Incidence of Elevation on Chemical Composition and Beverage Quality of Coffee in Central America

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SUMMARY

Chemical and beverage quality of green coffee samples from eight farms with different elevation in Poas region in Costa Rica (Trial 1) and from ten experimental plots with different elevations in El Salvador, Honduras and Costa Rica (Trial 2) were evaluated in 2003-2004 harvest. Coffee arabica trees in Trial 1 were at two different production years in a three-year rotational pruning cycle; while in Trial 2, trees were two and three year old. Bean size, dry matter weight and beverage quality were measured for Trial 1 samples, while biochemical content were estimated for both trials. Bean size and dry weight increased as elevation was higher and as shoot age was younger. Significant differences in chemical composition were observed in function of elevation in both trials and for beverage quality in Trial 1. Caffeine, chlorogenic acid and fat contents increased with elevation while trigonelline and sucrose decreased. Significant negative correlation between sucrose and fat content was observed. For beverage quality, tendency was that at higher elevation, better was classified the coffee with exception of one farm at intermediate elevation that was well classified. This farm was located in a very fertile area with outstanding plant nutrition and durable good cultural management. The study confirm that elevation is a very important factor for produce high quality coffee, but also that quality can be get by adequate cultural management in intermediate elevation.

INTRODUCTION

In Central America, in general coffee buyers and producers know that best quality coffees are produce in the highlands. Guyot et al. (1996) in a study made in Guatemala confirmed that coffee from higher elevation showed a better quality than those from lower elevations. Unfortunately, the lack of an accurately statistical design of the experiments did not permit clearly to differentiate the effects attribute to elevation of those attributes to use of shade, plant age or cultural management. The effects of tree physiological conditions on coffee quality are thought to be important, but have been rarely investigated. Coffee tree experiences a strong alternating production pattern, where after a series of high yields, the tree becomes exhausted. In intensive coffee cultivation, the coppicing practice takes place every five years or less. Bertrand et al. (2004) found that the year of production and canopy region influence the bean characteristics and beverage quality of the coffee. The purpose of this study was to examine the relationships between elevations and shoot age on bean size and coffee beverage quality.

MATERIALS AND METHODS

Trial 1

The experiment was carried out during 2002/2003 harvest in commercial high density plots without shade (7000 plants.ha^{-1}) of 'Caturra and Catuaí' cultivars in eight farms with different elevation, located in a linear transect in the south slopes of Poas volcano, Alajuela province, Costa Rica (Table 1). Plants were intensively managed receiving 1000 kg.ha^{-1} of 18N-3P-10K-8Mg-0.5B fertilizer annually split equally into two applications in May and August, 250 kg.ha^{-1} of N in November and two foliar applications of copper hydroxide (1,5 kg.ha^{-1}) to prevent leaf and fruit diseases such as coffee leaf rust (*Hemileia vastatrix*) and leaf and fruit brown eye spot (*Cercospora coffeicola*). In all farms, trees were managed on a three-year rotational pruning cycle, where one every three rows is stump 40-100 cm above ground level depending of each farm management (only two and three year old shoot are productive). Soils from this coffee region have a common volcanic origin, generally with high organic matter content (8-15%) and moderately acid pH (4,5 to 5,5), major cations calcium and magnesium are generally deficient, as availably phosphorus too. Soil amendment is a strongly recommended practice done every year before rain season begins (May to November). In order to study the effects of elevation and shoot age on bean chemical content and beverage quality, three replicates of ten trees randomly selected in the same row on second year after pruning (Y1) and ten from third year (Y2) were harvested. The statistical design used was a split-plot, were the farm is considered as main plot and the year of the production as sub-plot.

Trial 2

Samples from ten farms located in different Central America coffee regions in elevations between 700 to 1600 m were evaluated (See Table 1). Trial 2 samples represent the differences found in commercial coffee farms between soils, climatic conditions and agronomy practices used in each country. Because coppicing practices differ in each country, samples came from three year old trees of "Caturra, Catuaí, Pacas, Bourbon and Pacamara" cultivars randomly selected from shade and without-shade plots with 5000 plants.ha^{-1} each. Caturra, Catuaí and Pacas are dwarf cultivars while Bourbon is a tall cultivar, Pacamara derived from (Pacas x Maragogype) and Maragogype is a mutant from Bourbon that produces low yield and very large fruit. In Costa Rica, plants received same inputs described before. In El Salvador and Honduras, plants received 800 kg/ha/year of N-P-K (20-10-10) in May and September and 150 kg/ha/year of N in November, along with 1 foliar application of copper hydroxide. Elevations were compared by ANOVA for the following groups of elevations (namely [700-899], [900-1099], [1100-1199], [1200-1399] and [1400-1600]).

Harvest, processing and chemical analysis

Full ripe fruits were harvested and were prepared by wet processing method (wet de-pulping, 12 hours of anaerobic fermentation, sun-drying until reach 12% of water content and mechanical de-husking of parchment). For Trial 1, green coffee bean size percentage (diameter > 6,75 mm) was calculated. Dry weight of 200 beans was also recorded. For both trials, 50 g of dry green coffee sample from each farm was analyzed for caffeine, trigonelline, fat and sucrose content following Guyot et al. (1988) protocol. The analyses were performed by near infrared spectrometry by reflectance after grinding the green coffee to <0,5 mm. A NIR spectrometer system (Model 6500, NIRSystem, Inc. 1201 Tech Road Silver Spring, 20904, MD, USA) driven by NIRS2 (4.0) software (Intrasoft Int. LLC, Rd. 109, Sellers Lane, Port Matilda) was used for biochemical determination.

