Iron concentrations in roots and edible organs of African indigenous vegetable species

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Introduction

Iron (Fe) deficiency is among the leading risks for human health causing "hidden hunger" in Subsaharan Africa. In comparison to staple crops like maize and sorghum, in leafy vegetables Fe concentration and bioavailability are often higher. Therefore, increasing food diversity through vegetable production and consumption might be an option to mitigate Fe deficiency.

Few data is available on Fe concentrations in African indigenous vegetable (AIVs) and most of them are in an unrealistic high range, probably due to soil and dust contaminations that contain lots of Fe. However, Fe derived from contamination has no bioavailability and therefore leads to mispredictions regarding Fe for human nutrition.

In order to quantify Fe uptake and distribution between plant organs in AIV species and to measure plant responses to differential Fe supply, we chose a hydroponic experiment where contaminations are low.

Aims of this study

(i) to assess plant responses to low Fe supply
(ii) to assess Fe distribution among plant organs and the nutritional value of edible organs

Experimental conditions

AIV species	Spiderplant (*Cleome gynandra*)	Fe supply conditions Low: 1 µM Moderate: 30 µM High: 200 µM
	Amaranth (*Amaranthus cruentus*)	
	African Nightshade (*Solanum scabrum*)	
	Ethiopian Kale (*Brassica carinata*)	
	Cowpea (*Vigna unguiculata*)	
Imported species	Kale (*Brassica oleracea*, Acephala group)	

-hydroponic culture
- four repetitions
- one week treatment
-assessment of pH values, SPAD readings, biomass, mineral contents (ICP-OES), root morphology, ferric reductase

AIV species strongly differ in their responses to low Fe supply

Amaranth (*Amaranthus cruentus*)

Cowpea (*Vigna unguiculata*)

Figure 1: Development of leaf chloroses in Cowpea and root thickening in Amaranthus after 7 d Fe deficiency treatment.

