State Key Laboratory of Environmental Geochemistry
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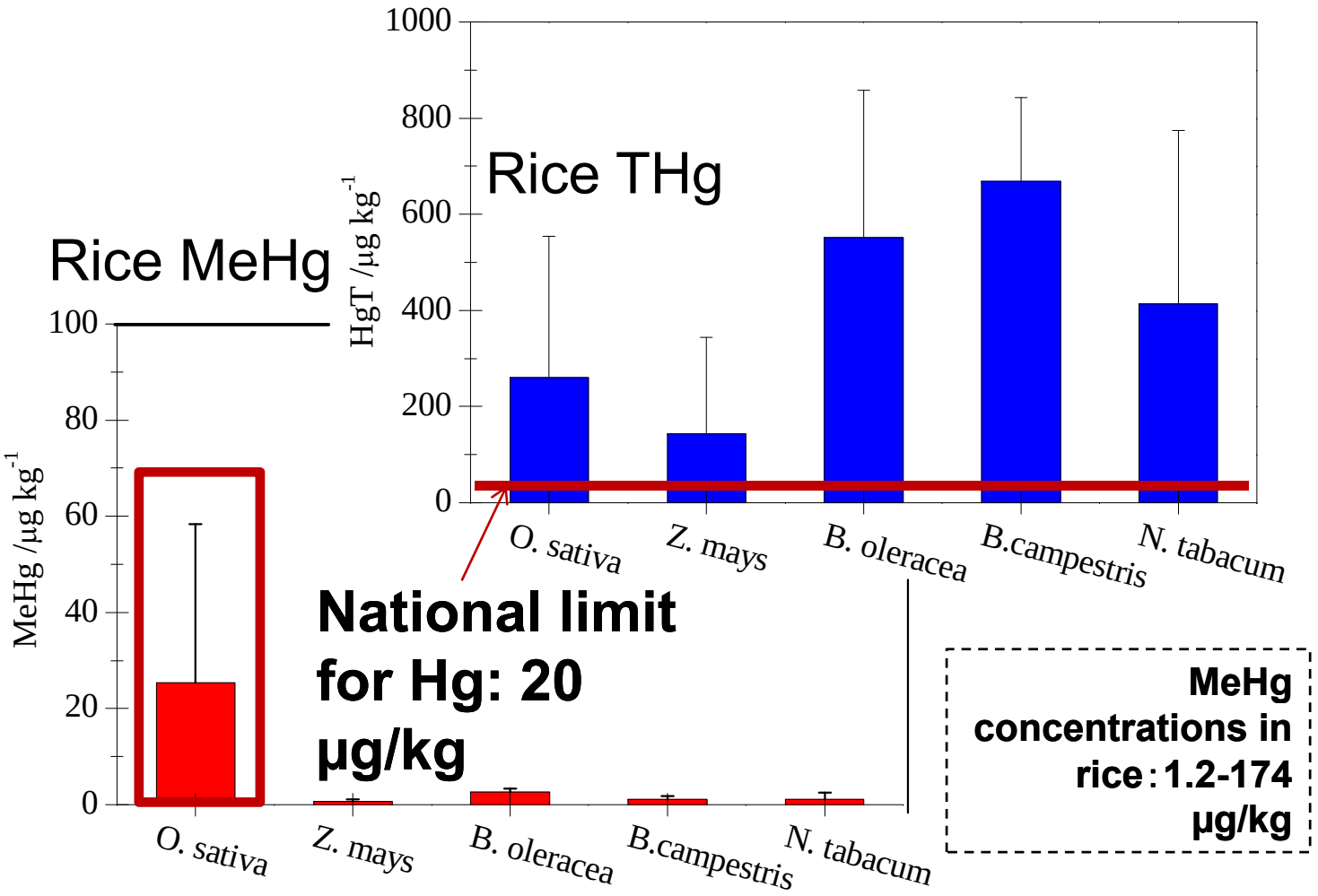
Antagonistic effect of selenium on mercury accumulation in rice plants (Oryza sativa L.)

June 16, 2014



Qiu et al., J. Agric. Food Chem., 2008

Environmental Science & Technology

Article

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Selenium in Soil Inhibits Mercury Uptake and Translocation in Rice (*Oryza sativa* L.)

