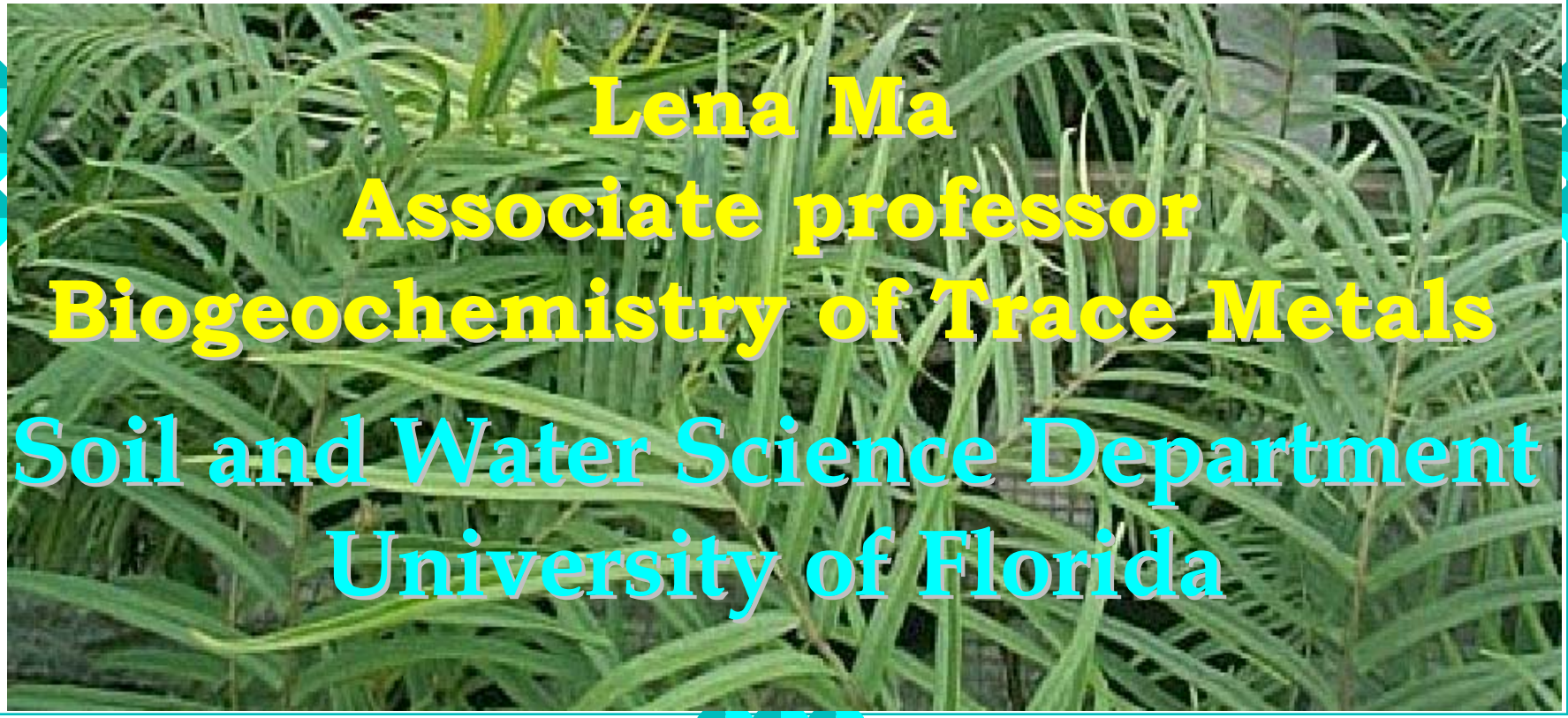
Arsenic hyperaccumulation by Chinese Brake fern (*Pteris vittata*)



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RESEARCH OBJECTIVE

- Understand the mechanisms of arsenic uptake, translocation, distribution, and detoxification by Chinese Brake fern
- Optimize plant arsenic accumulation to phytoremediate arsenic contaminated soils and water

Presentation outline

- How efficient it is in arsenic uptake
- Why it is efficient in arsenic uptake
- How arsenic is translocated and distributed
- What its potential is for phytoremediating arsenic contaminated sites
- Summary

Arsenic concentrations & enrichment factor (EF) in Chinese Brake fern

Sample	As concentration (ppm)		EF
#	Soil	Frond	Frond
1	0.47	64.0	*136*
2	0.84	33.8	40
3	2.95	45.1	15
4	38.9	7526	*193*
5	62.4	6236	100
6	1603	3186	2

