

## **Supplementary Information**

Text 1.

The samples were stored in standardized polyethylene bags for subsequent chemical analysis after removing plants roots and rocks. All samples were air-dried at room temperature and sieved through 2-millimeter (mm) aluminum sieve. The samples were mashed, grounded, and screened through several sieves up to 0.15mm of size. These soil samples were used to determined soil physical properties and elemental content (described later). Quality control and safety measures been strictly followed during handling and transporting of soil samples. The crop samples were oven-dried at 50 °C for at least 3 days to achieve a dry constant weight. Thereafter, the crops samples were grounded by a small electric grinder (< 0.25 mm), and stored in sealed polyethylene bags for Chemical analysis.

Text 2.

They were diluted with deionized (DI) water passed through a Milli-Q Plus filter. The pH of soil in DI water (1:2.5, w/v) was determined using a pH meter (PHB-4). Soil OM was measured with potassium dichromate sulfuric acid titration [76]. The determination of soil physicochemical properties was conducted as per the national standards applicable to the agricultural industry (NY/T 1121-2006). Total Se concentration in soil had narrow range (0.01-0.55). Out of total 371 soil samples, 128 soil samples were selected (with large differences in physicochemical properties) with similar soil texture and locations, were used to determined soil Se fractions (Table S1) [92, 117]. 0.5 g plant samples were digested by a 10 mL mixture of concentrated HNO<sub>3</sub> and HClO<sub>4</sub> (V:V = 4:1 for crops) or other electrolyte solutions [88].

Soil samples, free of plant roots and often debris, were oven-dried at approximately 50 °C for 24 hours, and then grounded in an agate- mortar to pass through a 0.15 mm sieve. 0.5–3.0g samples were weighed into a 50 ml conical flask and 10 ml of concentrated HNO<sub>3</sub> and HClO<sub>4</sub> (4:1, v/v) were added to each flask and covered with a glass funnel. The detailed procedure was described by Gao et al. (2011). The total Se concentration was then determined by Hydride Generation Atomic Fluorescence Spectrometry (HG-AFS 9230) (Beijing Titan Instrument Co., China). National standard soil reference materials GSS-1 were used for soil samples. The recovery of the standard reference materials ranged from 85.5% to 117.8%, and the relative standard deviation (RSD) of reference materials were calculated as 0.76%. The instrument detection limit (DL) was 0.08 mg/kg [118].

**Table S1.** Description for contents of soil Se and Se fractions in soil and soil physicochemical properties (n = 128).

	Mean	Median	SD	Range	Min	Max	IQR		Skewness	Kurtosis	CV (%)
							25 (%)	75 (%)			
T-Se (mg/kg)	0.209	0.208	0.089	0.483	0.010	0.493	0.146	0.255	0.380	0.302	42.60
B-Se (mg/kg)	0.034	0.031	0.020	0.117	0.003	0.120	0.019	0.045	1.122	2.177	58.09
B-Se (%)	15.887	14.930	5.206	22.310	7.956	30.266	11.605	19.490	0.742	-0.095	32.77
Fe (mg/kg)	22.551	22.459	3.822	31.987	0.630	32.616	20.832	24.826	-1.357	7.946	16.95
Zn (mg/kg)	51.774	47.710	19.935	187.390	17.890	205.280	42.353	56.730	4.460	29.813	38.50
Mn (mg/kg)	44.481	48.075	18.420	74.880	0.010	74.890	31.865	57.325	-0.358	-0.854	41.41
pH	8.27	8.30	0.37	1.73	7.21	8.94	8.01	8.56	0.02	0.89	3.70
OM (g/kg)	4.877	4.819	2.398	9.470	0.384	9.854	3.150	6.846	0.108	-0.895	49.17
CaCO <sub>3</sub> (g/kg)	23.500	23.826	6.918	34.965	6.757	41.722	19.447	27.630	-0.032	-0.037	29.44
Clay (%)	18.528	18.369	3.447	22.022	6.362	28.384	16.227	20.827	-0.074	0.653	18.60
Amorphous iron (g/kg)	0.591	0.578	0.295	1.458	0.000	1.458	0.390	0.776	0.318	0.001	49.86
Amorphous aluminum (g/kg)	0.514	0.476	0.265	1.412	0.018	1.430	0.327	0.653	0.715	0.923	51.61
CEC (cmol/kg)	11.286	11.140	2.335	14.058	4.189	18.247	10.030	12.823	-0.040	0.782	20.69

(Note): IQR= Interquartile range, SD= Standard deviation, T-Se= Total soil selenium, B-Se= Bioavailable selenium, B-Se(%)= Bioavailable selenium proportion in soil, Max=Maximum, Min=Minimum, CV=Coefficient of Variation.

**Table S2.** Descriptive statistics of cultivated and uncultivated/Natural soil of Zhongwei.

Cultivated soil (AS)						
	N	Range	Minimum	Maximum	Mean	SD
T-Se (mg/kg)	128	0.483	0.010	0.493	0.209	0.089
B-Se (mg/kg)	128	0.118	0.003	0.120	0.034	0.020
B-Se/T-Se (%)	128	38.075	7.536	45.611	16.553	6.532
Uncultivated soil/Natural soil (NS)						
	N	Range	Minimum	Maximum	Mean	SD
T-Se (mg/kg)	43	0.267	0.031	0.298	0.130	0.045
B-Se (mg/kg)	43	0.049	0.004	0.053	0.021	0.011
B-Se/T-Se (%)	43	34.370	10.000	44.370	15.697	7.106

Table S3. Selenium content in different crops (mg/kg).