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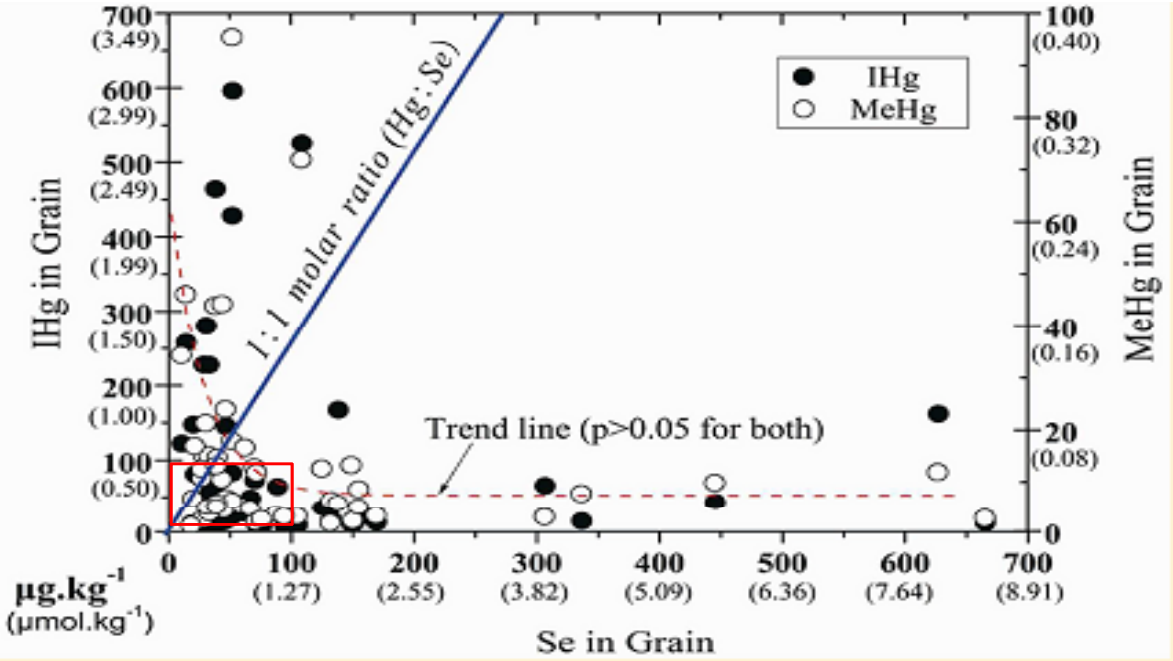
and Thorjørn Larssen[‡]



there appears to be a certain threshold value for Se for it to exert its antagonistic effect against Hg bioaccumulation in the rice plant.

Zhang, H., et al. (2012). ***Environ. Sci. & Technol****. 46, pp 10040–10046*

Existing knowledge indicates that **the involvement of Se in the environment can influence and restrict Hg's**

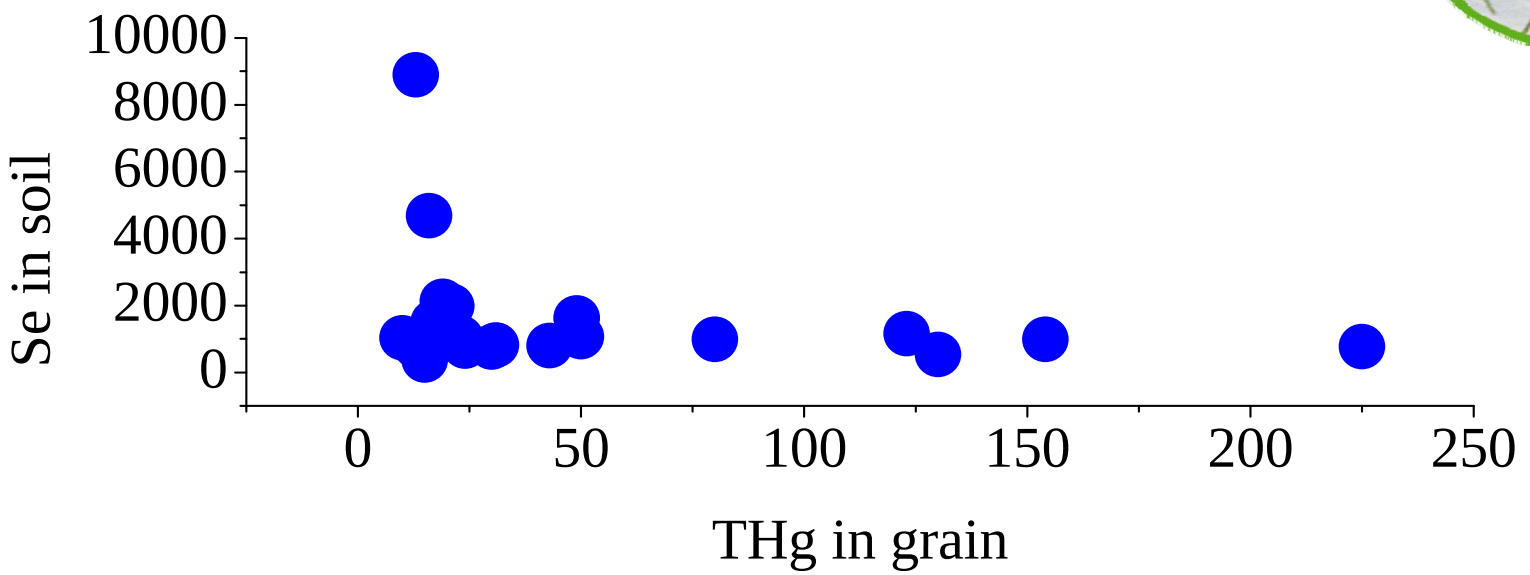
- *migration*
- *biogeochemical exposure*
- *bioavailability*
- *toxicological consequences*