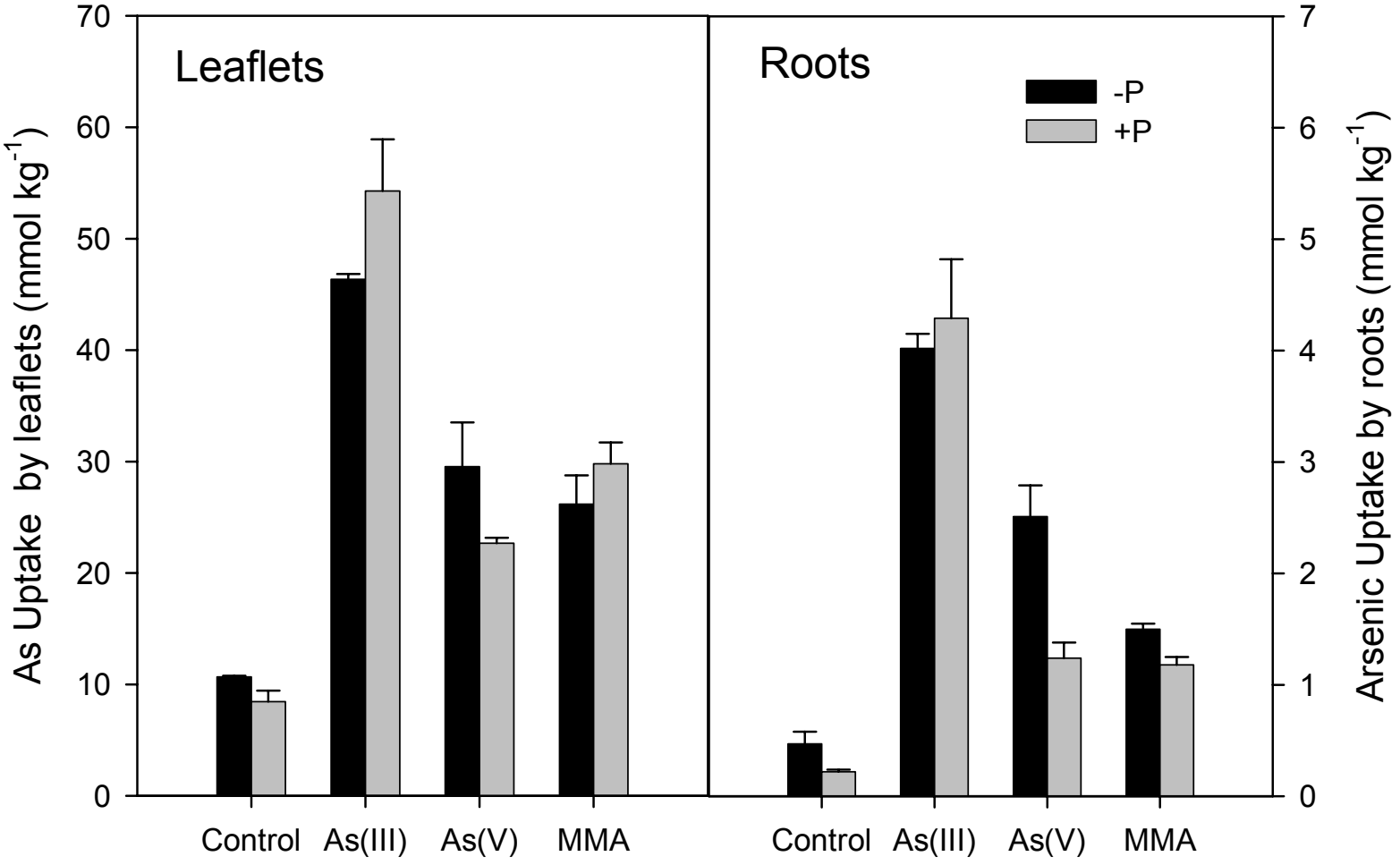
As uptake by CBF from a CCA and artificially contaminated soil (ppm)

Treatment	2 Weeks	6 Weeks
Control (~6)	755	438
CCA (~400)	3,525	6,805
50 ppm	5,131	3,215
500 ppm	7,849	21,290

As uptake by CBF from foliar application of 100 ppm arsenic (ppm)

	Arsenite ($NaAsO_2$)		Arsenate (Na_3AsO_4)	
Plant part	young	mature	young	mature
Leave (lamina)	4610	1100	3200	810
Stem (rachis)	1160	230	960	110
Spore	3710	1150	2210	760

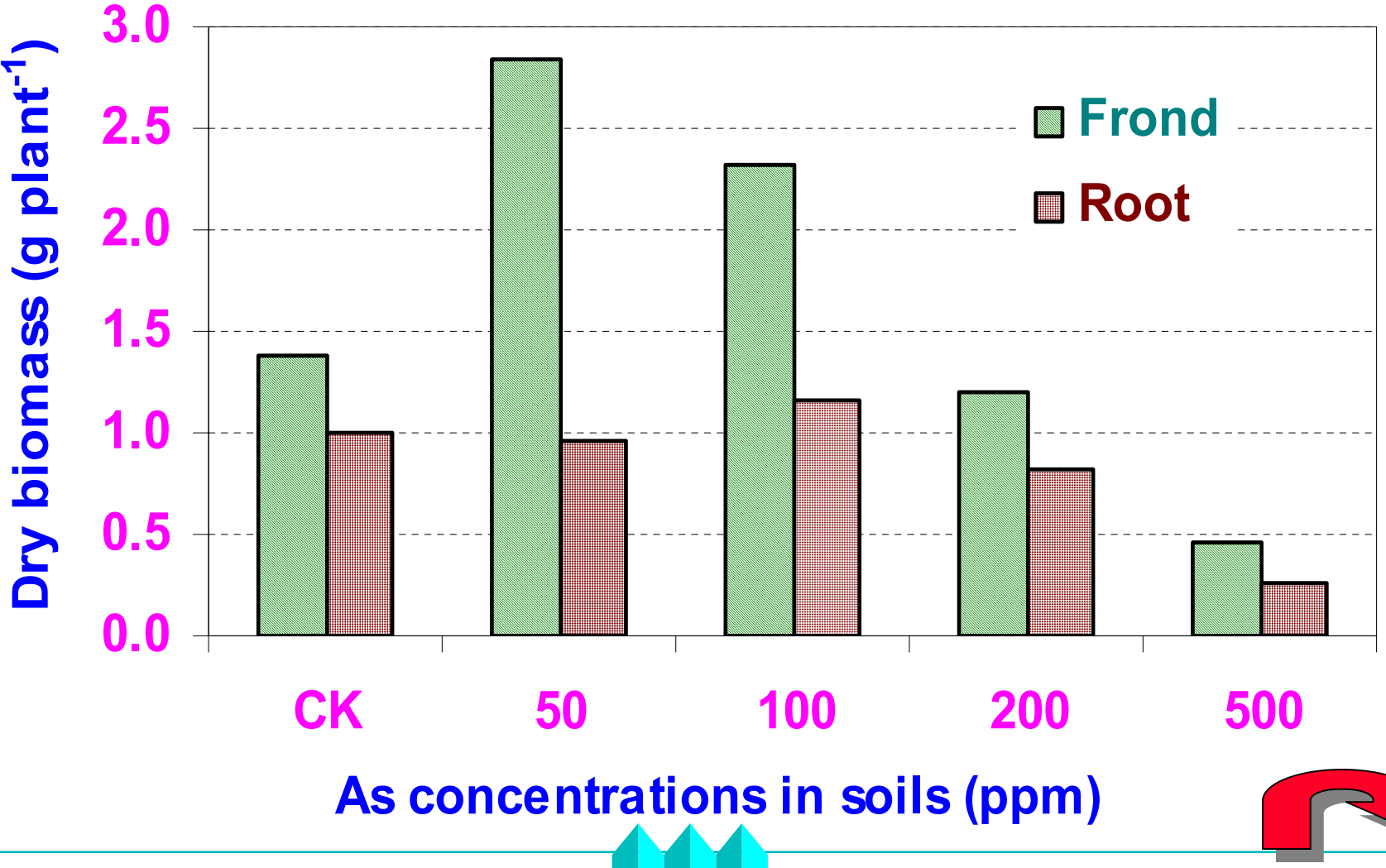
As uptake by excised CBF after exposing to 667 µm arsenic for 2 d



