# Distribution of selenium fractions and species in the rock-soil-plant interface of maize (Zea mays L.) from Naore Valley selenosis region.

Diego A. Pinzón-Núñez abc, Oliver Wiched , Zhengyu Baoaef, Shuyun Xieb, Bolu Fanag, Molan Tangag\*, Huan Tian ac\*

*a Faculty of Materials Science and Chemistry, China University of Geosciences, Wuhan* 430074, *China*

*b School of Earth Sciences, China University of Geosciences, Wuhan* 430074, *China*

*c Ziyang Zhongdida Selenium Technology Co. Ltd Ankang 72500 China*

*d Biology/Ecology Unit, Institute of Biosciences, Technische Universität Bergakademie Freiberg, Freiberg 09599, Germany*

*e Zhejiang Institute, China University of Geosciences, Hangzhou, 311305, China*

*f Ankang Se-Resources Hi-Tech Co. Ltd, Ankang* 725000, *China*

*g Scientific Research Academy of Guangxi Environment Protection, Nanning, 530022, China*

*h Guangxi Academy of Sciences, Nanning 530007, China*

Number of pages: 7

Number of tables: 8

**Supplementary material:**

**Table S1a**. Test result of SeMet (calculated by Se concentration) in ERM-BC20a

(n = 3)

|  |  |  |
| --- | --- | --- |
| Se form | Unit |  ERM-BC201a |
| Standard value ± uncertainty | Determined value ± SD |
| SeMet | mg/kg | 11.03 ± 1.05 | 10.21 ± 0.08 |

**Table S1.b.** Experimental results of spiked recovery of five Se species (calculated by Se concentration) in ERM-BC201a

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Se form | Background（mg/kg） | Spike amount（mg/kg） | Measured Value（mg/kg） | Extraction efficiency（%） |
| SeCys2 | 0.76 | 0.50 | 1.25 | 98.0 |
| 0.79 | 1.00 | 1.83 | 104.0 |
| 0.74 | 2.00 | 2.56 | 91.0 |
| MeSeCys | 0.25 | 0.50 | 0.74 | 98.0 |
| 0.59 | 1.00 | 1.64 | 105.0 |
| 0.46 | 2.00 | 2.39 | 96.5 |
| Se(IV) | 0.16 | 0.50 | 0.63 | 94.0 |
| 0.19 | 1.00 | 1.12 | 93.0 |
| 0.41 | 2.00 | 2.32 | 95.5 |
| SeMet | 10.30 | 0.50 | 10.73 | 86.0 |
| 10.17 | 1.00 | 11.25 | 108.0 |
| 10.17 | 2.00 | 12.06 | 94.5 |
| Se(VI) | 0.53 | 0.50 | 0.98 | 90.0 |
| 0.56 | 1.00 | 1.51 | 95.0 |
| 0.54 | 2.00 | 2.47 | 96.5 |