Antagonism of Hg and Se

The existence of a protective effect of Se against Hg toxicity has been recognized for nearly half a century, since 1967.

Parizek & Ostadalova 1967.

Se in Soil inhibits Hg Uptake and Translocation in Rice



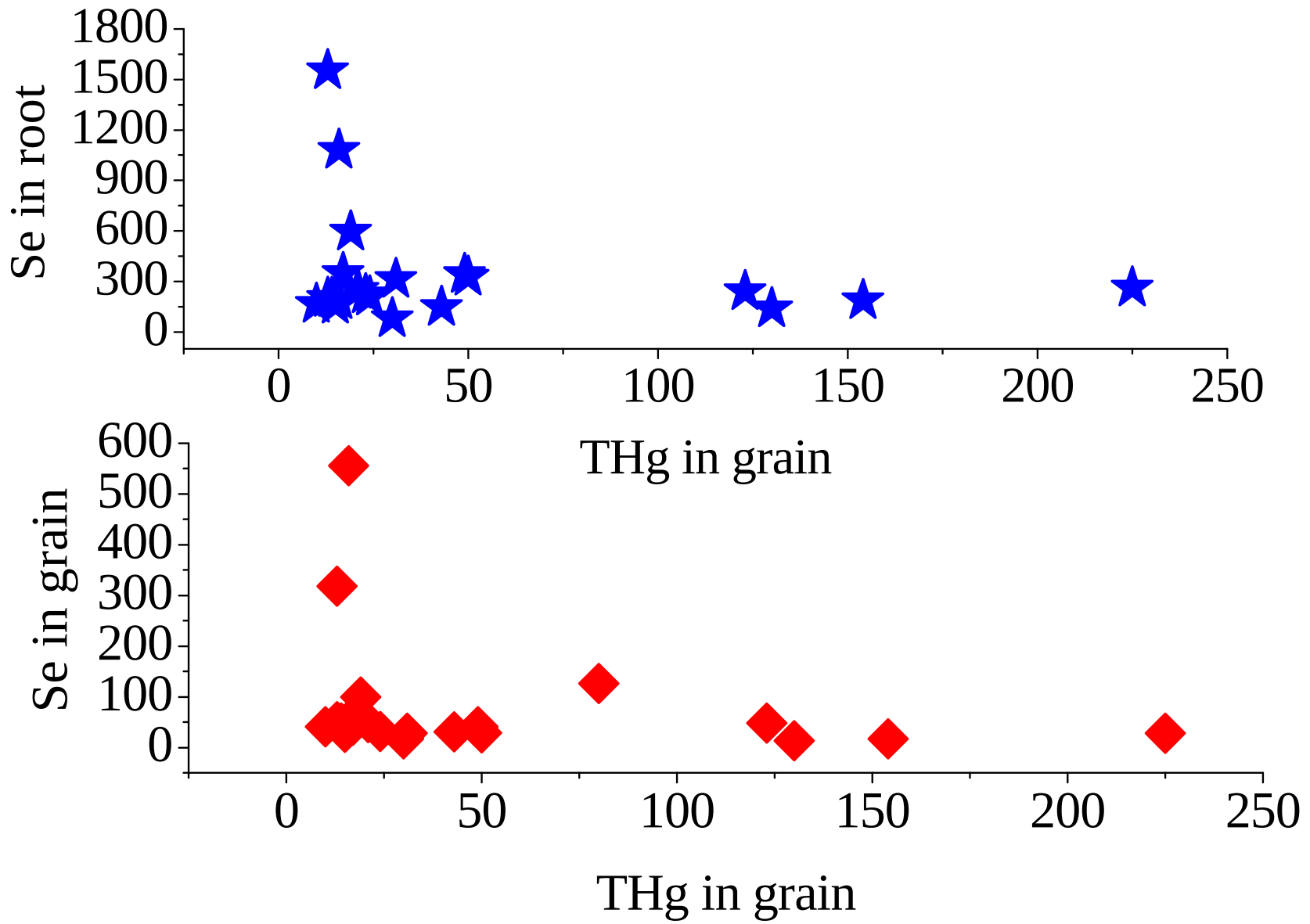
Translocation Factors of Hg were decreased with increasing Se Levels in soil from root zones