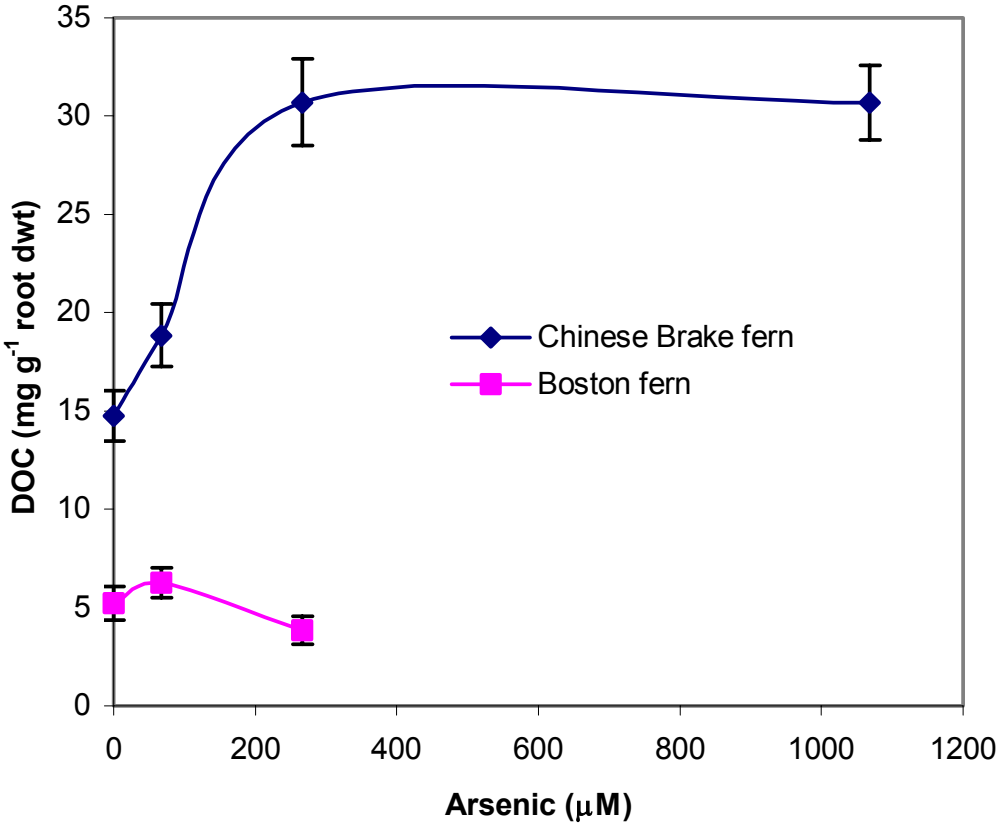
As levels in CBF in presence of metals after 8-wk growth (soil As=131ppm)

Metal concentration (ppm)	As concentrations (ppm)			
	Cd	Ni	Pb	Zn
0	4200	4200	4200	4200
50	1824	3412	3612	4100
200	1617	1538	3075	1913

Impacts of arsenic concentration on plant biomass after 12 wks of growth

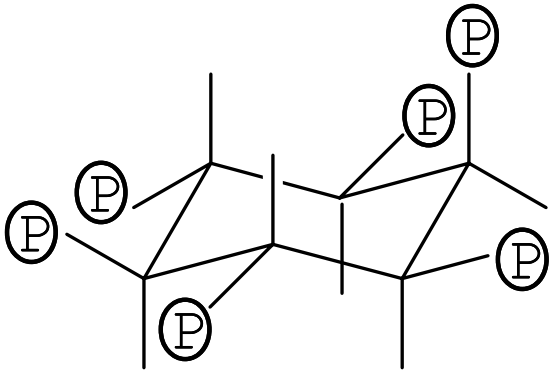


DOC in root exudates of CBF and Boston fern after growing in a hydroponic system for 2 d