**Table S2.** The fractions results of soils and rock parental material analyzed.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **pH** | **TOC** | **Type/Site** | **F1** | **F2** | **F3** | **F4** | **F5** | **Sum** | **tSe** | **Recovery**  | **SD** |
| 7.54 | 4.47 | Soil1 | 0.09 | 0.16 | 0.40 | 4.04 | 10.03 | 14.72 | 13.30 | 110.63 | 0.61 |
| 7.71 | 3.31 | Soil2 | 0.05 | 0.14 | 0.25 | 2.12 | 6.51 | 9.07 | 8.58 | 105.75 | 0.34 |
| 7.9 | 4.93 | Soil3 | 0.08 | 0.09 | 0.57 | 7.66 | 19.58 | 27.99 | 29.38 | 95.26 | 2.98 |
| 7.03 | 5.72 | Soil4 | 0.13 | 0.46 | 0.67 | 4.23 | 17.50 | 22.99 | 21.99 | 104.53 | 4.12 |
| 7.7 | 7.03 | Soil5 | 0.09 | 0.14 | 0.99 | 4.77 | 21.15 | 27.14 | 29.95 | 90.61 | 2.20 |
| 7.7 | 2.24 | Soil6 | 0.07 | 0.21 | 0.57 | 1.46 | 4.75 | 7.06 | 7.81 | 90.47 | 0.11 |
| 7.69 | 5.05 | Soil7 | 0.05 | 0.28 | 0.79 | 1.32 | 4.87 | 7.30 | 8.00 | 91.32 | 0.62 |
| 7.35 | 3.21 | Soil8 | 0.07 | 0.25 | 0.81 | 1.48 | 4.46 | 7.07 | 8.83 | 80.09 | 0.73 |
| 6.47 | 5.24 | Soil 9 | 0.08 | 0.26 | 0.76 | 2.24 | 6.67 | 10.01 | 11.12 | 90.07 | 0.76 |
| 7.59 | 4.28 | Soil10 | 0.09 | 0.17 | 0.50 | 7.65 | 17.50 | 25.92 | 27.80 | 93.22 | 1.22 |
| 7.6 | 5.19 | Soil11 | 0.05 | 0.15 | 0.37 | 1.36 | 13.41 | 15.34 | 14.23 | 107.83 | 1.77 |
| 9.33 | 1.93 | Rock12 | 0.02 | 0.22 | 0.16 | 1.43 | 0.19 | 2.03 | 2.02 | 100.76 | 0.24 |
| 9.04 | 2.05 | Rock13 | 0.05 | 0.39 | 1.06 | 7.41 | 0.51 | 9.41 | 9.86 | 95.49 | 0.44 |
| 8.5 | 1.07 | Rock14 | 0.16 | 0.69 | 4.83 | 38.60 | 0.59 | 44.86 | 41.46 | 108.21 | 0.56 |
| 8.73 | 8.41 | Rock15 | 0.03 | 0.08 | 0.57 | 7.84 | 0.38 | 8.91 | 7.73 | 115.24 | 6.77 |
| 8.04 | 13.12 | Rock16 | 7.81 | 11.24 | 22.86 | 28.69 | 19.99 | 90.58 | 85.48 | 105.97 | 4.13 |
| 8.32 | 3.42 | Rock17 | 0.00 | 0.08 | 3.18 | 0.09 | 0.58 | 3.92 | 3.85 | 98.21 | 0.48 |
| 9.14 | 3.06 | Rock18 | 0.13 | 0.50 | 0.58 | 5.53 | 0.72 | 7.46 | 6.09 | 0.13 | 0.26 |
| 9.35 | 8.13 | Rock19 | 0.02 | 0.28 | 0.30 | 0.71 | 0.19 | 1.50 | 1.30 | 0.02 | 0.57 |
| 9.32 | 3.82 | Rock20 | 0.00 | 0.47 | 0.13 | 3.22 | 0.44 | 4.26 | 3.69 | 115.38 | 1.05 |
| 6.53 | 14.97 | Rock21 | 0.25 | 2.29 | 21.68 | 19.51 | 4.4 | 48.13 | 40.87 | 117.78 | 1.10 |
| 8.8 | 0.22 | Rock 22 | 0.06 | 0.20 | 0.71 | 7.11 | 0.89 | 8.97 | 7.74 | 0.06 | 4.00 |

Note : F1: water soluble Se, F2: Exchangable Se, F3: Alkali-soluble Se, F4: Acid soluble Se, and F5: Residual Se. Fractions are given in Se mg kg-1, while TOC and recoveries are given in percentage.

**Table S3.** Pearson correlations between fractions and tSe.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pearson | SF2 | S-tSe | R-tSe | SF1+F2 | SF4+F5 | RF1-F2 | RF3-F4 | RF4-F5 | tSe-Root | tSe-Stalk | tSe-Leaf | tSe-Grain |
| S-F2 | 1 | -0.211 | 0.019 | **0.983\*\*** | -0.206 | -0.275 | -0.458 | -0.451 | 0.337 | 0.568 | **0.701\*** | 0.524 |
| S-tSe |  | 1 | 0.275 | -0.058 | **0.986\*\*** | 0.556 | **0.906\*\*** | **0.828\*\*** | 0.177 | -0.079 | -0.127 | -0.201 |
| R-tSe |  |  | 1 | 0.031 | 0.339 | 0.254 | 0.123 | 0.195 | -0.491 | -0.304 | -0.397 | -0.581 |
| SF1+F2 |  |  |  | 1 | -0.051 | -0.197 | -0.340 | -0.341 | 0.380 | 0.579 | **0.691\*** | 0.541 |
| SF4+F5 |  |  |  |  | 1 | 0.481 | **0.852\*\*** | **0.829\*\*** | 0.156 | -0.106 | -0.178 | -0.273 |
| RF1+F2 |  |  |  |  |  | 1 | **0.685\*** | **0.754\*** | 0.022 | -0.237 | -0.153 | -0.045 |
| RF3+F4 |  |  |  |  |  |  | 1 | **0.969\*\*** | 0.150 | -0.213 | -0.196 | -0.217 |
| RF4+F5 |  |  |  |  |  |  |  | 1 | 0.140 | -0.220 | -0.212 | -0.230 |
| tSe-Root |  |  |  |  |  |  |  |  | 1 | **0.685\*** | **0.76\*** | **0.653\*** |
| tSe-Stalk |  |  |  |  |  |  |  |  |  | 1 | **0.701\*** | **0.777\*** |
| tSe-Leaf |  |  |  |  |  |  |  |  |  |  | 1 | **0.684\*** |
| tSe-Grain |  |  |  |  |  |  |  |  |  |  | 1 |