* *Translocation Factors (TFs) = Concentration in aboveground parts/Concentration in root or soil*

***Note: these samples were selected from sites with highest levels of both of Se and Hg in soils.

Zhang, H., et al. (2012). ***Environ. Sci. & Technol****. 46, pp 10040–10046*

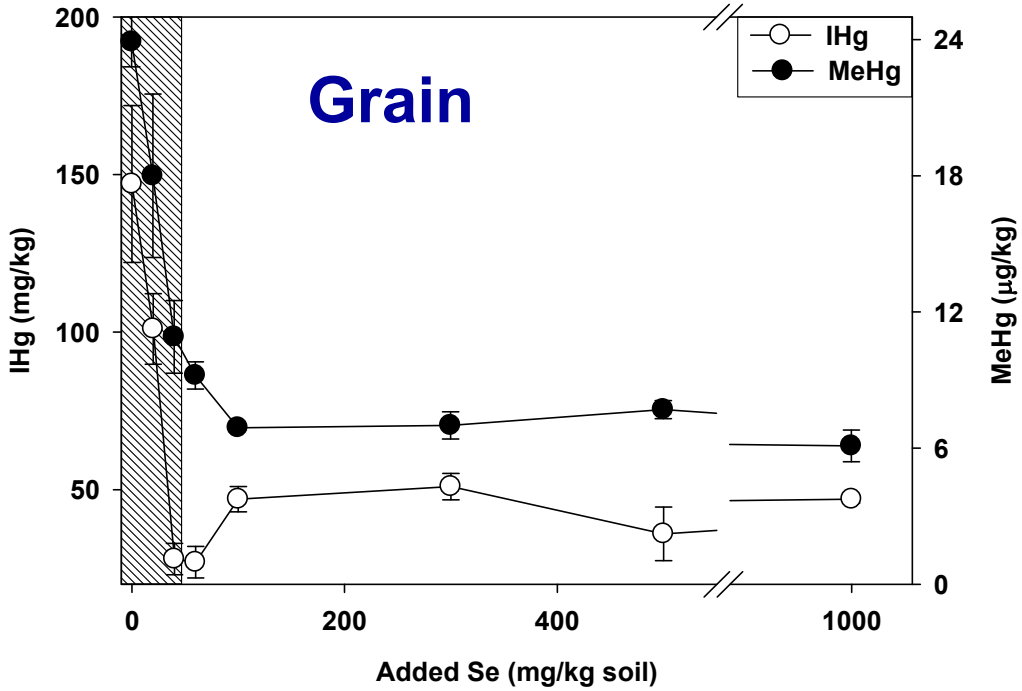
Correlations between THg in grain and Se in root and grain