Main compositions

- phytic acid
- oxalic acid



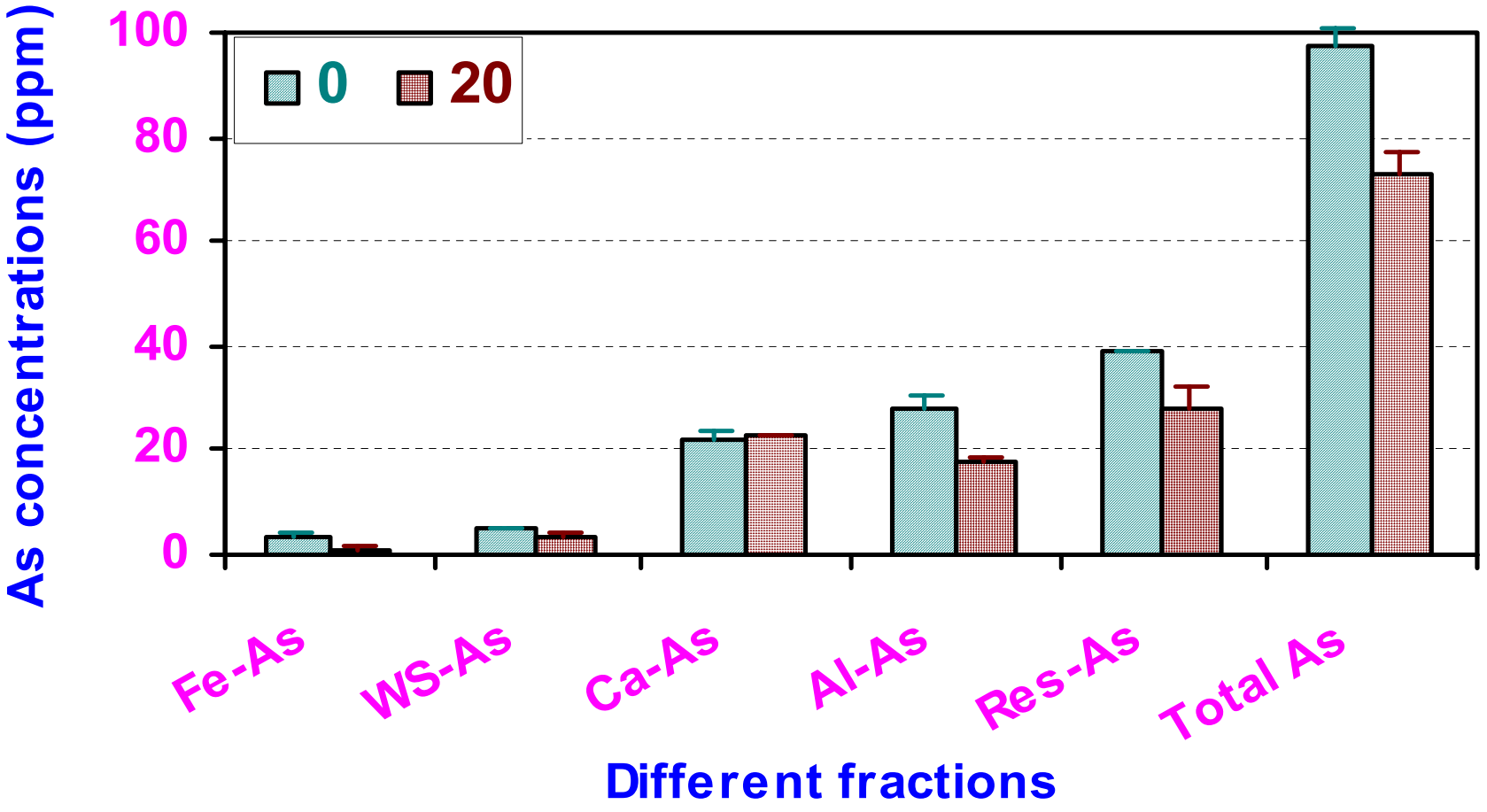
Ⓟ = OP_3H_2

Water-soluble As in CBF in presence of metals after plant As removal

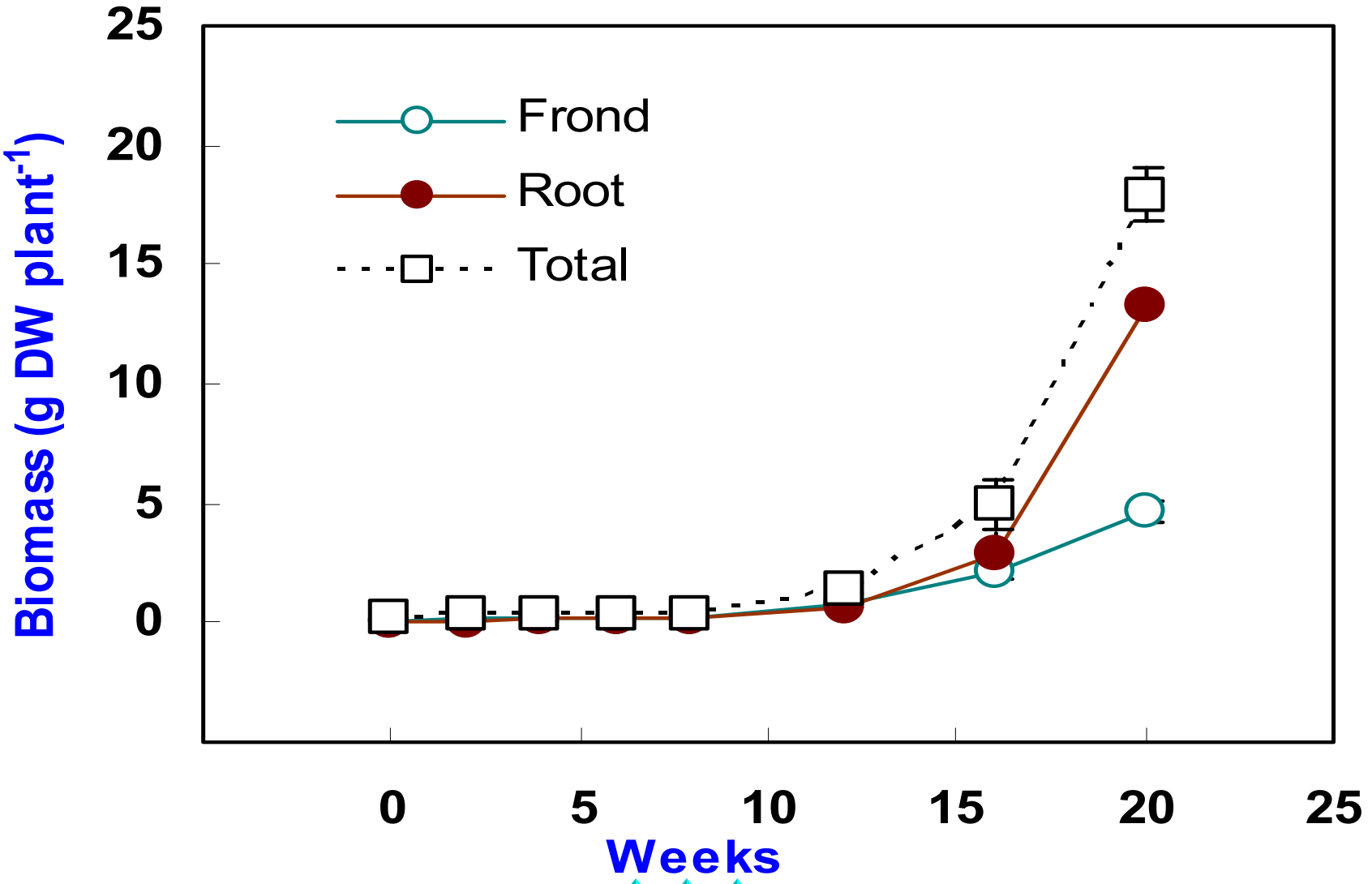
(soil As = 131 ppm)

Treatments	0-wk	5-wk	8-wk
Control	0.20	2.12	3.11
Cd-50	0.18	2.27	3.53
Cd-200	0.16	2.22	2.98
Ni-50	0.11	4.39	3.55
Ni-200	0.09	4.41	3.80
Zn-50	0.13	4.16	3.57
Zn-200	0.13	3.54	3.12
Pb-50	0.29	2.17	2.61
Pb-200	0.21	1.90	2.24

Effects of plant uptake on soil arsenic concentrations (20 wks)

