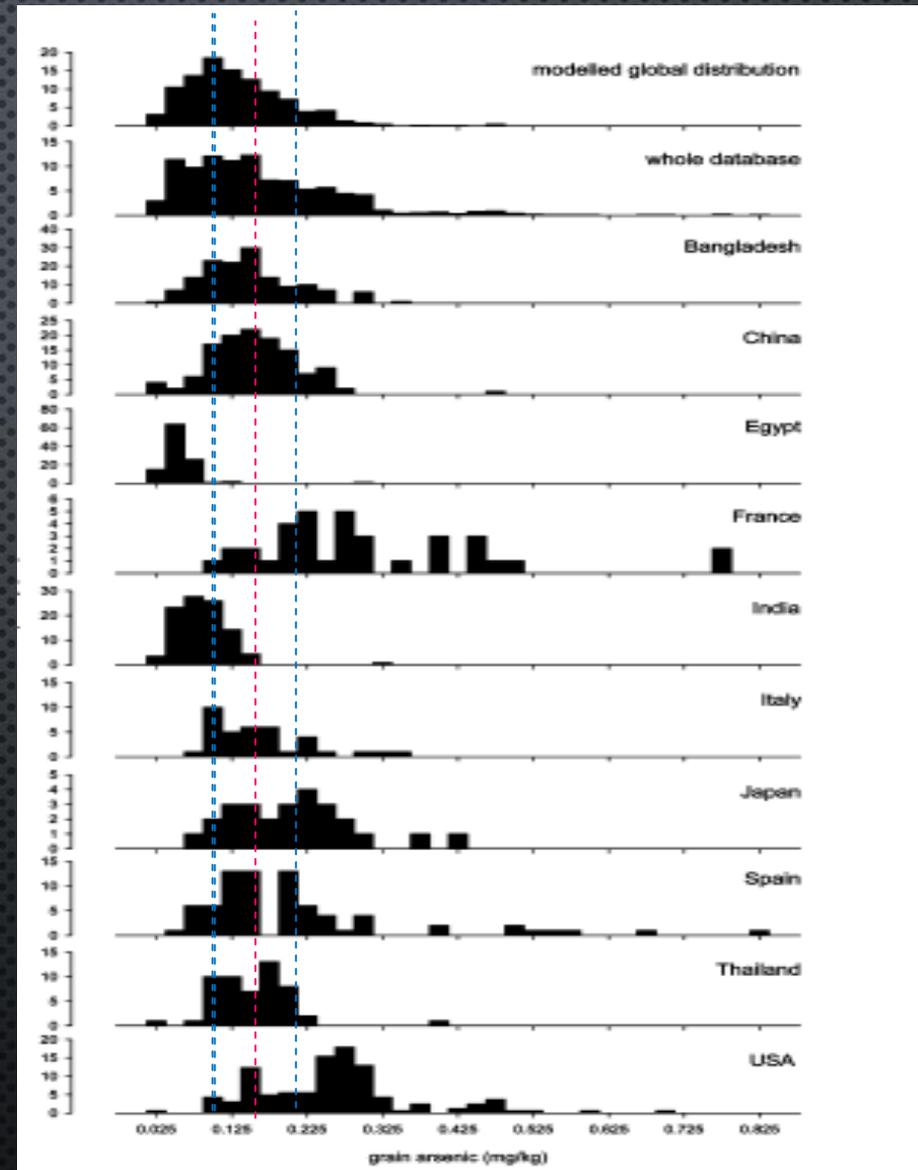
901 campioni a livello globale

Range: 10-820 $\mu\text{g kg}^{-1}$

Media: 150 $\mu\text{g kg}^{-1}$

«Range di normalità»: 80-200 $\mu\text{g kg}^{-1}$

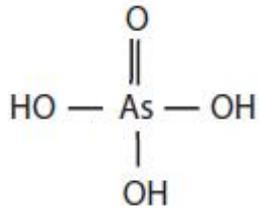
Frumento:
< 50 $\mu\text{g kg}^{-1}$; valore medio \approx 15 $\mu\text{g kg}^{-1}$



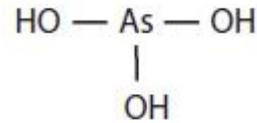
Meharg et al. (2009) *Env Sci Tech*, 43:1612.1627



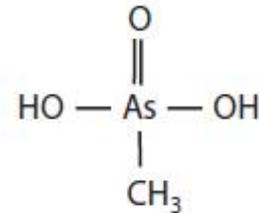
Forme principali di As nei suoli e nelle piante terrestri