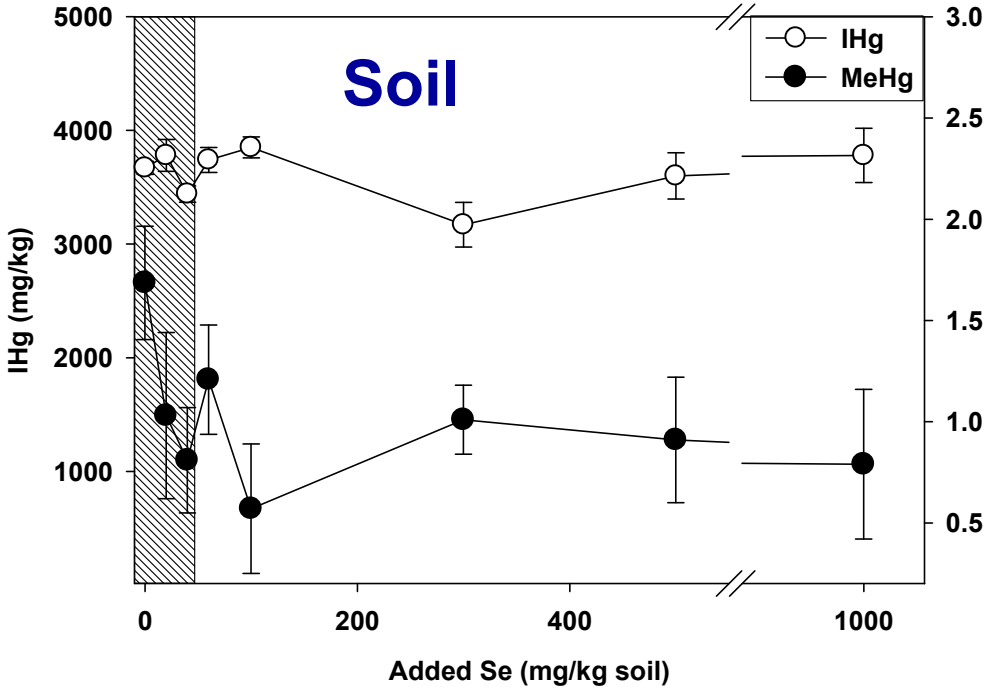


Selenium supplementation experiment

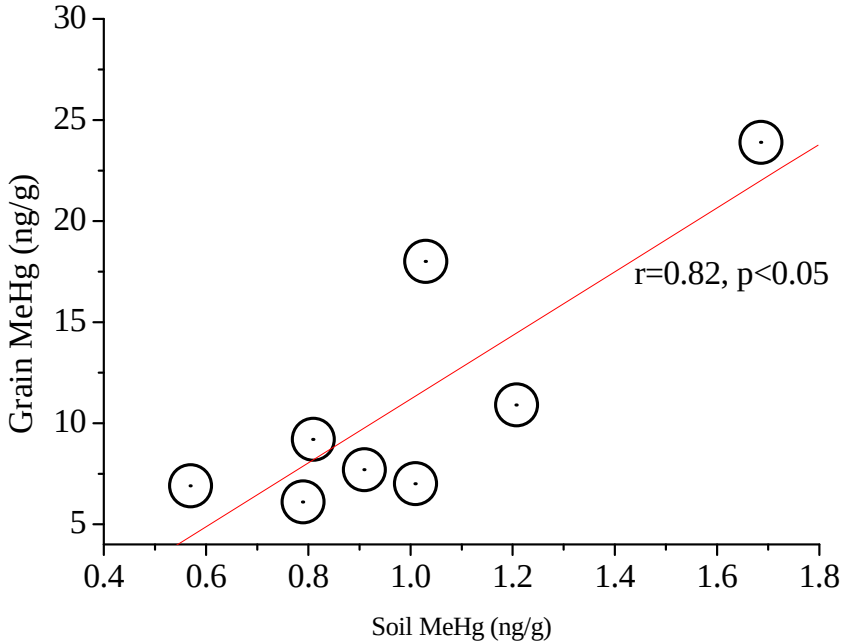
Na_2SeO_3 added

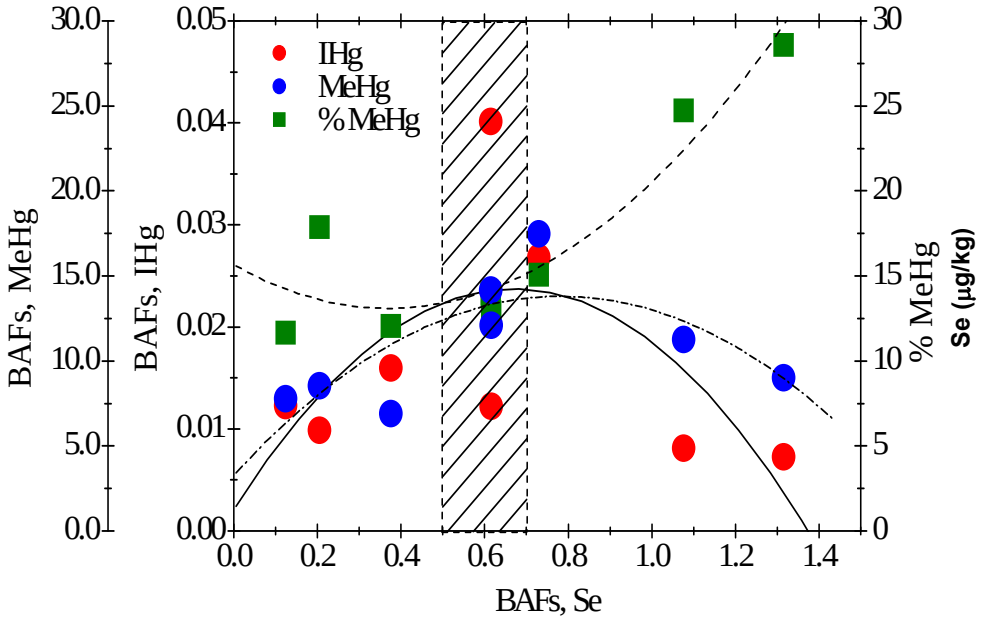