**Table S4.** Spearman correlations between fractions and tSe

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Spearman | SF2 | S-tSe | R-tSe | SF1+F2 | SF4+F5 | RF1-F2 | RF3-F4 | RF4-F5 | tSe-Root | tSe-Stalk | tSe-Leaf | tSe-Grain |
| S-F2 | 1 | -0.464 | -0.327 | **0.964\*\*** | -0.536 | -0.400 | -0.564 | -0.473 | 0.527 | **0.682\*** | **0.781\*** | **0.709\*** |
| S-tSe |  | 1 | **0.709\*** | -0.327 | **0.927\*\*** | 0.518 | 0.664 | **0.855\*\*** | -0.118 | -0.191 | -0.273 | -0.464 |
| R-tSe |  |  | 1 | -0.255 | **0.791\*\*** | 0.073 | 0.582 | 0.655\* | -0.091 | -0.200 | -0.191 | -0.382 |
| SF1+F2 |  |  |  | 1 | -0.427 | -0.300 | -0.509 | -0.400 | 0.555 | **0.691\*** | 0.791 | 0.800 |
| SF4+F5 |  |  |  |  | 1 | 0.436 | **0.773\*** | **0.864\*\*** | 0.018 | -0.073 | -0.200 | -0.491 |
| RF1+F2 |  |  |  |  |  | 1 | **0.609\*** | **0.664\*** | 0.091 | -0.055 | -0.136 | -0.255 |
| RF3+F4 |  |  |  |  |  |  | 1 | **0.918\*\*** | 0.000 | -0.136 | -0.255 | -0.391 |
| RF4+F5 |  |  |  |  |  |  |  | 1 | 0.000 | -0.127 | -0.236 | -0.464 |
| tSe-Root |  |  |  |  |  |  |  |  | 1 | **0.909\*\*** | **0.909\*\*** | 0.482 |
| tSe-Stalk |  |  |  |  |  |  |  |  |  | 1 | **0.918\*\*** | 0.582 |
| tSe-Leaf |  |  |  |  |  |  |  |  |  |  | 1 | **0.609\*** |
| tSe-Grain |  |  |  |  |  |  |  |  |  |  | 1 |

Note: For both tables (\*p < 0.05, \*\*p < 0.01, correlation coefficient), S and R mean soil and rock, respectively.