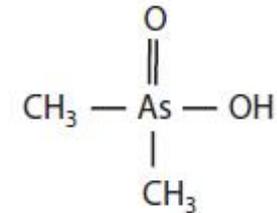
Arsenato



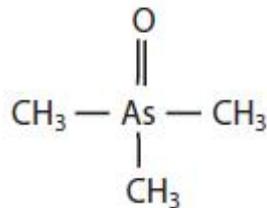
Arsenito



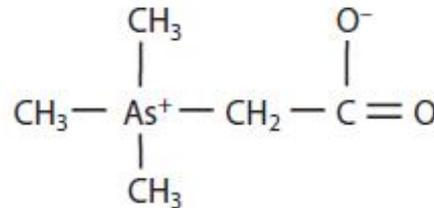
**Ac. monometilarsonico
(MMA)**



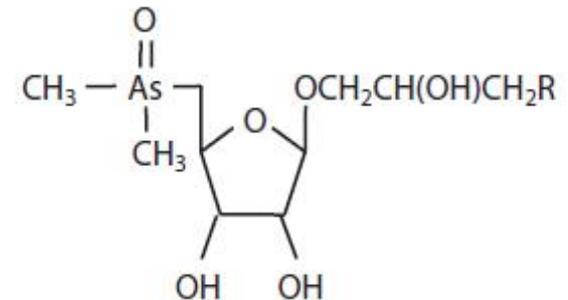
**Ac. Monometilarsinico
(DMA)**



Ossido di trimetil arsina



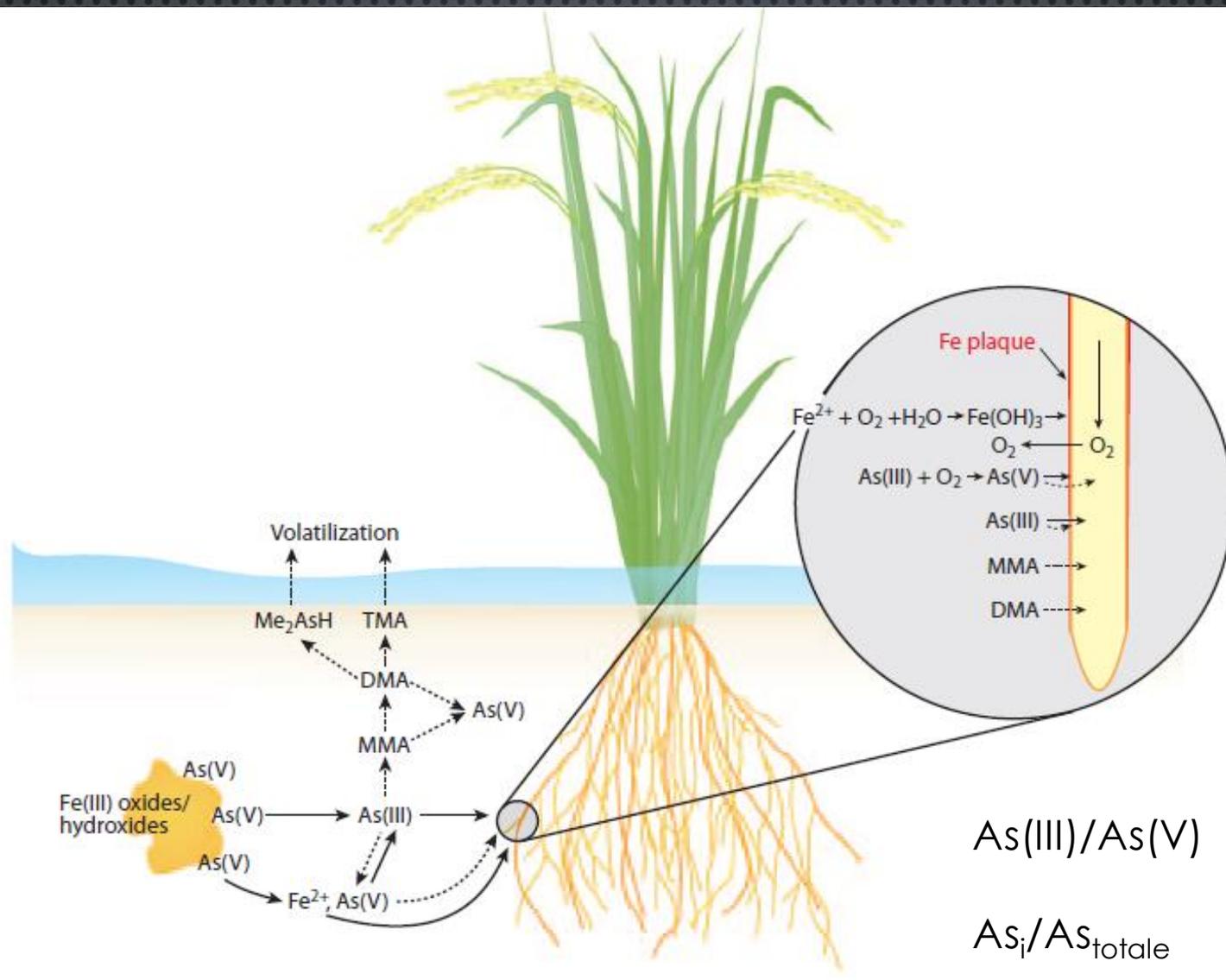
Arsenobetaina



Arsenzuccheri



Mobilizzazione e trasformazioni dell'As nei suoli sommersi e in rizosfera

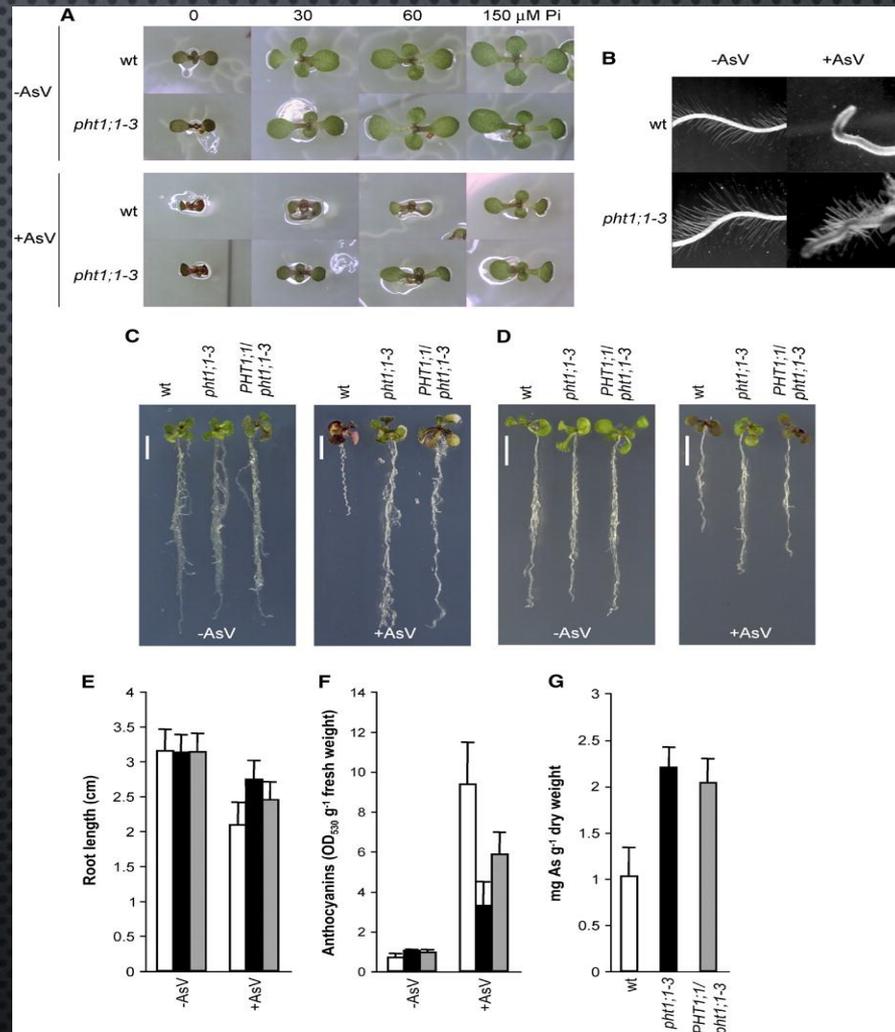
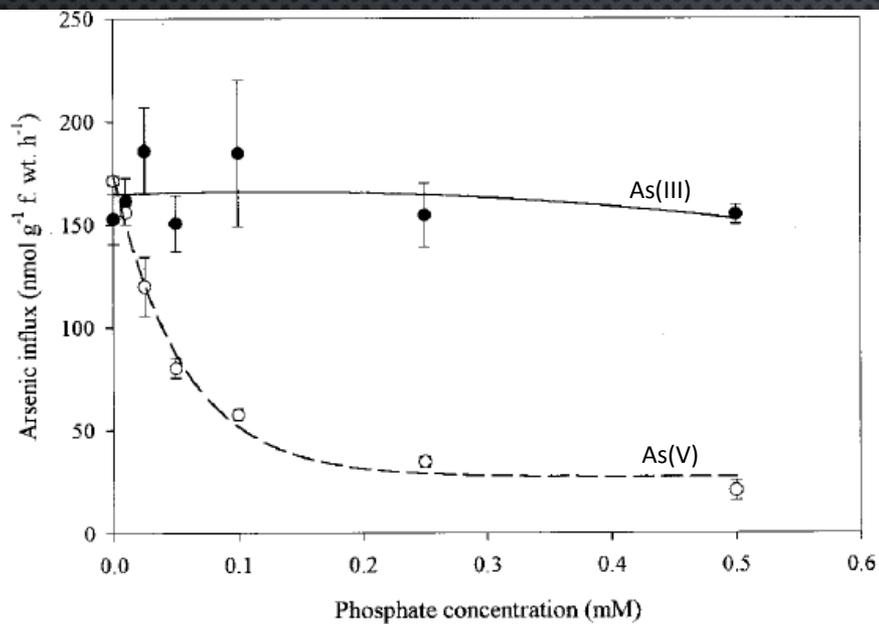
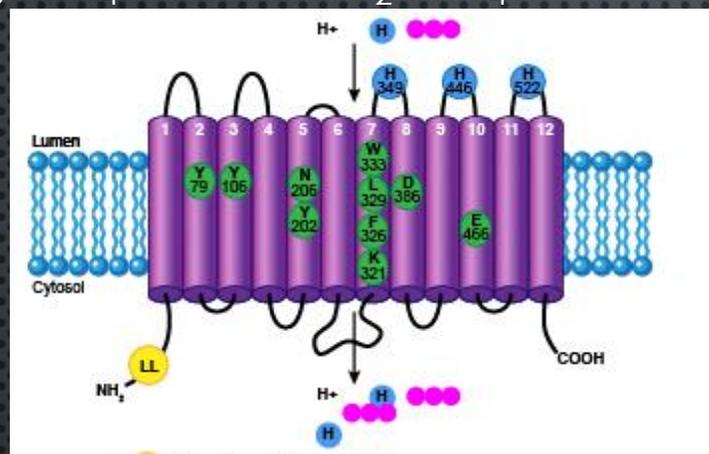


Zhao et al. (2010) Annu. Rev. Plant Biol., 61:535-559



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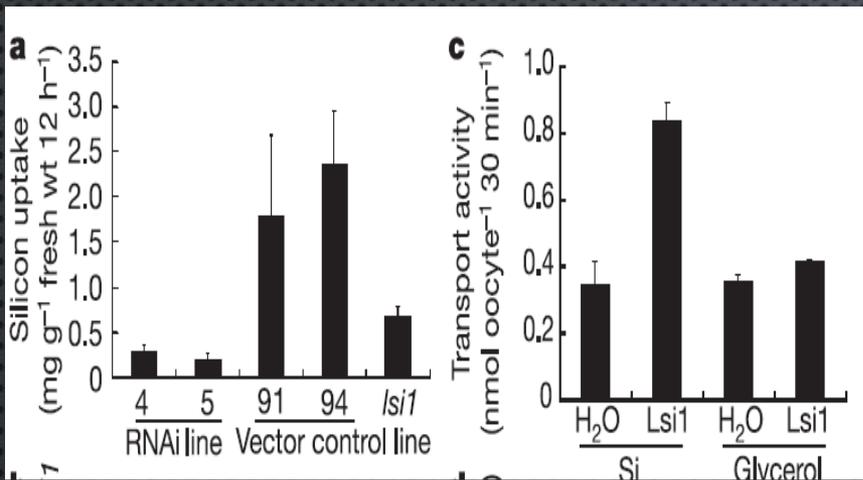
L' As(V) è assorbito attraverso i trasportatori del fosfato



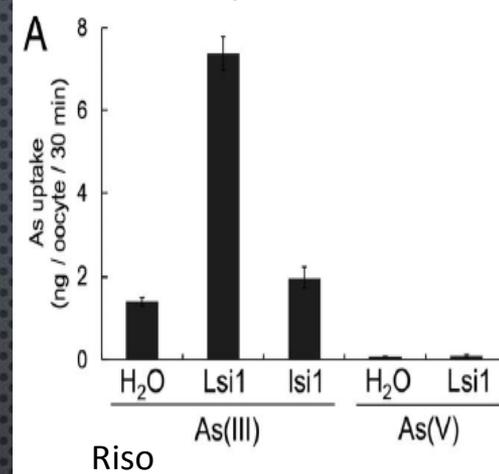
Catarecha et al. (2007) *Plant Cell*, 9:1123-1133



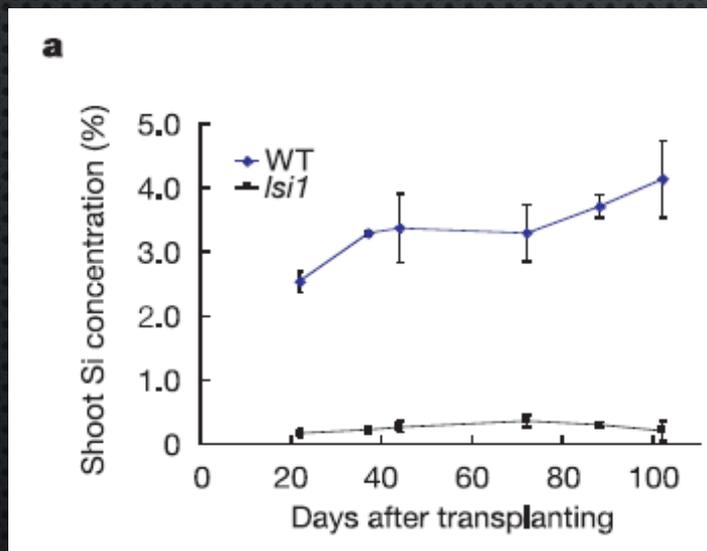
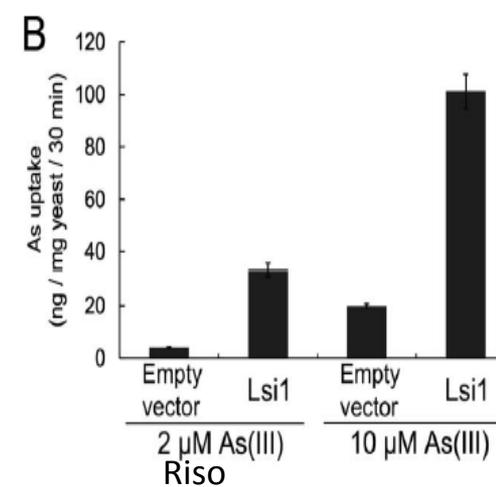
L' As(III) è assorbito attraverso i trasportatori del silicio



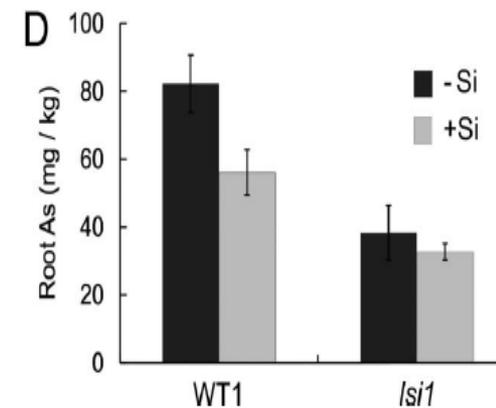
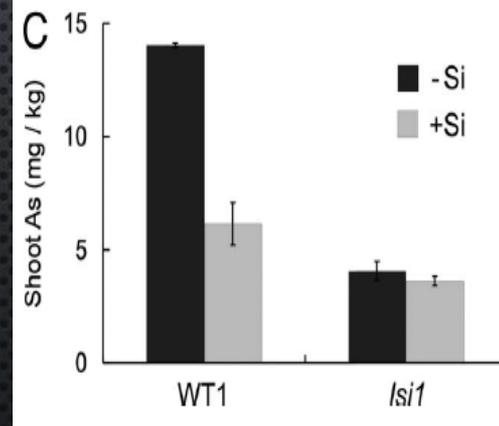
Oocita di *Xenopus*



