Agronomic biofortification to improve nutritional quality of cassava roots

F. Calle[1], G. Lyons[2], G. Pérez[3], J.C. Pérez[1], T. Sánchez[1], N. Morante[1], L.A. Becerra[1], H. Ceballos[1]

[1]HarvestPlus at International Center for Tropical Agriculture (CIAT). Palmira, Colombia.
[2]HarvestPlus at School of Agriculture, Food & Wine, University of Adelaide, Waite Campus, Australia.
[3]Soluciones Nutritivas. Palmira, Colombia
E-mail of contact person: h.ceballos@cgiar.org

Introduction

HarvestPlus focuses on three critical micronutrients that were recognized by the World Health Organization (WHO) as most limiting in diets: iron, zinc, and vitamin A[1]. In spite of early indications that there was genetic variation for Fe and Zn contents in cassava roots[2], later studies have determined that quantifications for these elements are affected by contamination from soil and processing tools and large genotype-by-environment interactions. Soil pH was shown to have a large effect. Breeding efforts to improve Fe and Zn contents in cassava roots were, therefore, shifted towards **agronomic biofortification** (increasing mineral contents by application of adequate types of fertilizers)

Materials and methods

Four edaphic environments and two varieties were used for this study. Experimental plots had three plants. Each experimental plot was surrounded by non-treated plants from the same variety. A split-plot experimental design with 3 - 4 replications was used. The two varieties were the main plots and fertilizers (within each variety) were the sub-plots. Different fertilizers and dosages were used for soil or foliar applications (Figure 1). The objective was to quantify the impact of Zn (ZnSO4), Fe (FeSO4), Se (Na2O4Se) and I (KH(IO3) 2) in the content of these elements in the root at harvest time.

Results

Tables 1 and 2 summarize the results for Fe and Zn contents in the roots harvested from the two varieties and the different agronomic treatments. The only differences in Fe and Zn content in the roots were due to locations effects which, as already known, are highly dependent of soil pH. Agronomic biofortification, therefore, failed to produce the expected results. The only quantified response to biofortification was on Selenium (Se) contents (Table 3). No measurable difference was observed for Iodine (I).

Table 1. Iron concentration in storage roots of 2 cassava varieties at 4 sites comparing controls with 7 different Fe treatments. Means of 3 replications.

	Root Fe concentration (mg/kg)								
Site	1		2		3		4		
Variety	1	2	1	2	1	2	1	2	Mean
Treatment									
Control	9.1	9.7	9.3	7	5.3	5.7	10.6	11.3	8.5
5 kg Fe/ha	6.5	6.5	7.2	4.7	4.9	4.9	7.6	10	6.5
10 kg Fe/ha	5.4	7.4		5.1		4.5	9.6	11.7	7.3
20 kg Fe/ha	5.9	8.4		5		5.6	10	8.8	7.3
Foliar Fe 2%	5.9	6.1		13		4.3	8.8	8.8	7.8
10 kg Fe/ha+Foliar Fe 2%	4.6	10.3	4.4	8.1	4.9	4.5	8.7	9.8	6.9
5 kg Zn+5 kg Fe/ha	5.1	11.6	8.1	5.2	5.2	4	9.5	9	7.2
15 kg Zn+15 kg Fe/ha	4.9	5.9	9.8	4.4	4.7	5.8	8.3	10.2	6.8
Mean	5.9	8.2	7.8	6.6	5	4.9	9.1	10	7.2
Mean of vars/site	7.1		7.2		5		9.6		

Blank boxes: sample not analysed
Overall LSDs: Site 4; Var 4; Treatment 3; Var/Treat 4.5

Figure 1. Foliar micronutrient application 45 days after planting.

Table 2. Zinc concentration in storage roots of 2 cassava varieties at 4 sites comparing controls with 7 different Zn treatments. Means of 3 replications.

	Root Zn concentration (mg/kg)								
Site	1		2		3		4		
Variety	1	2	1	2	1	2	1	2	Mean
Treatment									
Control	5	6	6.6	6.4	4.6	5	6.1	9.2	6.1
5 kg Zn/ha	4.5	5.5	6.4	6.3	5.5	4.8	7.1	6.3	5.8
10 kg Zn/ha	5.1	5.5				4.9	7.1	6.3	6
20 kg Zn/ha	4.7	5.7		6.8		5.2	10.7	6.2	6.6
Foliar Zn2%	5	5.4	9.4	7.4	5.3	5.2	8.4	7.7	6.7
10 kg Zn/ha+foliar Zn 2%	5.3	5.7		6.6		4.4	9.7	6.1	6.3
5 kg Zn+5 kg Fe/ha	5.6	11.6	4.9	8.1	6	4.5	7.1	7.7	6.9
15 kg Zn+15 kg Fe/ha	5.5	5.3	5.8	4.7	5.1	5.3	6.9	7.4	5.8
Mean	5.1	6.3	6.6	6.7	5.3	4.9	7.9	7.1	
Mean of varieties/site	5.7		6.7		5.1		7.5		

Blank boxes: sample not analysed
Overall LSDs: Site 1.5; Var 1.6; Treatment 1.2; Var/Treat 1.5

Table 3. Se concentration in cassava storage root and leaves of 2 varieties at 4 sites. Controls compared with plants treated with 150 g/ha Se as sodium selenate. Means of 3 replications.

Site	Variety 1		Variety 2		LSD (0.05)	
	Control	+Se	Control	+Se	Treat	Var
Quantifications in the roots(µg/kg DW)						
1	22	80	33	105	32	80
2	30	115	13	64	115	211[1]
3	49	113	36	101	24	51
4	5	27	10	43	2	5[2]
Mean	27	84	23	78		
[1] High Rep.Var.Tr. CV% of 129; [2] Low Rep.Var.Tr. CV% of 5						
Quantifications in the leaves (µg/kg DW)						
1	553	1,533	477	2,667	1	553
2	430	2,167	283	2,767	2	430
3	820	2,233	577	2,900	3	820
4	137	370	111	540	4	137
Mean	485	1,576	362	2,219	Mean	485
LSDs (0.05) (all sites): Var 429; Treat 584; Site 415; Var/Treat 584; Var/Site 548; Treat/Site 683; Var/Treat/Site 860.						

References

[1] Pfeiffer WH, McClafferty B. 2007b. Biofortification: Breeding Micronutrient-Dense Crops. *In* M.S. Kang and P.M. Priyadarshan (eds.). Breeding Major Food Staples. Blackwell Publishing, 61-91.

[2] Chávez AL, Sánchez T, Jaramillo G, Bedoya JM, Echeverry J, Bolaños EA, Ceballos H, Iglesias CA. 2005. Variation of quality traits in cassava roots evaluated in landraces and improved clones. Euphytica 143:125-133.