**Table S5.** Pearson correlations between tSe and biomass in maiz organs, and tSe and Se soil fractions in soils

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pearson | tSe-Root | Root-B | tSe-Stalk | Stalk-B | tSe-Leaf | Leaf-B | tSe-Grain | Grain-B | tSe-soil | SF1 | SF2 | SF3 | SF4 | SF5 |
| tSe-Root | 1 | -0.412 | **0.678\*\*** | -0.060 | **0.756\*\*** | -0.320 | **0.629\*\*** | -0.300 | 0.177 | 0.257 | 0.320 | 0.239 | 0.111 | 0.018 |
| Root-B |  | 1 | -0.320 | -0.136 | **-0.533\*** | **0.361\*** | -0.220 | **0.501\*** | **-0.371\*** | **-0.403\*** | **-0.344\*** | **-0.697\*\*** | -0.231 | -0.332 |
| tSe-Stalk |  |  | 1 | **0.089\*\*** | **0.688\*\*** | 0.043 | **0.767\*\*** | **-0.346\*** | -0.077 | 0.293 | **0.547\*\*** | 0.296 | -0.112 | -0.181 |
| Stalk-B |  |  |  | 1 | 0.106 | -0.112 | -0.295 | **0.372\*** | **0.389\*** | 0.127 | 0.130 | 0.072 | 0.381\* | 0.280 |
| tSe-Leaf |  |  |  |  | 1 | -0.036 | **0.659\*\*** | -0.198 | -0.133 | 0.214 | **0.686\*\*** | **0.502\*** | -0.214 | -0.252 |
| Leaf-B |  |  |  |  |  | 1 | 0.053 | -0.085 | **-0.672\*\*** | **-0.663\*\*** | -0.182 | 0.049 | **-0.590\*\*** | **-0.606\*\*** |
| tSe-Grain |  |  |  |  |  |  | 1 | **-0.441\*** | -0.195 | 0.243 | **0.4816\*** | **0.382\*** | -0.284 | **-0.348\*** |
| Grain-B |  |  |  |  |  |  |  | 1 | -0.227 | -0.217 | -0.020 | **-0.626\*\*** | -0.008 | -0.274 |
| tSe-soil |  |  |  |  |  |  |  |  | 1 | 0.559 | -0.168 | 0.258 | **0.757\*\*** | **0.862\*\*** |
| SF1 |  |  |  |  |  |  |  |  |  | 1 | **0.487\*** | 0.246 | **0.542\*** | **0.611\*\*** |
| SF2 |  |  |  |  |  |  |  |  |  |  | 1 | **0.329\*** | **-0.302\*** | -0.173 |
| SF3 |  |  |  |  |  |  |  |  |  |  |  | 1 | -0.072 | 0.098 |
| SF4 |  |  |  |  |  |  |  |  |  |  |  |  | 1 | **0.828\*\*** |
| SF5 |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |

Note: S represents soils and B represents biomasses (\*p < 0.05, \*\*p < 0.01, correlation coefficient).

**Table S6.a**. Se species concentrations (mg kg-1) (calculated by Se concentration) in maize's grain and leaf.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Organ | SeCys2 | MeSeCys | SeMet | Se(IV) | Se(VI) | Sum | tSe | Recovery (%)  |
| Grain 1 | 0.24 | 0.19 | 4.25 | 0.02 | 0.04 | 4.74 | 4.81 | 98.54 |
| Grain 2 | 0.52 | 0.08 | 5.04 | 0.03 | 0.02 | 5.7 | 5.33 | 106.90 |
| Grain 3 | 0.3 | 0.12 | 4.41 | 0.02 | 0.01 | 4.86 | 4.5 | 108.07 |
| Grain 4 | 0.47 | 0.09 | 6.20 | 0.04 | 0.07 | 6.87 | 7.35 | 93.45 |
| Grain 5 | 0.29 | 0.13 | 5.47 | 0.02 | 0.01 | 5.93 | 5.47 | 108.45 |
| Grain 6 | 0.57 | 0.2 | 7.2 | 0.03 | 0.01 | 8.02 | 7.88 | 101.71 |
| Grain 7 | 0.52 | 0.12 | 5.01 | 0.06 | 0.03 | 5.75 | 5.51 | 104.30 |
| Grain 8 | 0.44 | 0.13 | 4.79 | 0.02 | 0.02 | 5.39 | 5.9 | 91.47 |
| Grain9 | 0.77 | 0.28 | 8.91 | 0.03 | 0.03 | 10.01 | 9.41 | 106.38 |
| Grain 10 | 0.40 | 0.08 | 3.41 | 0.04 | 0.04 | 3.96 | 5.05 | 78.51 |
| Grain 11 | 0.19 | 0.03 | 0.62 | 0.01 | < dl | 0.85 | 0.97 | 87.81 |
| Leaf 1 | 0.15 | 0.19 | 2.95 | < dl | 0.07 | 3.36 | 12.41 | 27.08 |
| Leaf 2 | 0.28 | 0.56 | 2.85 | 0.04 | 0.06 | 3.8 | 4.73 | 80.33 |
| Leaf 3 | 0.31 | 1.8 | 5.44 | 0.03 | 0.16 | 7.74 | 12.36 | 62.62 |
| Leaf 4 | 0.44 | 2.5 | 9.49 | 0.04 | 0.35 | 12.81 | 24.56 | 52.18 |
| Leaf 5 | 0.29 | 0.92 | 6.61 | 0.07 | 0.35 | 8.23 | 11.03 | 74.65 |
| Leaf 6 | 0.49 | 1.8 | 7.19 | 0.11 | 0.25 | 9.83 | 19.03 | 51.65 |
| Leaf 7 | 0.58 | 2.4 | 11.96 | 0.15 | 0.79 | 15.88 | 29.56 | 53.72 |
| Leaf 8 | 0.26 | 0.91 | 5.1 | 0.03 | 0.14 | 6.44 | 11.92 | 53.99 |
| Leaf 9 | 0.45 | 1.08 | 10.5 | 0.13 | 0.48 | 12.64 | 22.42 | 56.4 |
| Leaf 10 | 0.34 | 1.27 | 5.46 | 0.03 | 0.03 | 7.13 | 14.36 | 49.64 |
| Leaf 11 | 0.04 | 0.1 | 0.27 | < dl | 0.02 | 0.43 | 1.32 | 32.38 |