Saccaromyces cerevisiae



Lsi1

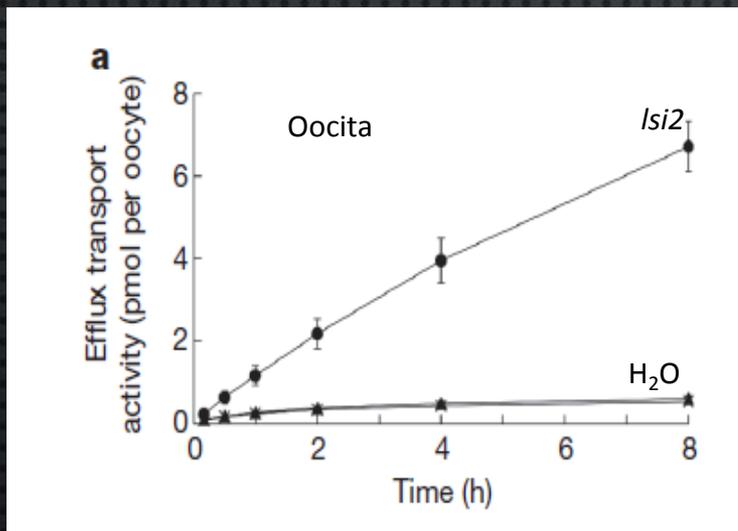
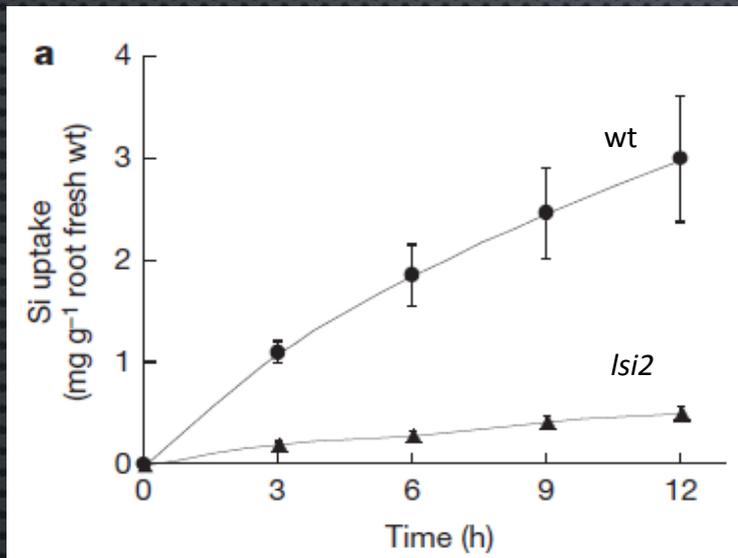


Ma et al. (2008), PNAS 105: 9931-9935

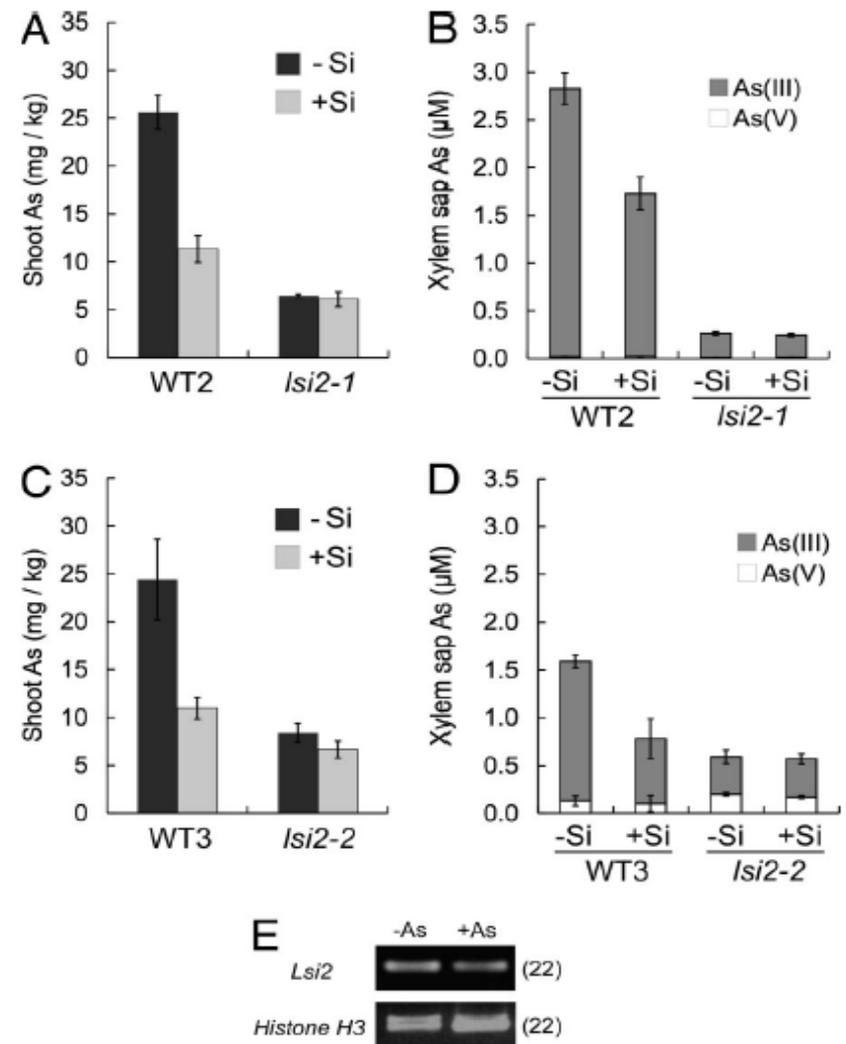
Ma et al. (2006), Nature 440: 688-691



L' As(III) è assorbito attraverso i trasportatori del silicio



LSi2

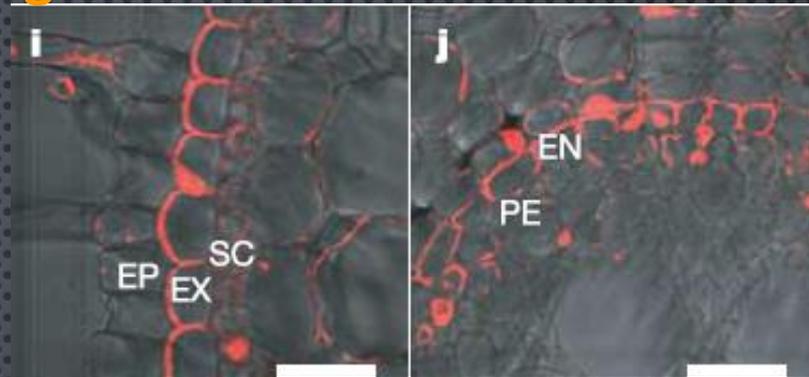
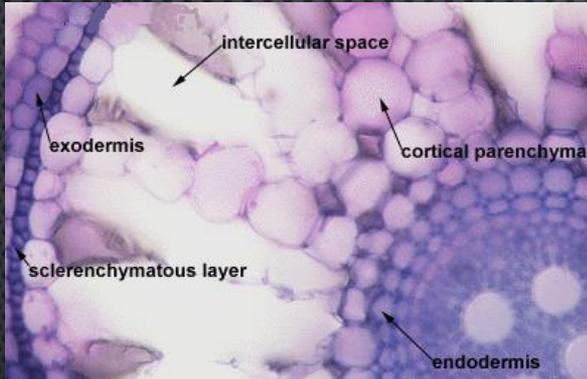


Ma et al. (2007), Nature 448: 209-212

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

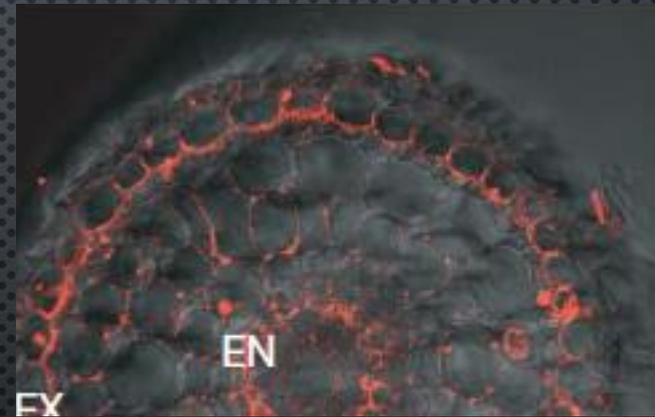


Localizzazione istologica di LSi1 e LSi2 in riso



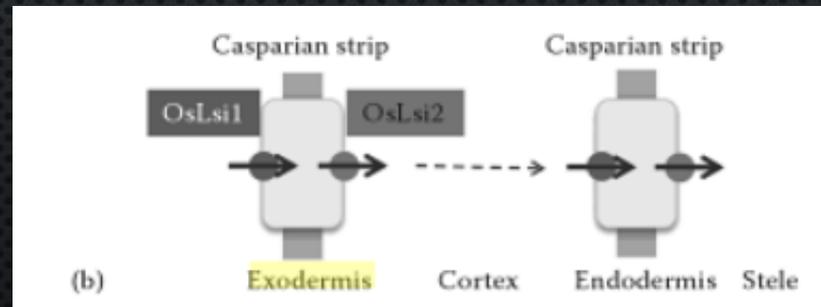
LSi1

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



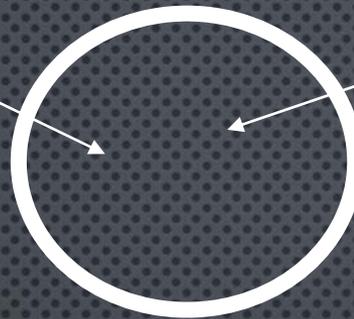
LSi2

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

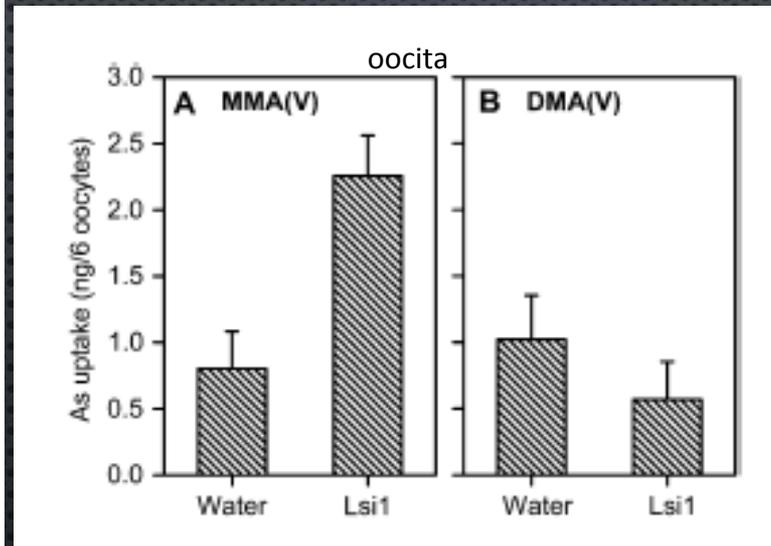
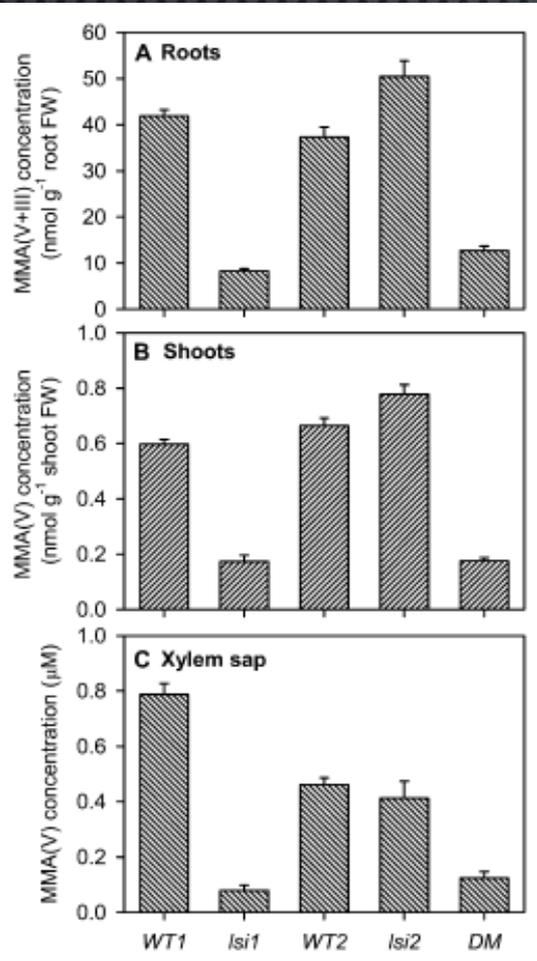