Harvested

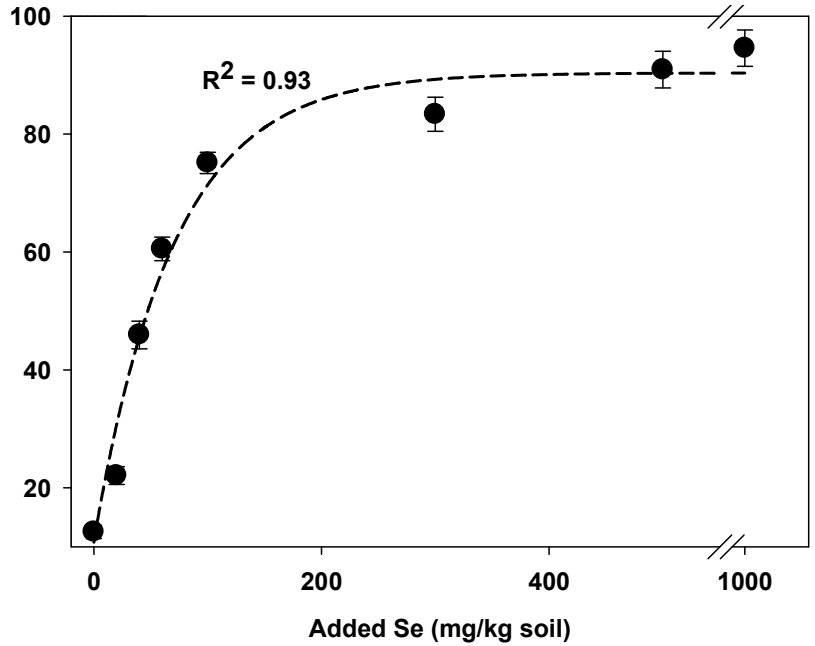




- Reduction of IHg in grain ranged from 31% to 82%;
- Reduction of MeHg in grain ranged from 25% to 74%.