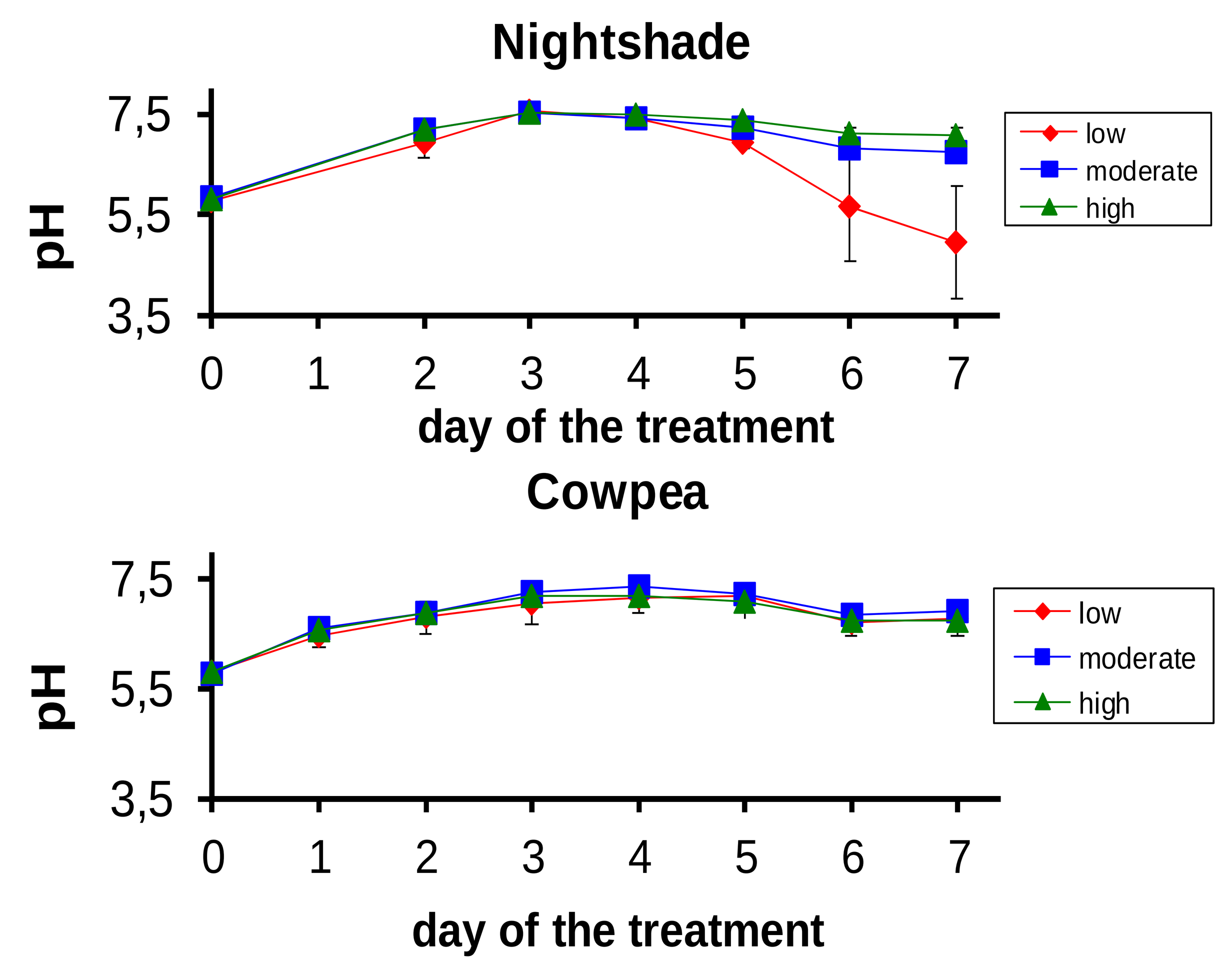

Figure 2: Fe deficiency-induced pH decrease in Nightshade but not in Cowpea. Initial rising of the pH is due to the N nutrition by nitrate.

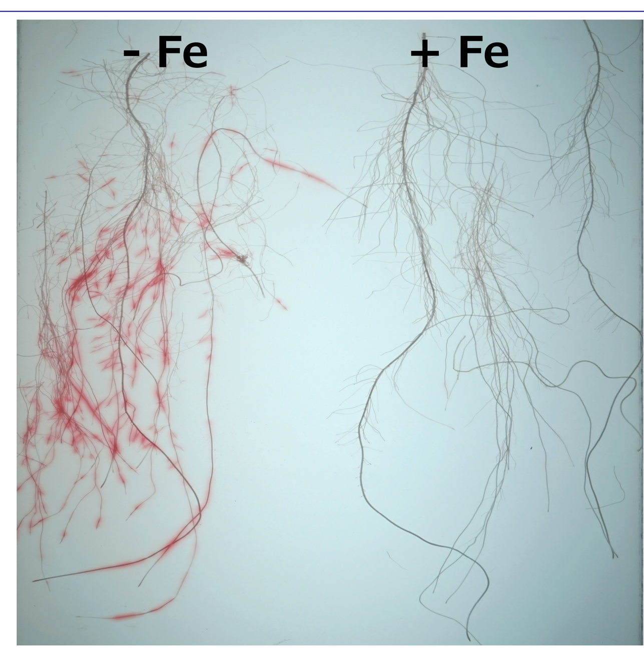

Figure 3: Fe deficiency-induced increase in ferric chelate reductase in Nightshade roots. Roots were embedded in agarose containing Fe^{3+}-EDTA and the Fe^{2+}-specific chelator BPDS. Red areas around the roots indicate ferric chelate reductase activity.