LSi1 media anche l'assorbimento delle forme metilate dell'As in riso

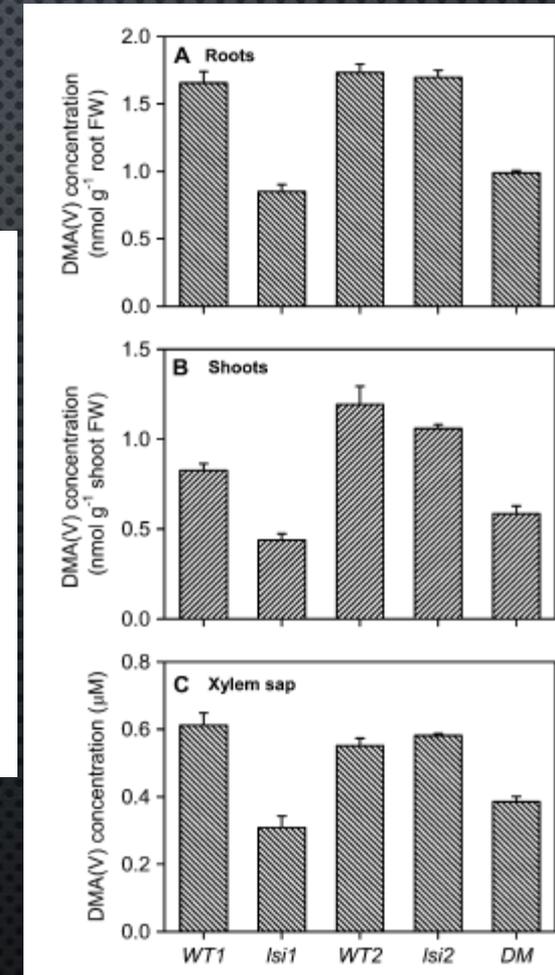
$[^3\text{H}]\text{MMA}$
 $P = 1,4 \times 10^{-13}$



$[^3\text{H}]\text{DMA}$
 $P = 4,5 \times 10^{-11}$

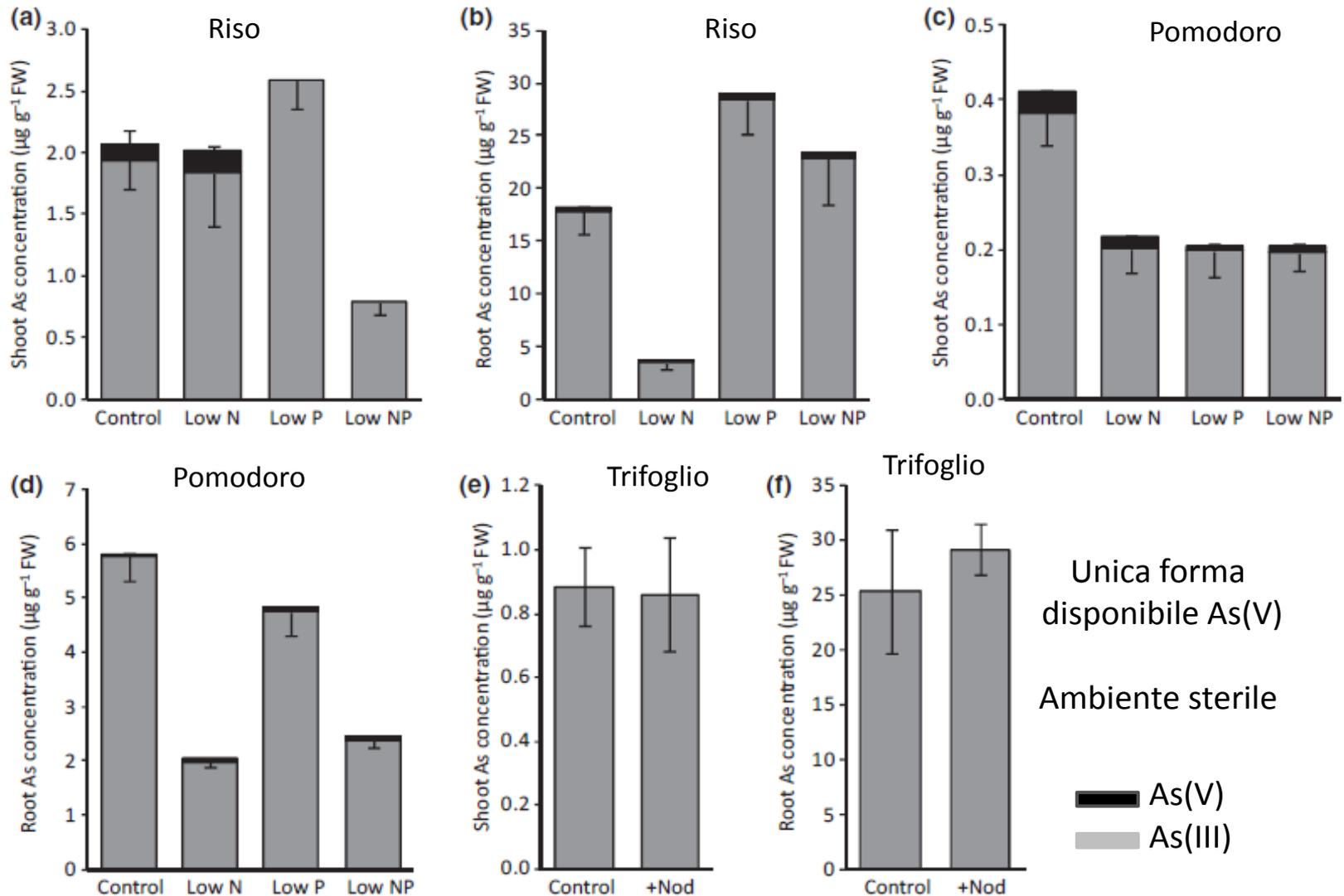


Li et al., (2009) *Plant Physiol*, 150: 2071-2080



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

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

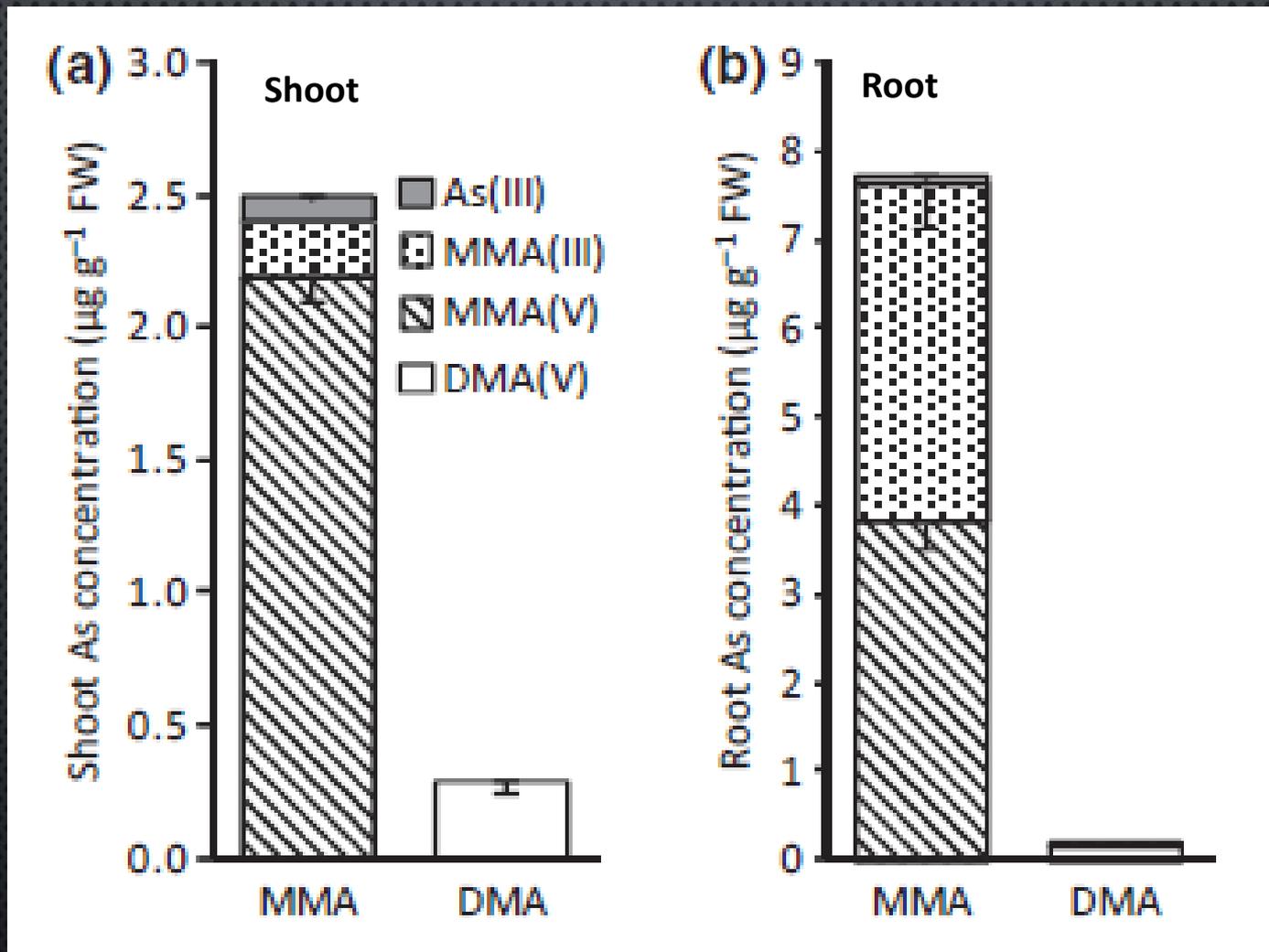


In sterilità non si evidenziano forme metilate dell'As nelle piante



Specie dell'As in piante in sterilità esposte a MMA(V) o DMA(V)

