The combined effects of shade and altitude on the quality of coffee beans grown at Gorongosa Mountain, Mozambique

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Introduction

Environmental conditions related with shade and altitude are pointed to have beneficial effects on coffee bean quality. This work studied the effect of shade and altitude on the quality of coffee, grown in an agroforestry system (AFS) at Gorongosa Mountain, Mozambique, using native trees for shading.

Materials and Methods

The impact of shade and/or altitude on leaf ecophysiological performance where assessed on 4 years old *Coffea arabica* L. cv. Costa Rica plants, under three altitudes (650, 825, 935 m) and three light levels (deep shade, DS; moderate shade, MS; full Sun, FS) [1]. Chemical analyses for quality evaluation were carried out on green beans: CQAs, diCQAs, FQAs, *p*-coumaric acid) and caffeine and trigonelline [1]. Statistical analysis: two-way ANOVA.

Table: Characterization of chemical composition, regarding trigonelline, caffeine, *p*-coumaric acid, caffeoylquinic acids (CQAs), feruloylquinic acids (FQA) and dicaffeoylquinic acids (diCQA) in green coffee beans from *C. arabica* obtained under three light exposure conditions (deep shade, DS; moderate shade, MS; full Sun, FS) and three altitudes (650, 825 and 935 m).

Atributtes	Light condition	Altitude		
		650 m	825 m	935 m
Trigonelline (mg g^{-1} DW)	DS	11.1 ± 0. 3 Aa	10.4 ± 0.3 Aa	9.37 ± 1.01 Ba
	MS	11.4 ± 0.6 Ab	9.91 ± 0.8 Ab	25.8 ± 0.2 Aa
	FS	11.9 ± 0.5 Ab	9.63 ± 0.6 Ab	32.1 ± 1.4 Aa
p-coumaric acid (mg g^{-1} DW)	DS	0.41 ± 0.01 Aa	0.57 ± 0.01 Aa	0.43 ± 0.07 Aa
	MS	0.43 ± 0.01 Aa	0.30 ± 0.03 Ba	0.42 ± 0.04 Aa
	FS	0.41 ± 0.01Aa	0.42 ± 0.04 ABa	0.33 ± 0.04 Aa
Caffeine (mg g^{-1} DW)	DS	16.2 ± 0.2 Aa	13.8 ± 0.4 Aa	14.7 ± 0.5 Aa
	MS	15.9 ± 0.2 Aa	14.2 ± 0.2 Aa	15.1 ± 0.3 Aa
	FS	15.2 ± 0.4 Aa	13.6 ± 0.3 Aa	14.8 ± 0.2 Aa
3-CQA (mg g^{-1} DW)	DS	2.42 ± 0.13 Aa	2.52 ± 0.26 Aa	1.92±0.18 Aa
	MS	2.41 ± 0.09 Aa	2.24 ± 0.19 Aa	2.35±0.07 Aa
	FS	2.50 ± 0.05 Aa	2.62 ± 0.07 Aa	2.17±0.12 Aa
4-CQA (mg g^{-1} DW)	DS	3.32 ± 0.09 Aab	3.61 ± 0.11 Aa	2.67±0.31Ab
	MS	3.51 ± 0.15 Aa	3.24 ± 0.10 Aa	3.34±0.11 Aa
	FS	3.60 ± 0.19 Aa	3.60 ± 0.24 Aa	3.08±0.14 Aa
5-CQA (mg g^{-1} DW)	DS	21.6 ± 0.6 Aa	28.2 ± 1.2 Aa	25.8± 0.8 Aa
	MS	21.8 ± 1.3 Ab	25.9 ± 0.9 Aab	32.0 ± 0.8 Aa
	FS	24.9 ± 2.3 Aa	30.0 ± 1.9 Aa	28.4 ± 0.9 Aa
Total CQAs (mg g^{-1} DW)	DS	27.4 ± 0.5Aa	34.3 ± 1.4 Aa	30.4 ± 3.3 Aa
	MS	27.7 ± 1.4 Ab	31.3 ± 1.1 Aab	37.7 ± 1.0 Aa
	FS	31.1 ± 2.7 Aa	36.2 ± 2.3 Aa	33.7 ± 1.2 Aa
4-FQA (mg g^{-1} DW)	DS	0.32 ± 0.04 Aa	0.16 ± 0.01 Bb	0.16 ± 0.04 Ab
	MS	0.31 ± 0.02 Aa	0.18 ± 0.02 ABb	0.18 ± 0.01 Ab
	FS	0.25 ± 0.02 Aa	0.23 ± 0.02 Aa	0.17 ± 0.01 Aa
5-FQA (mg g^{-1} DW)	DS	2.79 ± 0.16 Aa	1.84 ± 0.07 Bb	1.79 ± 0.29 Ab
	MS	2.82 ± 0.09 Aa	2.13 ± 0.21 ABb	2.16 ± 0.14 Ab
	FS	2.55 ± 0.14 Aab	3.14 ± 0.20 Aa	2.11 ± 0.14 Ab
3,4-diCQA (mg g^{-1} DW)	DS	0.98 ± 0.08 Aa	0.65 ± 0.03 Aab	0.34 ± 0.11 Ab
	MS	1.17 ± 0.10 Aa	0.44 ± 0.15 Ab	0.54 ± 0.03 Ab
	FS	1.02 ± 0.09 Aa	0.56 ± 0.03 Ab	0.60 ± 0.03 Ab
3,5-diCQA (mg g^{-1} DW)	DS	3.03 ± 0.10 Aa	2.04 ± 0.08 Aab	1.26 ± 0.42 Ab
	MS	3.42 ± 0.28 Aa	1.49 ± 0.15 Ab	1.83 ± 0.55 Ab
	FS	2.90 ± 0.29 Aa	1.76 ± 0.47 Aa	1.69 ± 0.07Aa
4,5-diCQA (mg g^{-1} DW)	DS	0.80 ± 0.06 Aa	0.48 ± 0.04 Aab	0.37 ± 0.11 Ab
	MS	1.08 ± 0.10 Aa	0.23 ± 0.03 Ab	0.53 ± 0.04 Ab
	FS	0.82 ± 0.07 Aa	0.40 ± 0.10 Ab	0.45 ± 0.11 Aab

Results and Discussion

Trigonelline showed one of the most striking responses, being markedly increased at the highest altitude, under MS (126%) and FS (170%) (Table). Caffeine and *p*-coumaric acid contents showed mostly non-significant changes, although a reduction of the latter was observed under MS and FS at 825 m. Caffeoylquinic acids 3-CQA and 4-CQA showed minor changes, with a tendency to lower values at 935 m, whereas the most abundant (5-CQA) tended to greater values at 835 or 935 m, all without differences between light conditions. The 4-FQA and 5-FQA declined at 935 m in comparison with 650 m. Moreover, both FQA isomers increased from DS to FS (mostly at 825 m). For the diCQA isomers no change was observed between light conditions, but all greatly declined at 835 and 935 m [1].

Conclusions and Perspectives

Overall, light level did not greatly modify the chemical bean attributes. In contrast, altitude (associated with lower temperature, greater water availability through rainfall and fog, and extended fruit maturation period), was a major driver for these traits changes, likely improving coffee quality. As perspective, one intends to extend coffee plantations to higher altitude in Gorongosa Mountain, having in mind a better quality of coffee beans.

Reference:
[1] Cassamo, C.T. *et al*., 2022, *Agronomy*, **12**, 2540. DOI: 10.3390/agronomy12102540

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