Crop Types	Mean	Median	SD	Range	Max	Min	CV (%)
Veg. (18)	0.005	0.004	0.004	1.014	0.014	0.001	84.3
Apple (75)	0.012	0.011	0.004	0.190	0.018	0.003	32.8
Go'ji (28)	0.022	0.015	0.026	4.323	0.138	0.007	115.3
Jujube (17)	0.043	0.030	0.031	0.111	0.127	0.016	73.5
Rice (23)	0.056	0.048	0.031	0.107	0.124	0.017	55.5
Potato (60)	0.019	0.018	0.008	0.051	0.031	0.003	42.8
Grains (36)	0.044	0.042	0.026	2.955	0.157	0.008	58.0

(Note): Veg.=vegetables, Go'ji=Goji berry, SD= Standard Deviation, Max=Maximum, Min=Minimum, CV=Coefficient of Variation.

**Table S4.** The proportion of Se levels according to the classification of distribution standards of total Se contents (mg/kg) in different counties of Zhongwei, Haiyuan (HY), Zhongning (ZN), Shapotou (ST) and Zhongwei (ZW).

Selenium Effect	Se content classification	(Tan, 1989)*	HY	ZN	ST	ZW	Ningxia <sup>+</sup>	HY	ZN	ST	ZW
		T-Se (mg/kg)	Proportion / %				T-Se (mg/kg)	Proportion / %			
Se Toxicity	Toxic	≥3.0	0	0	0	0	≥ 3.0	0	0	0	0
Effective for Biofortification	Adequate to High	>0.4 - <3.0	0.62	0	4.35	1.62	0.222~3.0	24.22	16.84	57.39	32.08
Healthy for plants and human	Moderate	0.175-0.40	52.17	43.16	72.17	55.53	0.175~0.222	28.57	26.32	19.13	25.34
Selenium enrichment	Marginal (Low)	0.125-0.175	32.30	30.53	16.52	26.95	0.116~0.175	34.16	36.84	18.26	30.19
Selenium poisoning	Deficient	<0.125	14.91	27.37	6.09	15.63	<0.116	13.04	22.11	5.22	12.40

\*(Tan, 1989) selenium-enriched soil standard, <sup>+</sup> Ningxia selenium-enriched soil standard.

**Table S5.** The proportion of Se levels according to the classification standards of total Se contents (mg/kg) Zhongwei soil (n=371).

Selenium Effect	Se content classification	(Tan, 1989) (mg/kg)		Ningxia selenium-enriched soil standard	
		T-Se (mg/kg)	Proportion / %	T-Se (mg/kg)	Proportion / %
Se Poisoning	Toxic	$\geq 3.0$	0	$\geq 3.0$	0
Effective for Biofortification	Adequate to High	$>0.4 - <3.0$	1.62	0.222~3.0	32.08
Healthy for plants and human	Moderate	0.175-0.40	55.53	0.175~0.222	25.34
Selenium enrichment	Marginal (Low)	0.125-0.175	26.95	0.116~0.175	30.19
Selenium poisoning	Deficient	$<0.125$	15.63	$<0.116$	12.40

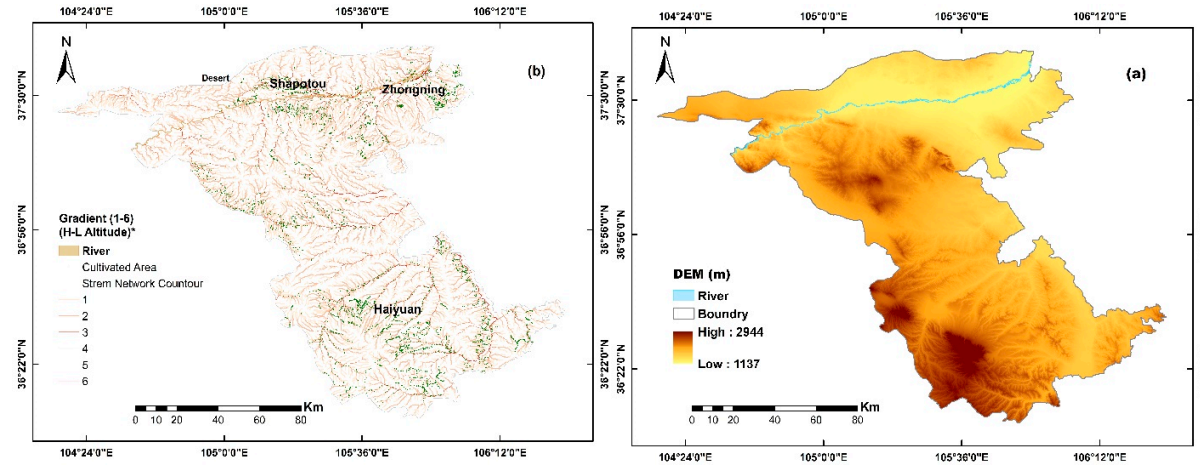


Figure S1. (a) Digital Elevation Model (DEM); (b) Gradient (Green dots in figure (b) Showing cultivated areas in Zhongwei city and different line colors are representing gradient, gradient is lowest with yellow river in north of Zhongwei city). \*High-Low altitude.