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

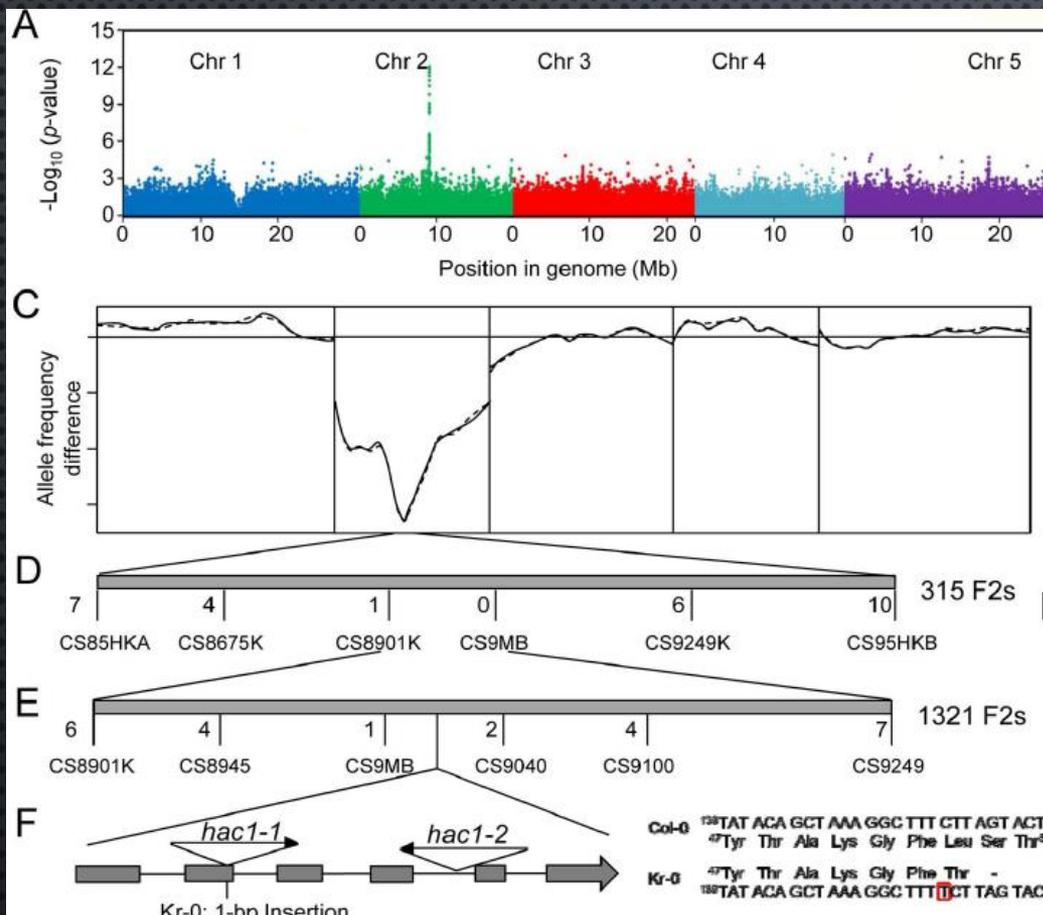


Le piante non sono in grado di metilare l'As, ma assorbono le forme metilate prodotte dai microrganismi

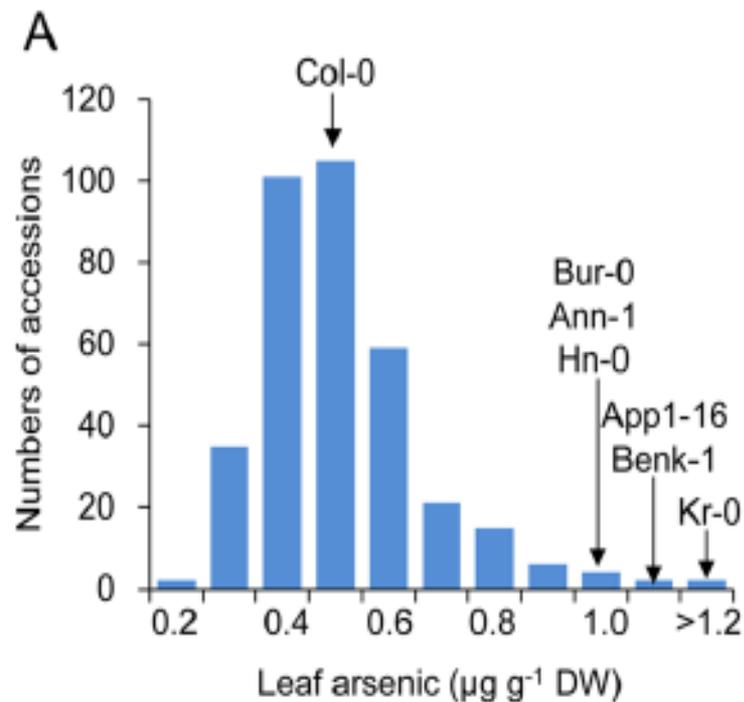


Una volta assorbito l'As(V) è ridotto ad As(III)

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



349 accessioni; 248584 diallelic SNPs



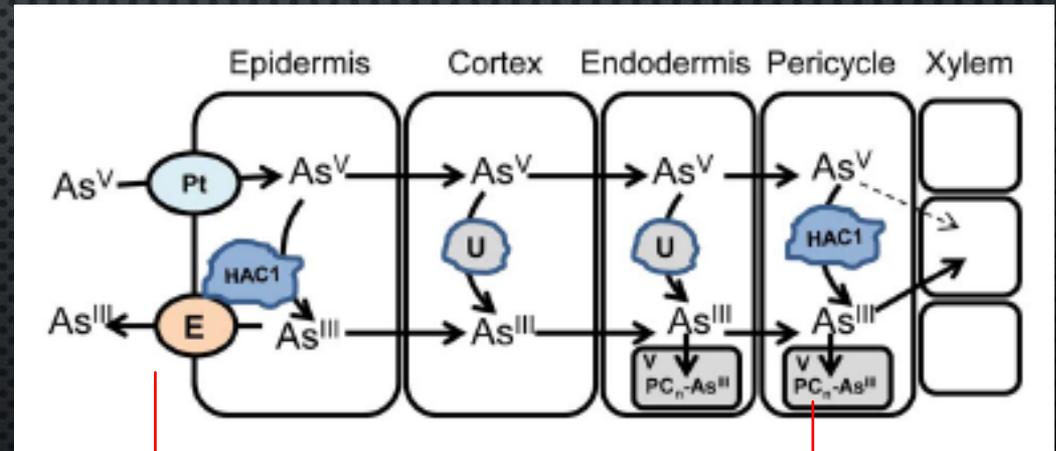
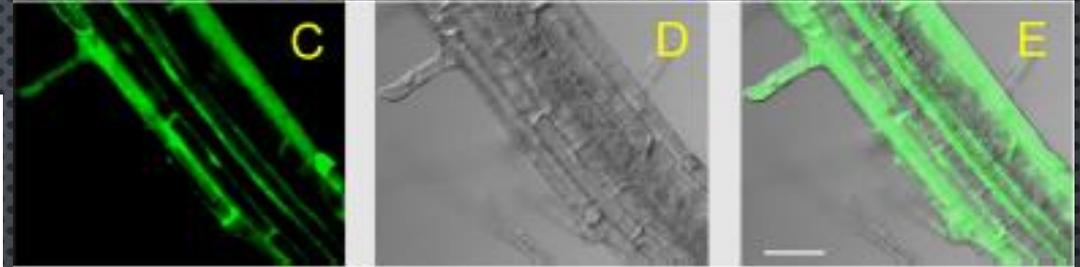
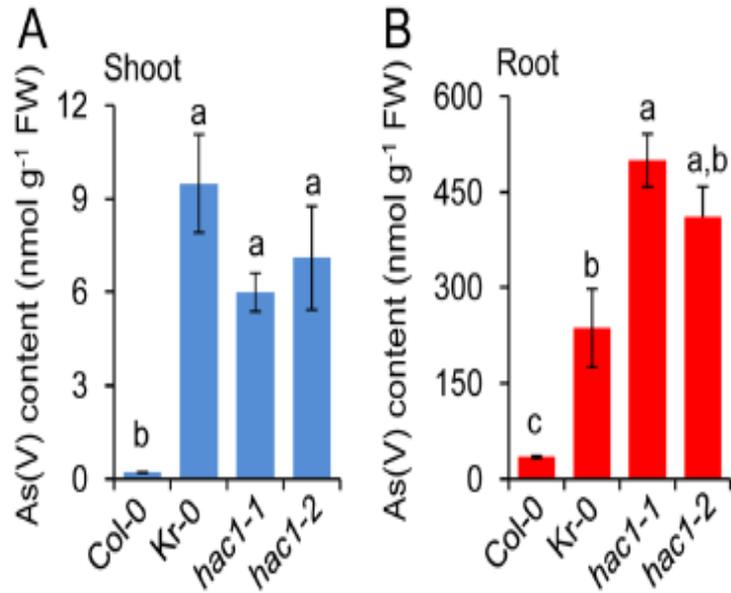
Chao et al. (2015) *PLOS Biology*, 12: e1002009

GWAS: As(V) reduttasi HAC1 (Hig Arsenic Content 1) in *A. thaliana*



Ruolo di HAC1 nel metabolismo radicale dell'As

Chr2:9008060 $\begin{matrix} \nearrow \text{Kr-0 (C)} \\ \searrow \text{Col-0 (T)} \end{matrix}$: F1 \downarrow F2 25% \uparrow

