Gains from selection to improve carotenoids content in cassava roots

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In the last decade there has been a significant increase in the efforts to improve the nutritional quality of different crops. With the support of HarvestPlus, CIAT and other institutions developed and implemented a rapid cycling recurrent selection scheme to increase total carotenoids content (TCC) and total β-carotene (TBC) in cassava roots.

Materials and Methods

The breeding scheme takes advantage of the high heritability of the traits to improve. Selection was made at the seedling stage when only one plant (from germinated botanical seeds) per genotype is available. Selected genotypes were cloned and planted in crossing blocks the following season which lasted for a year and a half. Each cycle of selection, therefore, lasted two or three years (Figure 1).

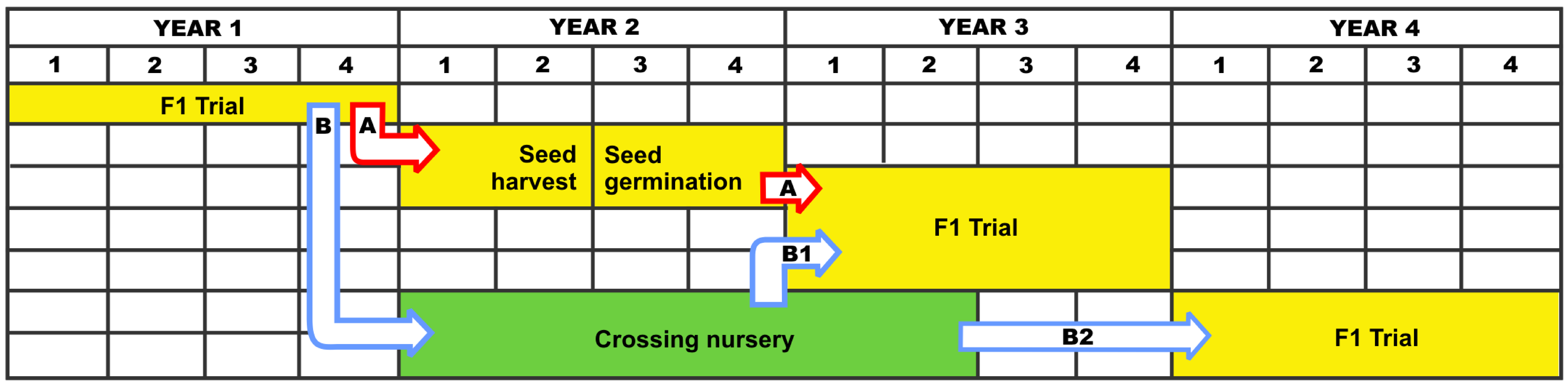

Figure 1. Chronology of rapid cycling recurrent selection in cassava. Occasionally, if selected seedling plants were flowering at harvest time (A), they could be left on the field and used to make crosses that would contribute to a new cycle of selection. Otherwise (B) plants had to be cloned and depending on their flowering habit recombinant seed would be obtained for evaluations in Year 3 or Year 4.

All measurements are reported on a fresh weight basis (unless otherwise stated). Year-to-year results suggested continuous gains. However, these comparisons are affected by year to year variation. Therefore, a replicated trial in two locations was planted with the best five clones from each seedling nursery from 2004 to 2010 were grown side by side for comparison. Plants were harvested from eight to eleven months after planting. However average results will be presented here.

Results

Ten years ago maximum TCC levels were around 8-10 μg/g, whereas those for TBC were around 5-6 μg/g. Maximum levels of TCC now have surpassed 25 μg/g and the nutritional goal of 15 μg/g for TBC has been reached. Results indicated statistically significant gains to increase TCC and TBC (0.904 and 0.542 μg/g per year, respectively). Interestingly data from the original seedling nurseries on sexual seed (Table 1) and in the replicated trial in 2011 based on clonned materials: 5 highest carotene content by year (Table 2) suggest that improvement of the nutritional quality can be accomplished while maintaining (or even increasing) dry matter content (DMC) in the roots.

Table 1. Evaluation trials. Only roots with yellow parenchyma would be pre-selected for analysis. (Seedling nursery).

Year	n	DMC (%)	TCC (μg g^{-1} FW)		TBC (μg g^{-1} FW)		TBC/TCC (%)	Regr. coeff.
		Average	Average	Max.	Average	Max.		DMC vs TCC
2004	1315	37.0	2.4	10.3	n.a	n.a	n.a	-0.001
2005	930	38.1	2.8	11.2	n.a	n.a	n.a	-0.111
2006	288	34.9	3.1	12.7	2.3	9.9	74	-0.118
2007	173	29.9	6.8	19.1	5.5	12.8	81	-0.123
2008	178	33.4	7.3	15.0	n.a	n.a	n.a	0.056
2009	345	33.5	10.6	18.9	4.9	10.3	46	0.103
2010	490	30.2	11.4	24.7	9.8	19.1	86	0.014
2011	332	37.1	15.6	25.8	8.5	15.0	54	-0.012
2012	415	35.7	14.7	24.3	8.6	16.2	59	0.079

DMC= Dry matter content; TCC= total carotenoids content; TBC= total β-carotene.
n.a.: Not available.

Table 2. Averages for dry matter content (DMC), total carotenoids content by spectrophotometry (TCCSPEC), total carotenoids content by HPLC (TCCHPLC), total β-carotene (TBC) and total carotenoids content on a dry weight basis (TCCDW). (2011 harvest on clonal seed).

	DMC (%)	TCCSPEC (μg g^{-1} FW)	TCCHPLC (μg g^{-1} FW)	TBC (μg g^{-1} FW)	TCCDW (μg g^{-1} DW)
YEAR OF ORIGINAL NURSERY					
2004	34.89	7.78	8.17	5.26	23.71
2005	37.65	9.24	9.65	5.52	26.04
2006	35.67	7.50	7.33	4.67	20.61
2007	36.71	10.31	10.93	7.25	29.87
2008	37.39	10.37	10.93	6.21	29.57
2009A	38.38	11.76	12.45	7.48	32.47
2009B	38.57	12.96	13.77	8.61	35.96
LSD 0.05	0.72	0.49	0.56	0.41	1.36
LSD 0.01	0.94	0.65	0.74	0.54	1.79

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