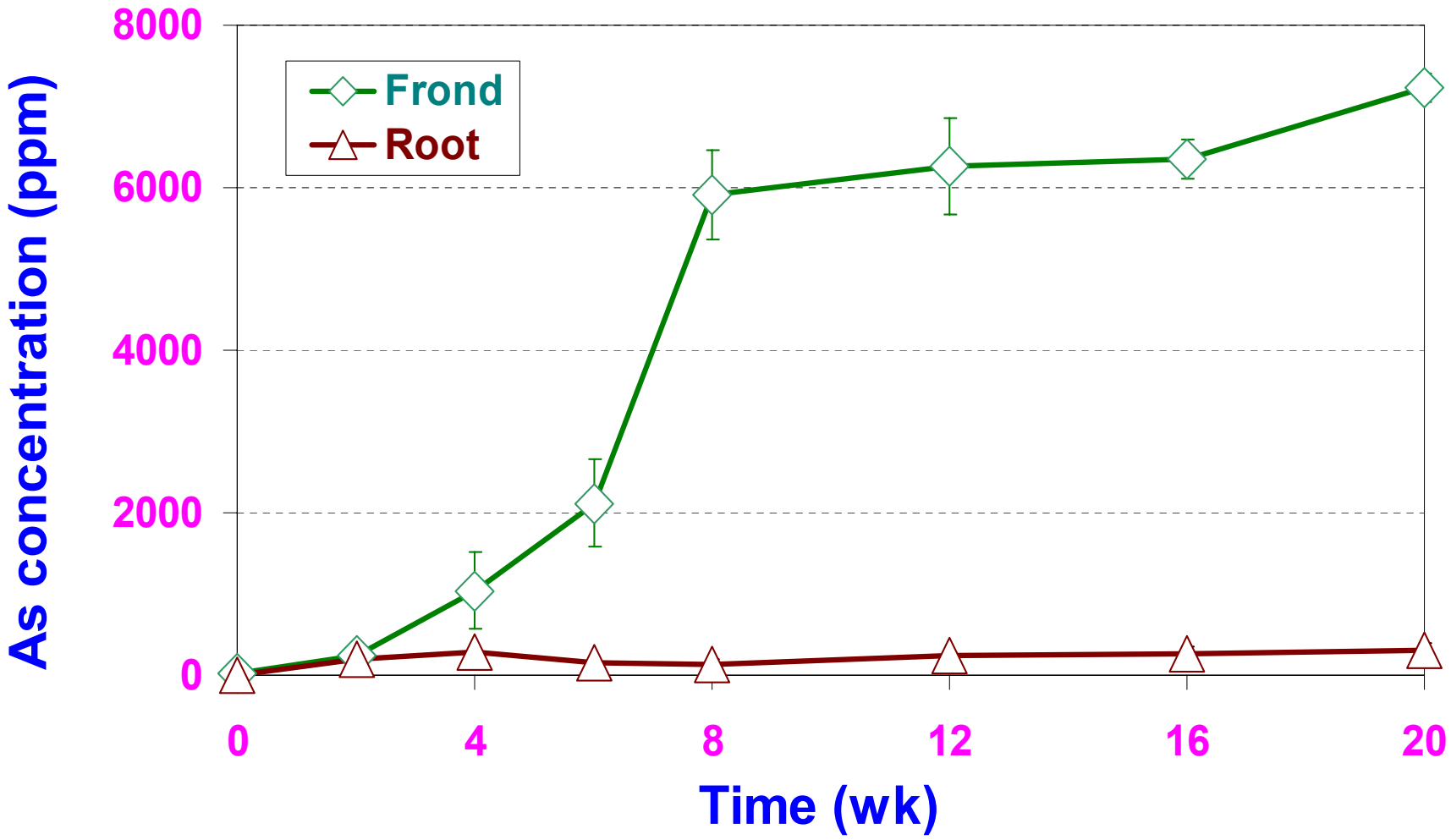


Plant biomass (Soil As=97 ppm)

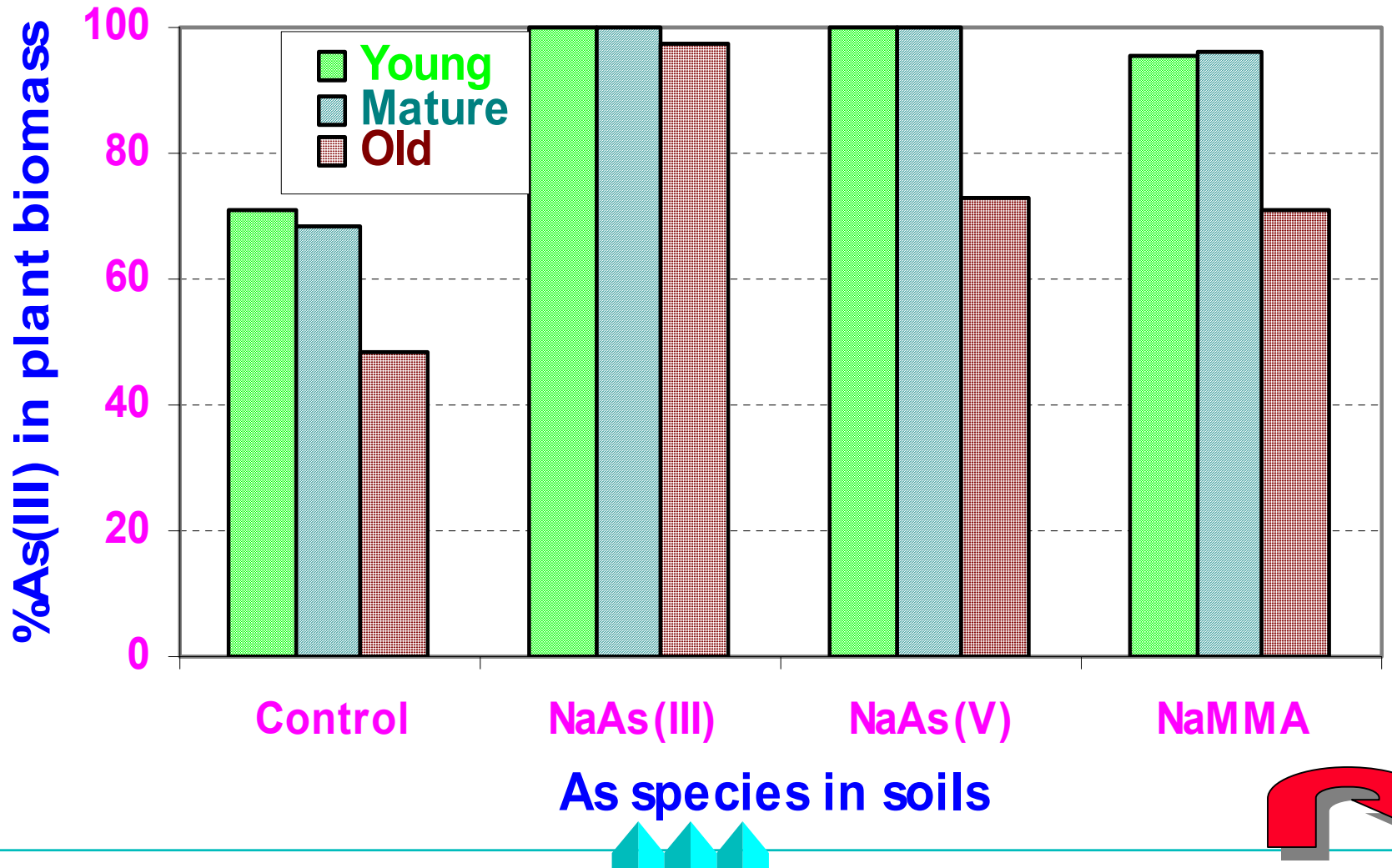



1. 18. 2000

Arsenic distribution in CBF (soil As = 97 ppm)