Note: <dl indicates that the content is lower than the detection limit. The data in the table are expressed as Se content in each form. If converted into selenium amino acid content, the following formula can be used for conversion: C SeMet = C Se-SeMet/0.4026, C SeCys2 = C Se-SeCys2/0.4727, C MeSeCys = C Se-MeSeCys/0.4699.

**Table S6.b.** Se species concentrations (mg kg-1 ) (calculated by Se concentration) in maize’s stalk and root.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Organ | SeCys2 | MeSeCys | SeMet | Se(IV) | Se(VI) | Sum  | tSe | Recovery (%) |
| Stalk 1 | 0.19 | 0.1 | 0.47 | < dl | 0.11 | 0.87 | 2.71 | 31.96 |
| Stalk 2 | 0.14 | 0.25 | 0.71 | < dl | 0.09 | 1.19 | 2.43 | 48.9 |
| Stalk 3 | 0.1 | 0.21 | 0.82 | < dl | 0.28 | 1.42 | 3.33 | 42.60 |
| Stalk 4 | 0.29 | 0.75 | 1.18 | < dl | 0.39 | 2.61 | 5.48 | 47.53 |
| Stalk 5 | 0.1 | 0.05 | 0.37 | 0.01 | 0.02 | 0.55 | 2.16 | 25.63 |
| Stalk 6 | 0.13 | 0.27 | 0.84 | < dl | 0.08 | 1.32 | 3.36 | 39.28 |
| Stalk 7 | 0.13 | 0.43 | 0.86 | < dl | 0.21 | 1.62 | 3.99 | 40.53 |
| Stalk 8 | 0.14 | 0.14 | 0.45 | < dl | 0.05 | 0.79 | 2.27 | 34.53 |
| Stalk 9 | 0.42 | 0.98 | 2.30 | < dl | 0.72 | 4.41 | 8.26 | 53.39 |
| Stalk 10 | 0.13 | 0.05 | 0.78 | < dl | 0.06 | 1.03 | 3.42 | 30.15 |
| Stalk 11 | 0.06 | 0.04 | 0.13 | < dl | 0.02 | 0.26 | 1.38 | 18.50 |
| Root 1 | 0.03 | 0.05 | 0.17 | 0.02 | < dl | 0.27 | 7.74 | 3.52 |
| Root 2 | 0.07 | 0.47 | 0.5 | 0.03 | < dl | 1.07 | 6.95 | 15.37 |
| Root 3 | 0.12 | 0.37 | 0.48 | 0.03 | < dl | 0.99 | 8.71 | 11.42 |
| Root 4 | 0.17 | 0.41 | 0.60 | 0.18 | 0.03 | 1.37 | 9.44 | 14.55 |
| Root 5 | 0.08 | 0.28 | 0.64 | 0.07 | < dl | 1.07 | 7.47 | 14.34 |
| Root 6 | 0.06 | 0.27 | 0.23 | 0.08 | < dl | 0.64 | 8.00 | 8.01 |
| Root 7 | 0.13 | 0.59 | 0.86 | 0.26 | 0.04 | 1.89 | 9.81 | 19.24 |
| Root 8 | 0.25 | 0.83 | 1.55 | 0.51 | 0.03 | 3.17 | 3.72 | 85.17 |
| Root 9 | 0.2 | 1.07 | 2.09 | 0.53 | 0.07 | 3.96 | 9.67 | 40.99 |
| Root 10 | 0.06 | 0.23 | 0.34 | 0.03 | < dl | 0.66 | 7.8 | 8.4 |
| Root 11 | 0.09 | 0.48 | 0.87 | 0.04 | < dl | 1.48 | 2.54 | 58.39 |

Note: <dl indicates that the content is lower than the detection limit. The data in the table are expressed as Se content in each form. If converted into selenium amino acid content, the following formula can be used for conversion: C SeMet = C Se-SeMet/0.4026, C SeCys2 = C Se-SeCys2/0.4727, C MeSeCys = C Se-MeSeCys/0.4699.