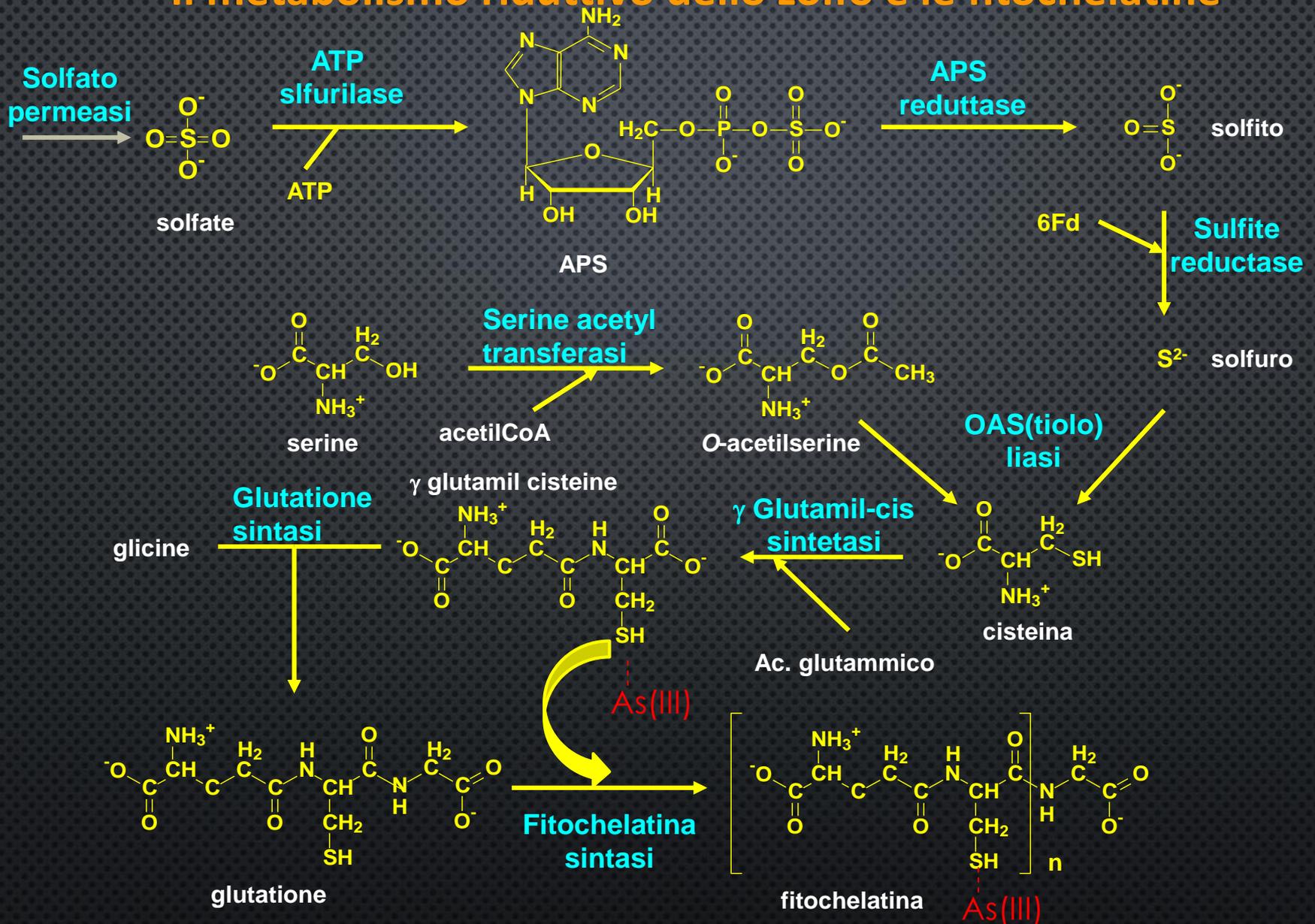


Meno As nella pianta?