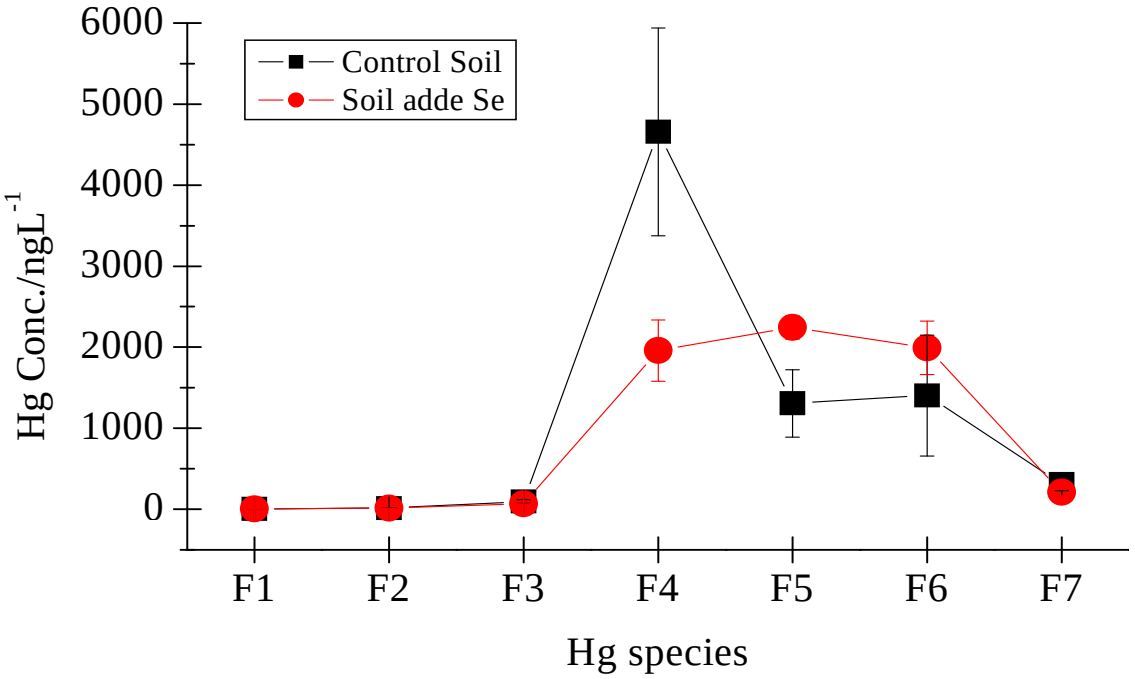


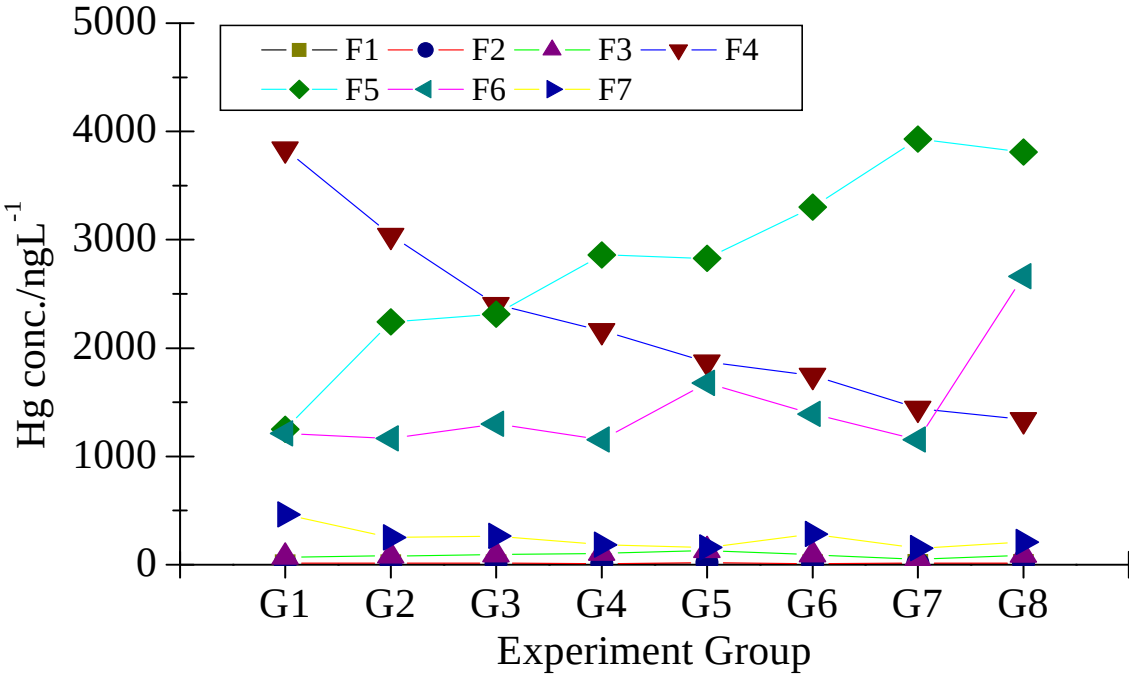




Se BAFs ranged between 0.5 and 0.7

Selenium also accumulated in grain





F1-DDW

F2-0.1 M CH_3COOH+ 0.01 M HCl

F3-1M KOH (fulic acid)

F4-1M KOH(humic acid)