Table 1: Ranking of AIV plant responses to low Fe supply

	Amaranth	Nightshade	Spiderplant	Ethiopian Kale	Kale	Cowpea
Fe-deficiency symptoms						
Fe-assimilation reactions						

Fe distribution among plant organs and nutritional value of edible organs

Table 2: Fe concentrations in organs of AIV species grown under moderate Fe supply

	mg/kg DW			Ratio	
	Leaves	Stems	Roots	Root/leaf	Stem/leaf
Amaranth	62	24	677	10,9	0,4
Cowpea	96	27	294	3,1	0,3
Ethiopian Kale	43	33	567	13,1	0,8
Kale	48	22	671	14,1	0,5
Nightshade	79	28	263	3,3	0,4
Spiderplant	73	25	864	11,8	0,3

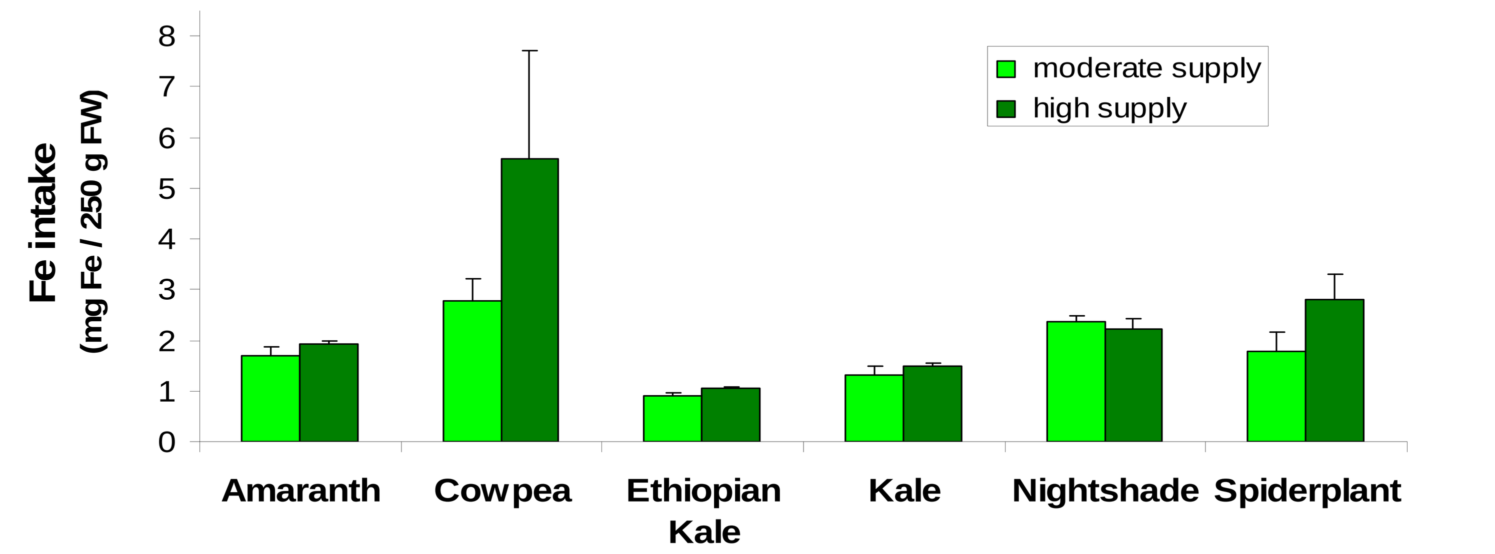

Figure 4: Fe intake in a meal of leaves of the AIV species, calculated as mg Fe per 250 g fresh weight. WHO recommends 8 - 18 mg/day.

Conclusions

- o Strongest responses to Fe deficiency were found in Amaranth and Nightshade (Figs. 1-3, Table 1), indicating that these species are best adapted to Fe-deficient soils.
- o In all species Fe was poorly translocated from roots to leaves (Table 2), indicating that breeding for better root-to-shoot transfer is valuable. Highest translocation was found in Cowpea and Nightshade (Table 2).
- o In Cowpea and Spiderplant Fe intake with a 250 g vegetable dish was substantially increased when plants were grown with high Fe supply (Fig. 4). This indicates that in these species Fe fertilization is a good measure to improve the human Fe nutritional status.
- o Regarding Fe nutrition, Brassica species are not recommended.

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