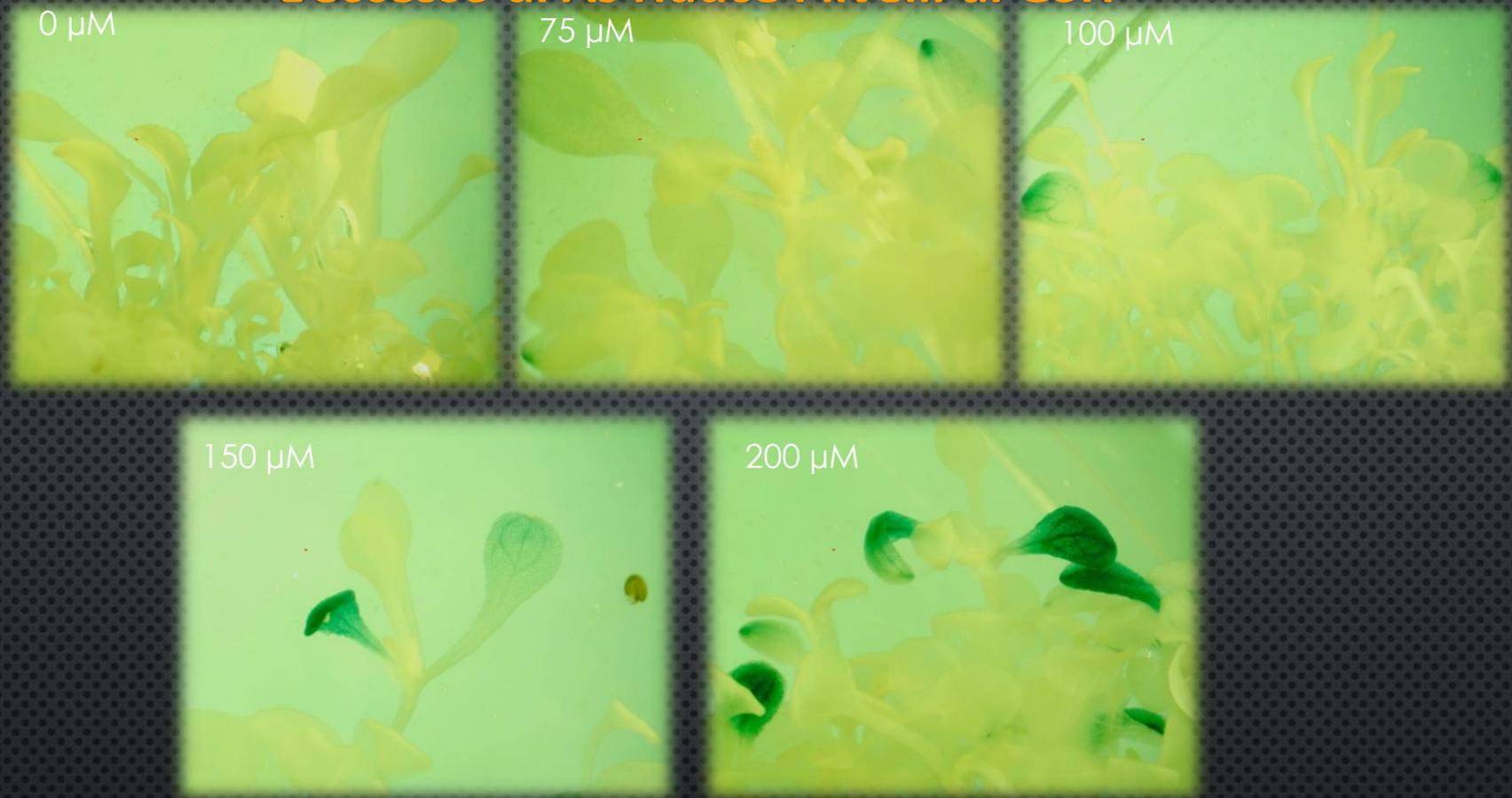
Fitochelatine



Il metabolismo riduttivo dello zolfo e le fitochelatine

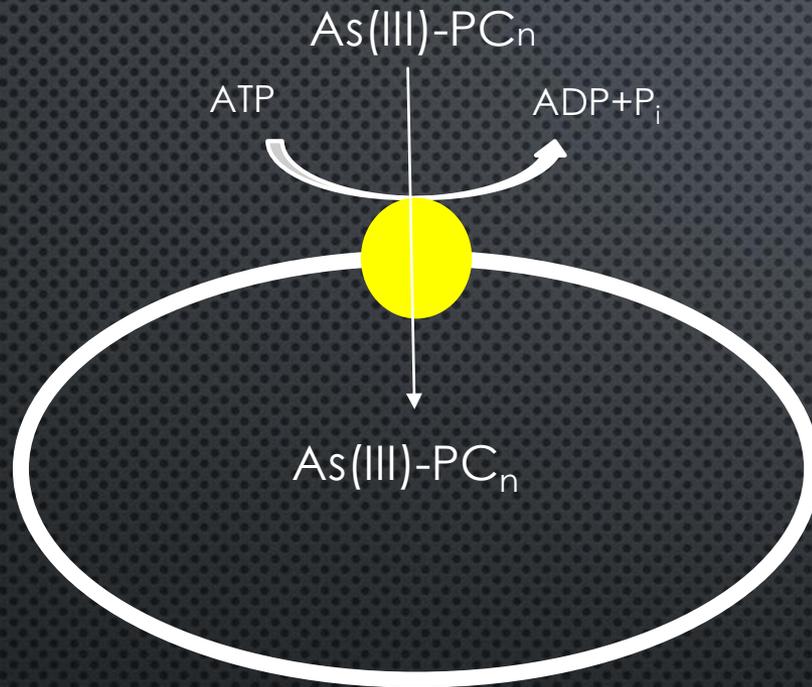


L'eccesso di As riduce i livelli di GSH



At1G12030::GUS un bioindicatore dello stato nutrizionale solforato delle piante





A. thaliana, O. sativa

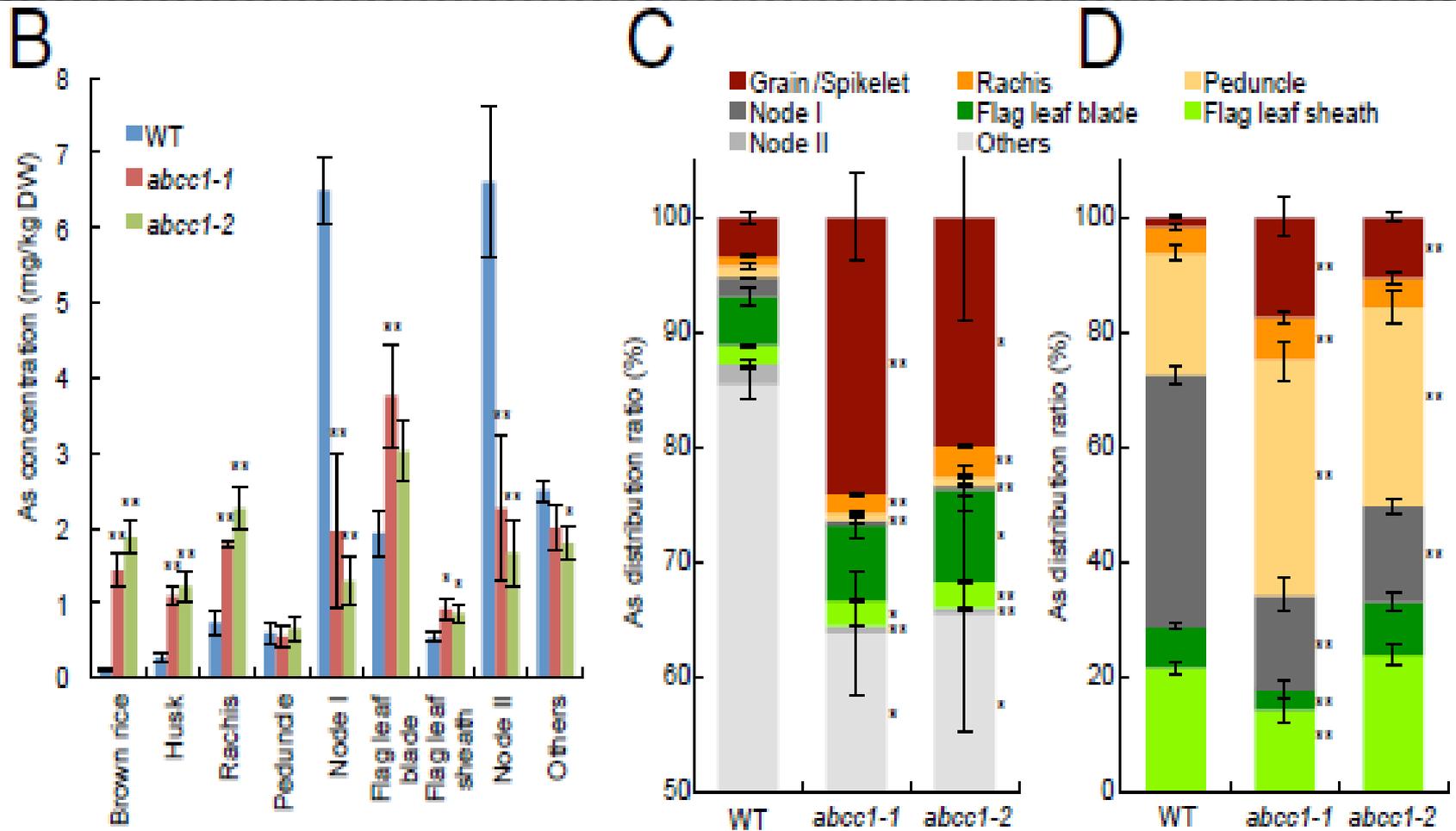


P. vittata, Iperacumuatrici



OsABCC1 e accumulo di As nella granella del riso

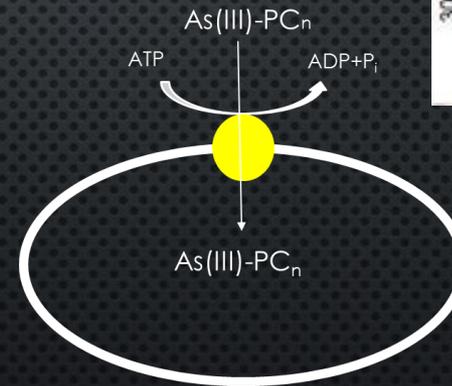
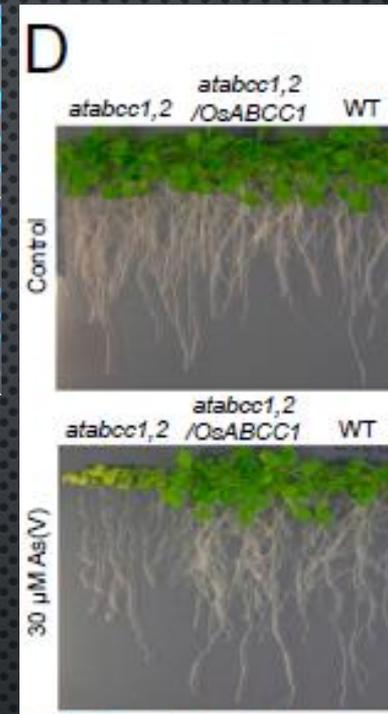
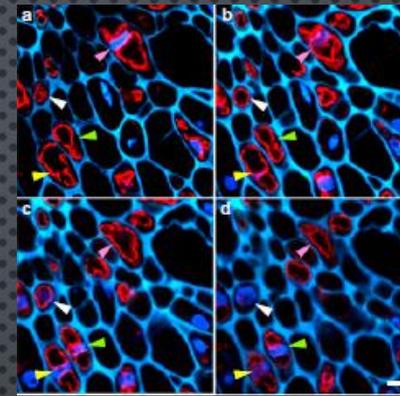
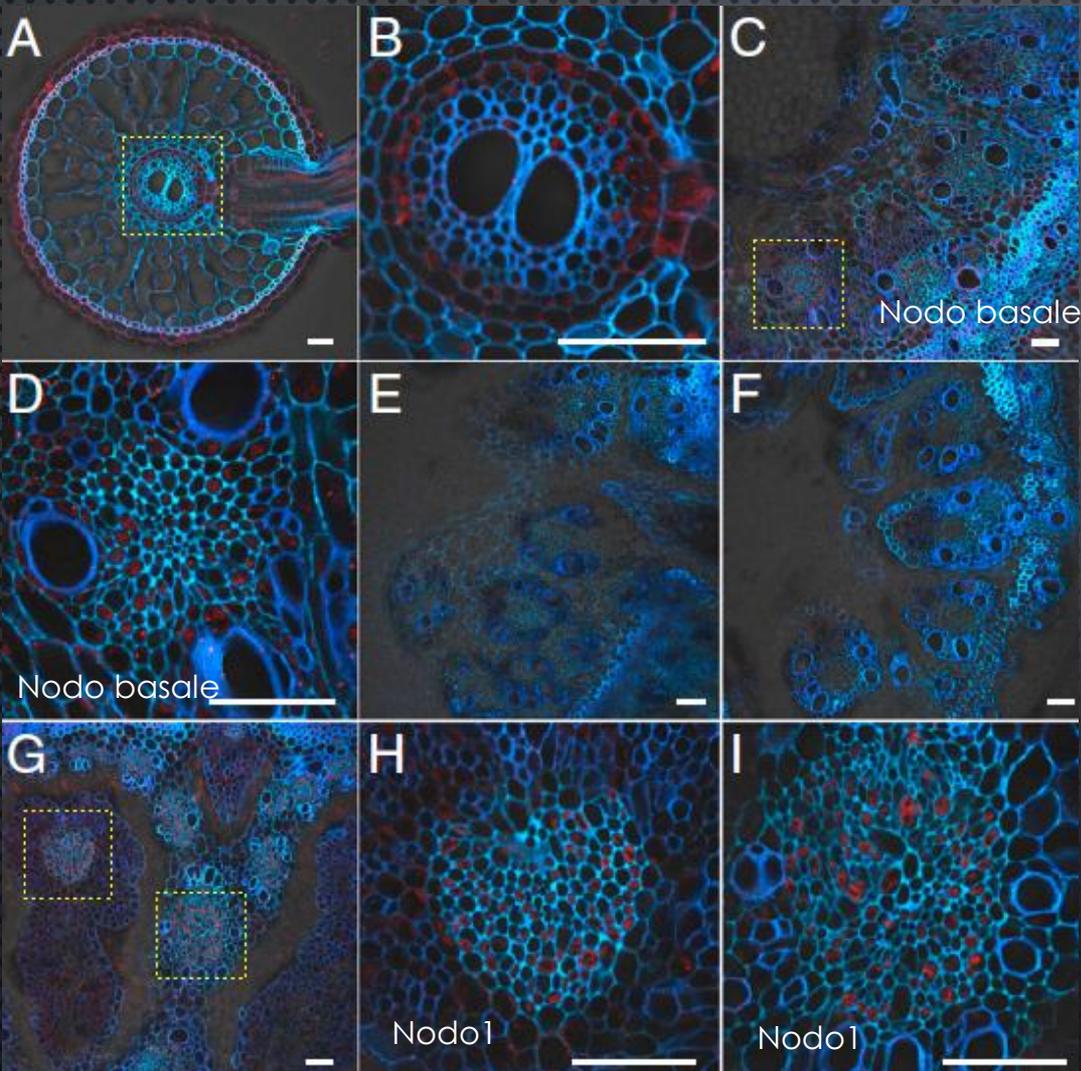
OsABCC1 ortologo di AtABCC1 e AtABCC2: sono ABC-cassette box-transporter



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



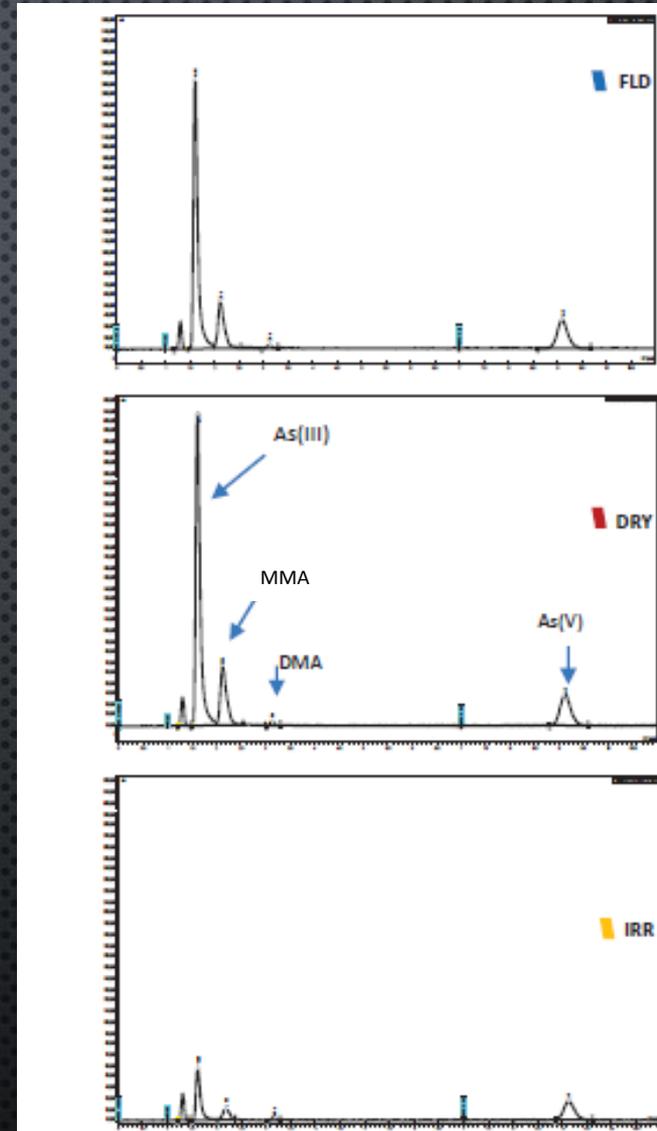
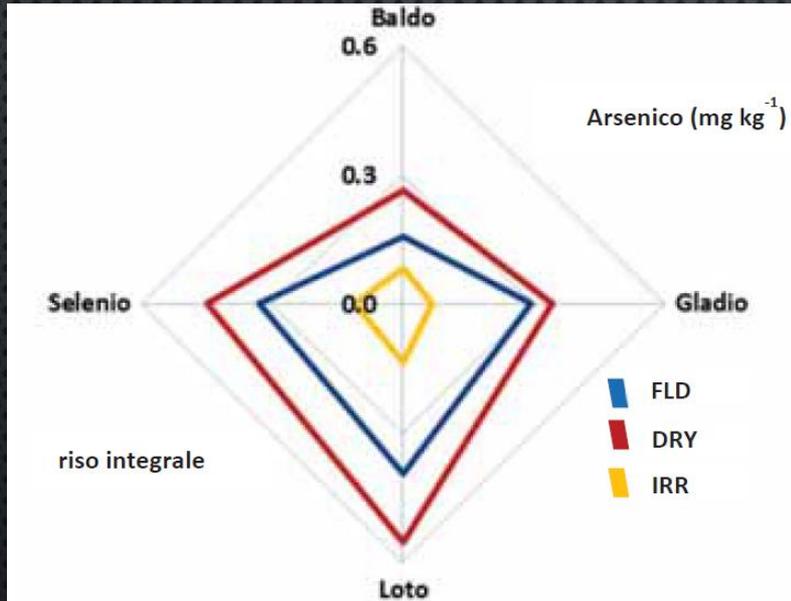
Localizzazione e attività di OsABCC1



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



Gestione idrica della risaia e di As in graella



Sacchi et al., (2014)



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Livelli di As nella granella integrale di 300 cv di riso



Sacchi et al. (2015)