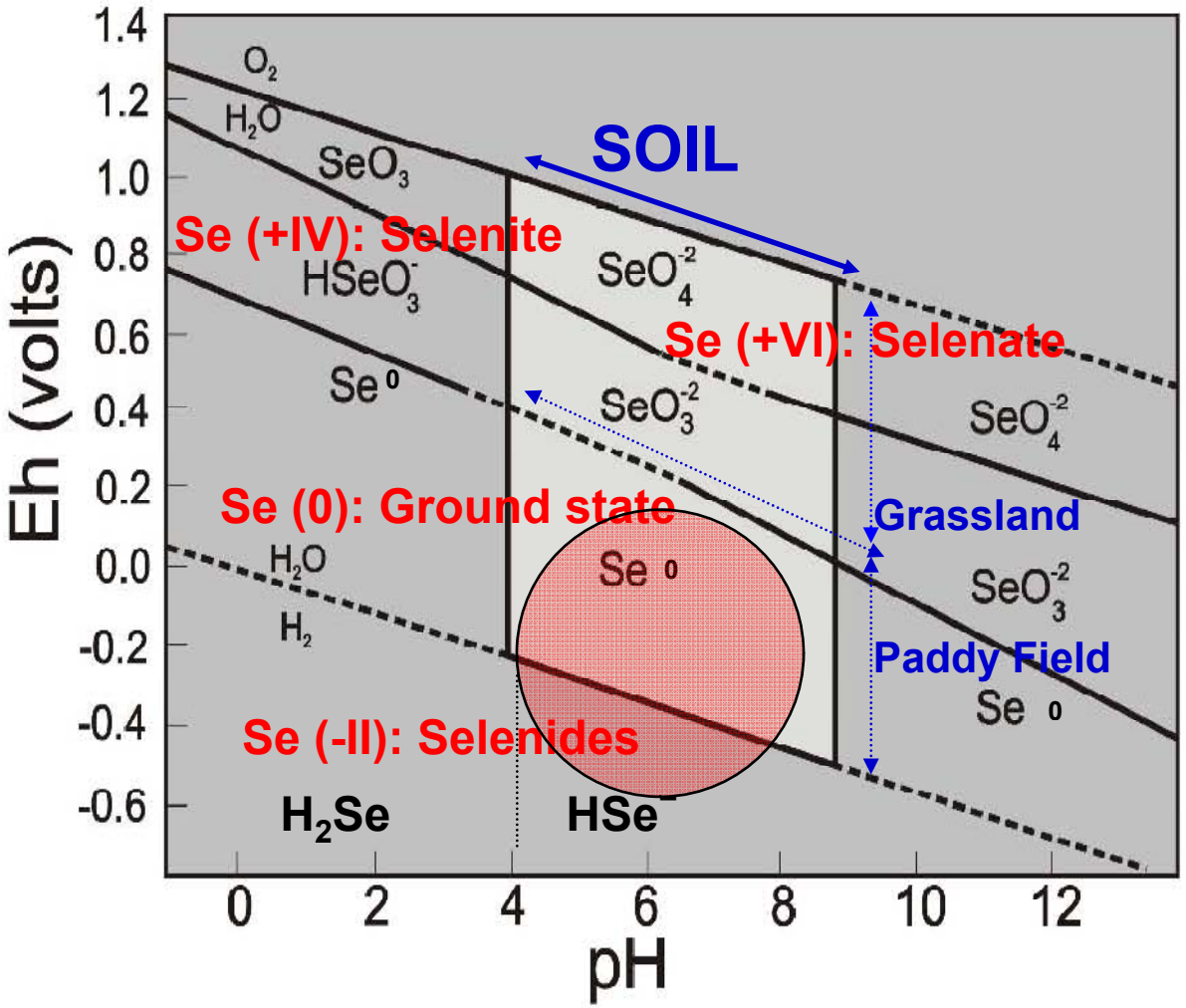
F5-12M HNO_3(elemental form)

F6-Aqua regia (sulfur form)

F7-HCl+HF(residual)

F4 → F5 F6

Eh-pH diagram of Se in soils (Mayland et al., 1989)



Proton Dissociation Equilibria

$H_2SeO_4^0 \xrightarrow[-3.0]{pK_1} HSeO_4^- \xrightarrow[1.70]{pK_2} SeO_4^{-2}$

$H_2SeO_3^0 \xrightarrow[2.61]{pK_1} HSeO_3^- \xrightarrow[8.32]{pK_2} SeO_3^{-2}$

$H_2Se \xrightarrow[3.90]{pK_1} HSe^- \xrightarrow[11.0]{pK_2} Se^{-2}$

pe+pH >15: Selenate

pe+pH = 7.5-15: Selenite

pe+pH: <7.5: Selenide

Redox Equilibria

$SeO_4^{2-} + 4H^+ + 2e \rightleftharpoons H_2SeO_3 + H_2O \quad 1.15\ V$

$H_2SeO_3 + 4H^+ + 4e \rightleftharpoons Se + 3H_2O \quad 0.74\ V$

$Se + 2H^+ + 2e \rightleftharpoons H_2Se \quad -0.40\ V$

Hg(II) + HSe(I) = HgSe(s) + H^+ (1)

MeHg(I) + HSe(I) = HgSe(s) + CH_4 (2)

Still unclear……

✓What is the mechanism of selenium antagonistic effects on mercury in rice plant?

✓Can the Se-treatment method be used for remediation of mercury contamination?

✓How to evaluate the health risk on both selenium and mercury?