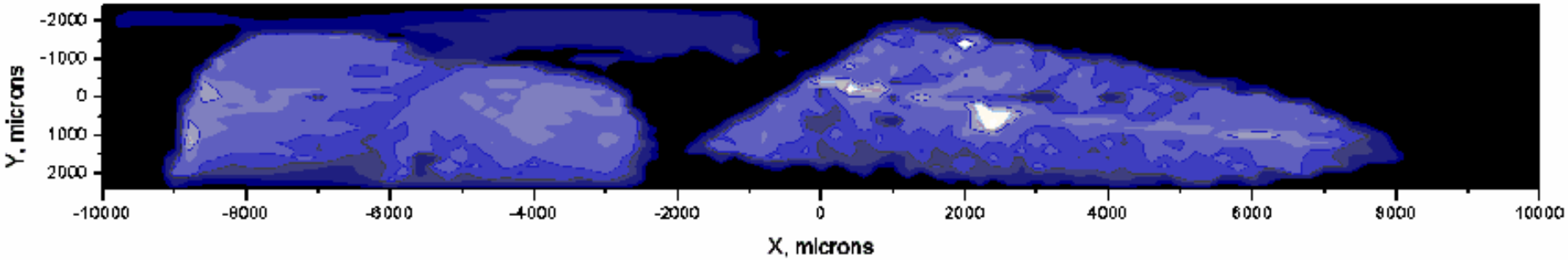
Impacts of soil As species on frond As species in CBF (soil As= 50 ppm)

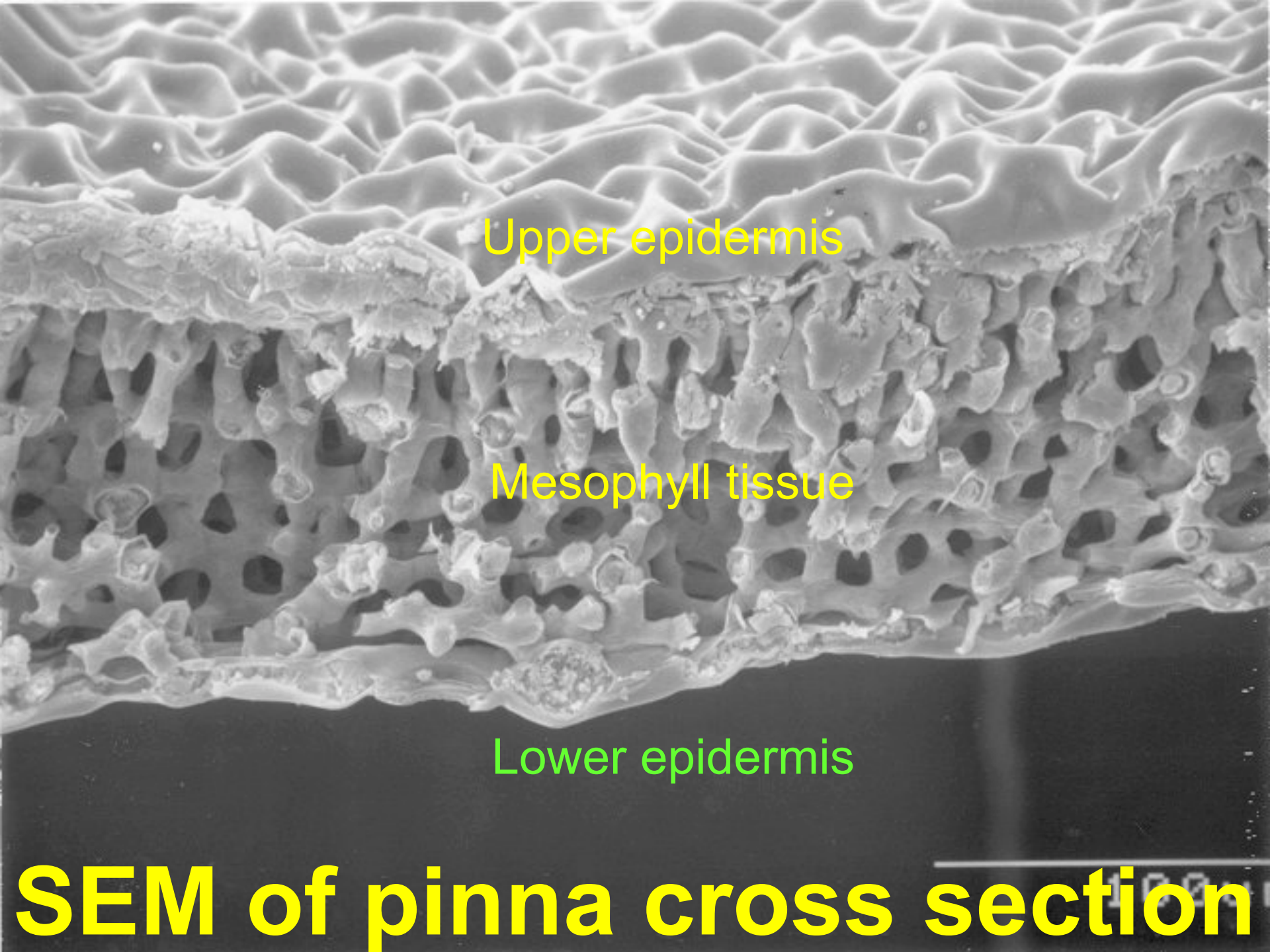


As concentration (ppm) in xylem sap of CBF growing in a hydroponic system for 3 d

Treatment	plant As	sap As	sap As-III	sap As-V
0 ppm As	71.3	0	0	0
10 ppm As(III)	166	10.4	3.5	6.9
50 ppm As(III)	502	9.8	6.6	3.2
10 ppm As(V)	148	118	9.4	109
50 ppm As(V)	434	75	12	63