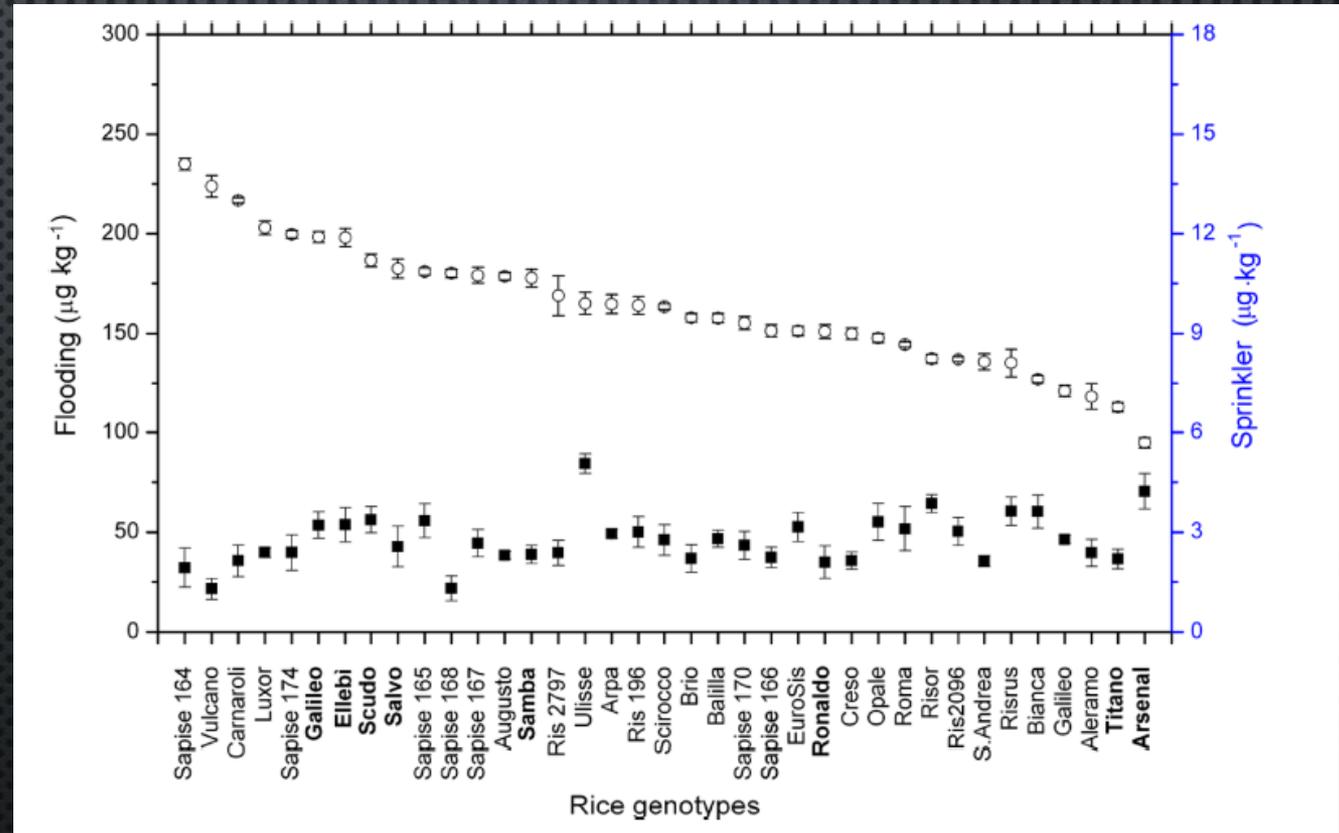
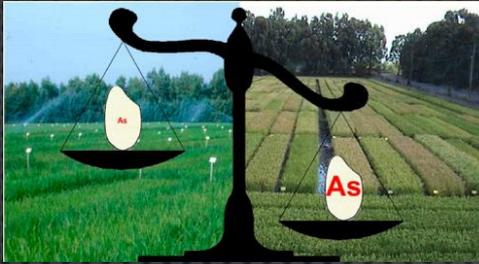
As

mg kg⁻¹



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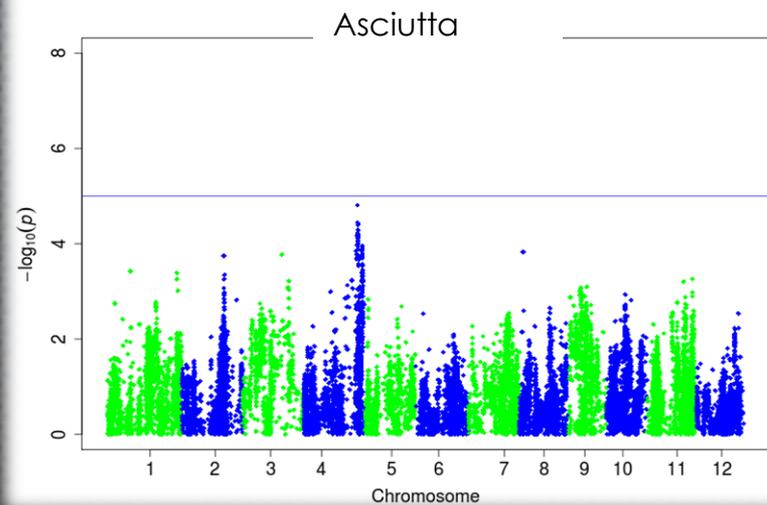
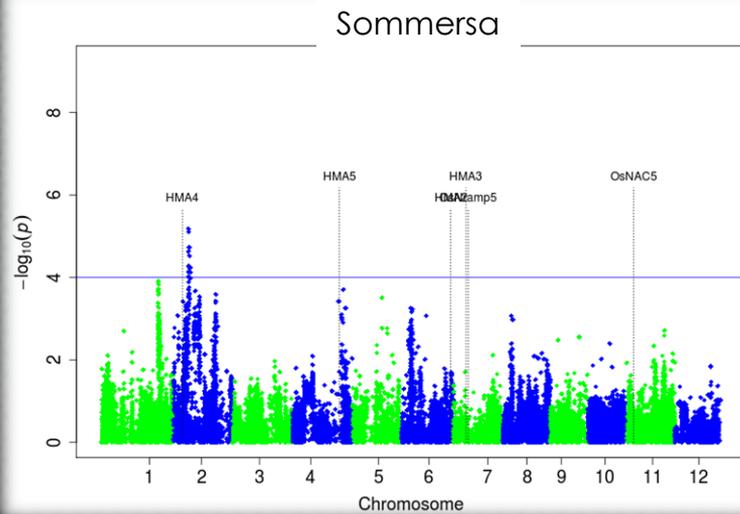
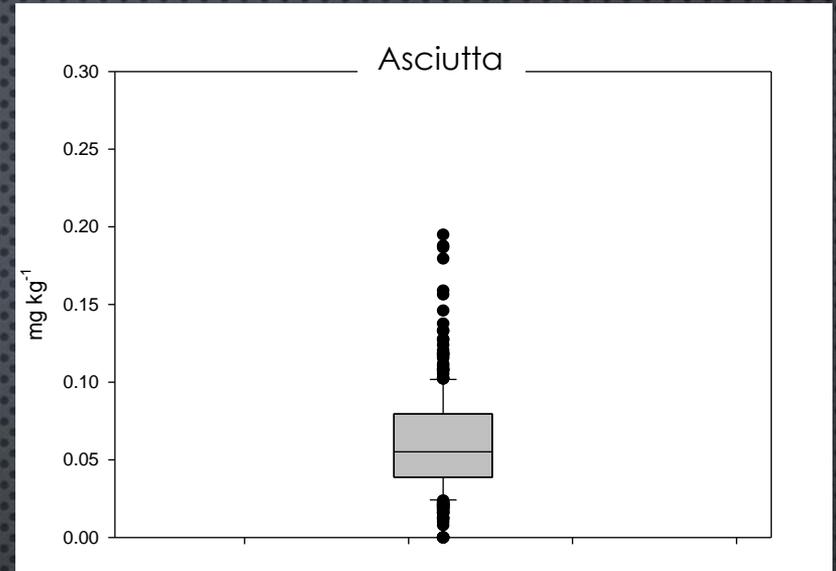
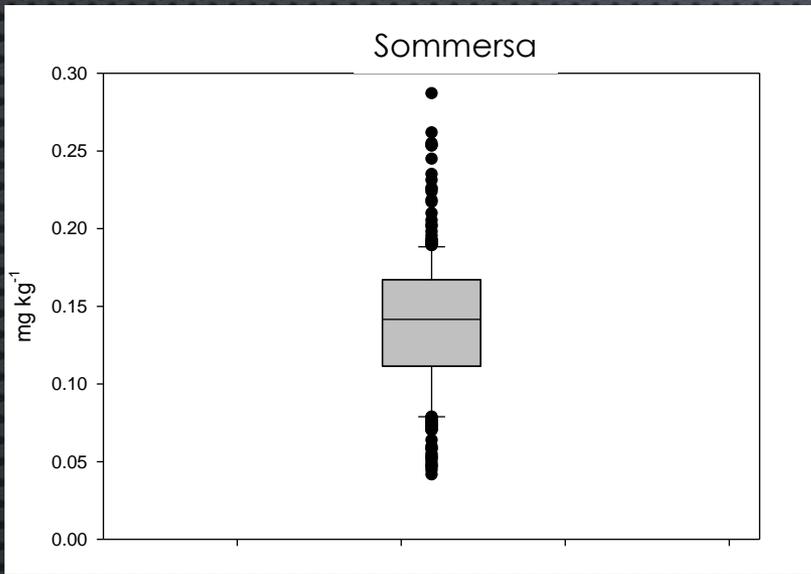
Riduzione del bioaccumulo dell'As nella granella con l'irrigazione a getto della risaia



Spanu et al. (2012) *Env. Sci Tech.*, 46:8333-8340



GWAS: contenuti di As nella granella integrale di 300 accessioni di riso

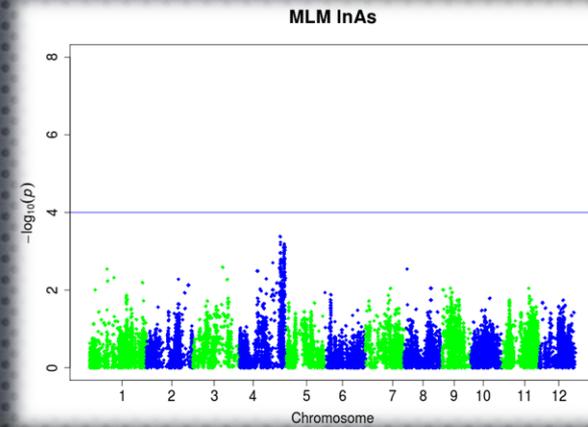


QTL identificati :

- **sul cromosoma 2 in sommersa**
- **sul cromosoma 4 in asciutta**



GWAS: contenuti di As nel germoglio di 134 accessioni di riso



QTL identificati :

➤ sul cromosoma 4 in sommersa



GRAZIE

M. Romani (ENR)
G. Valè (CRA)
R. Greco (PTP)
P. Piffanelli (PTP)
M. Porrini (UNIMI)
A. Abruzzese (UNIMI)
G. Lucchini (UNIMI)
M. Maghrebi (UNIM)

Regione Lombardia



Fondazioni per AGER



MiPAFF-POLORISO



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