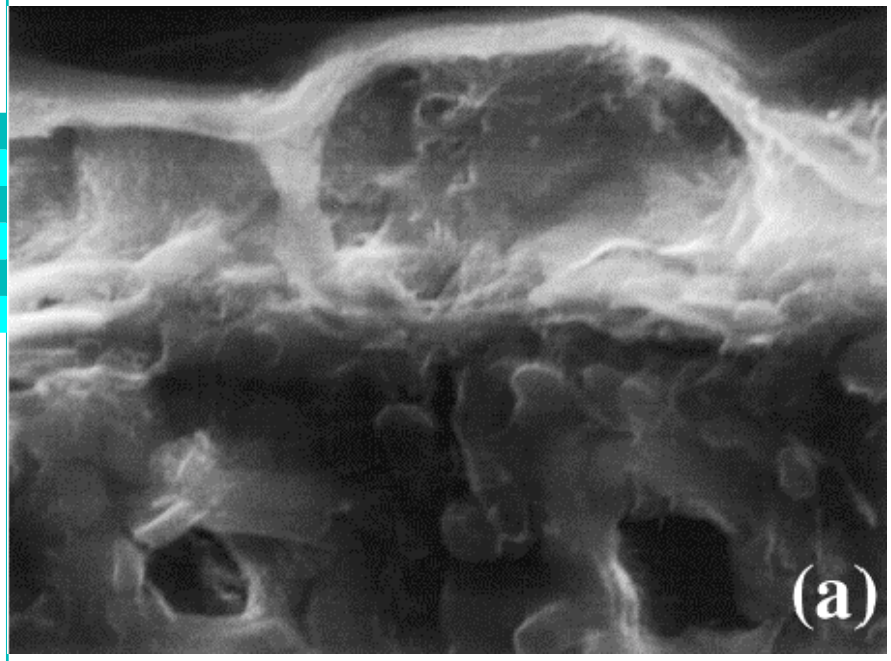
Arsenic fluorescence map of CBF pinna (light areas represent higher concentrations of arsenic)





SEM of pinna cross section

Scanning electron micrograph of epidermal cells (a), and corresponding EDXA dot-map of As (b).




9. 21. 2000


7. 19. 2001

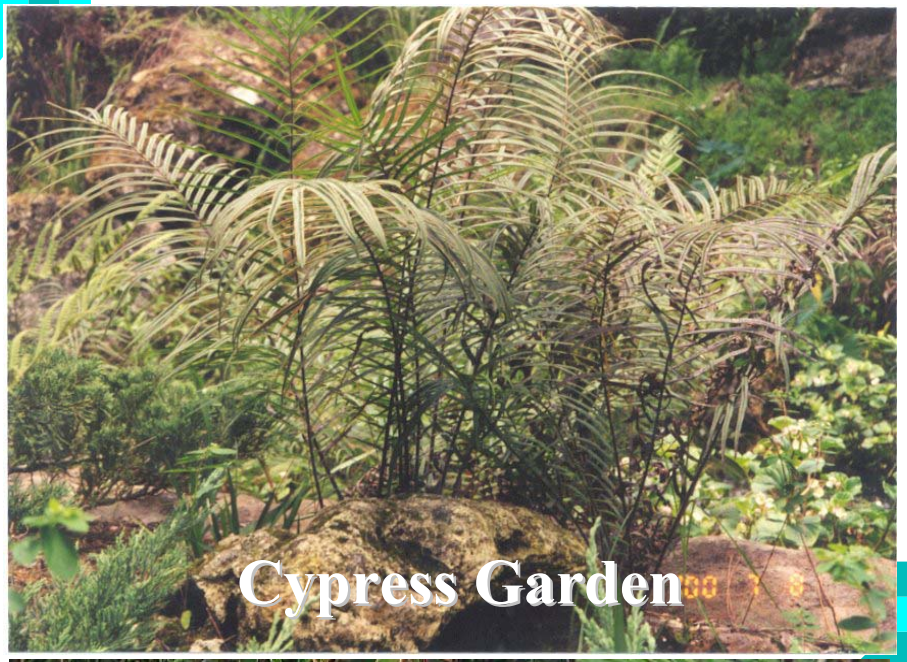

7. 7. 1997


7. 22. 2002

Arsenic removal in the field by CBF

	Average As concentration (mg/kg)			Total As depletion	
Sample depth (cm)	2000	2001	2002	mg/kg	%
0-15	190	182	140	50	26%
15-30	278	212	158	120	43%
30-60	191	180	169	22	12%


UF Campus
5. 12. 1999


Cypress Garden


Magic Kingdom


Hawaii

SUMMARY-1

- **Chinese Brake is an efficient, true arsenic hyperaccumulator**
  - **Significant accumulation (EF= 200)**
  - **Efficient translocation (TF=42)**
  - **Large biomass**
  - **Take up As**
    - **From low and high levels (0.5-500 ppm)**
    - **By root and leave**
    - **Live or excised**
    - **Different species (As-III, As-V, MMA, & DMA)**
    - **In presence of other metals**

SUMMARY-2

Hyperaccumulation characteristics

- High root exudates-DOC (phytic & oxalic acids)
- Extensive root system
- High affinity for As uptake
- Low As concentration in root
- High P concentration in root
- Reduce As to As(III)
- Store As in vacuole

SUMMARY-3

- **Chinese Brake fern has many desirable attributes for use in remediating arsenic contaminated soils**
  - **Perennial & accumulate As in its fronds**
  - **Fast growing and has a large biomass**
  - **Hardy plant and tolerate sun**
  - **Easy to reproduce**
  - **Prefer alkaline and moist environment**
  - **Work on both high & low As levels and difference species**

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