Table 1. Sample origin description: farm, location, elevation (m), presence of shade and variety of Trails 1 (Costa Rica) and 2 (Central America).

	Farm	Location	Elevation	Shade	Cultivar
Trial 1	La Trinidad	Alajuela, CR	900	No	Catuaí
	La Esperanza		1000	No	Catuaí
	Bariloche		1100	No	Caturra
	La Fortuna		1200	No	Catuaí
	La Emilia		1300	No	Catuaí
	La Luisa		1350	No	Catuaí
	Alsacia		1400	No	Caturra
	Loma Bonita		1450	No	Catuaí
Trial 2	ICAFE	Pérez Zeledón, CR*	680	No	Caturra, Catuaí
	San José	Usulatán, ES*	850	Yes	Caturra
	Hda. San Rafael	Naranjo, CR	930	Yes	Caturra
	San Jorge	Santa Ana, ES	1120	Yes	Pacas, Bourbon
	CICAFE	Heredia, CR	1120	No	Caturra, Catuaí
	Pirineos	Usulatán, ES	1250	Yes	Catuaí, Bourbon
	El Milenio	Auchapán, ES	1350	Yes	Bourbon, Pacamara
	Las Lagunas	Marcala, Hon*	1440	Yes	Caturra, Catuaí
	Doka	Alajuela, CR	1400	No	Catuaí, Pacamara
	Solís	Dota, CR	1580	No	Caturra, Catuaí

(*) CR = Costa Rica, ES = El Salvador, Hon = Honduras

Table 2. Elevation effect on beverage quality of samples from Trial 1 (Costa Rica).

	Elevation	Flavor	Body	Acidity	Bitterness	Preference
	900	3,30 ab	2,76 ab	2,53 dc	1,93 a	2,53 c
	1000	3,45 a	2,90 ab	3,32 ab	1,58 ab	3,12 ab
	1100	3,30 ab	2,56 b	2,40 d	1,99 a	2,53 c
	1200	3,0 b	2,58 b	3,32 ab	1,22 b	2,41 c
	1300	3,53 a	2,85 ab	2,85 bc	1,53 ab	2,75 ab
	1350	3,48 a	2,96 ab	3,37 a	1,55 ab	3,16 a
	1400	3,51 a	2,83 ab	3,16 ab	1,51 ab	3,25 a
	1450	3,61 a	3,19 a	3,41 a	1,35 b	3,38 a
F probability	0,01	3,61 a	3,19 a	3,41 a	1,35 b	3,38 a

(*) Means within a column separated for Duncan test, P= 0,05

Beverage quality assessment

A sample of 150 g of large bean size green coffee from each treatment from trial 1 was roasted for 10-11 minutes a 230°C. Cup quality tests were carried out on an infusion prepared with 12 g of ground coffee in which 120 ml of boiling water was added, when temperature descend to 50-60°C. A panel of nine professional judges tasted three cups of each sample. The main beverage attributes (aroma, body, acidity) were estimated using a scale ranging from 0 to 5, where 0 = nil, 1 = very light, 2 = light, 3 = regular, 4 = strong and 5 = very strong. A preference score was used ranging from 0-5 where, 0 = not good for drinking, 1 = very bad, 2 = bad, 3 = regular, 4 = good and 5 = very good. The tests were repeated two times. Values presented are means of the two tasting sessions.

Data analysis

Statistica© software (Statsoft, Inc. 1993) was used to perform all statistical analyses. The mean values of relevant factors were compared by the Duncan test at $P \leq 0.05$.

RESULTS

Effect of elevation on coffee bean size (Trial 1) and chemical composition (Trials 1 and 2)

In Trial 1 coffee bean size was significantly affected by the elevation (Figure 1). The higher is the elevation, higher is proportion of large size beans. This relation is observed until 1400 m. At 1450 m, bean size decreased significantly. Dry weight increased as well with the elevation. Elevation had significant effect on chemical composition in Trials 1 and 2; trigonelline, caffeine, fat and ACG contents were dependent of elevation.

Effect of elevation on beverage quality (Trial 1)

Samples from 1300 m and higher elevations were preferred for cuppers than those elevations below, with exception from samples from 1000 m farm (Table 2). Higher elevation samples showed more acidity and aroma, and less bitterness than those from lower elevations. Samples from 1100 m and below presented more bitterness and less acidity.

Effect of shoot age on bean size and dry weight (Trial 1)

Shoot age had significant effect over dry weight of 200 beans sample ($P = 0,03$). Dry weight from beans produced on two year old shoot (Y1) was slightly higher than three year old (Y2) [33,45 and 33,01 respectively] (Data no shown).

DISCUSSION

Ripening problems due to extremely cloudy and cold temperatures can explain why the size, dry weight and fat content of the green bean decrease at 1450 m of elevation in Trial 1, these data suggest that in extremely high growth coffee areas, in years with rainfall excess (when lack of dry season avoid to concentrate flowering induction) and when prolonged low temperatures periods set up especially during coffee ripening, a yield lost can be hide for the producer.

Elevation influence on cup quality and chemical content is very well known, but this is the first report of a work done commercial conditions in the same area, with equal tree conditions (Trial 1) and where same cultivar trees with equal age and physiological condition but growth in different elevations (Trial 2) are compare for different chemical content variables.

Results demonstrates that good quality coffee can be produce in intermediated elevation if soil conditions and agronomy management are efficiently conducted, and that this quality also comes together with high levels of fat content, caffeine and chlorogenic acids.

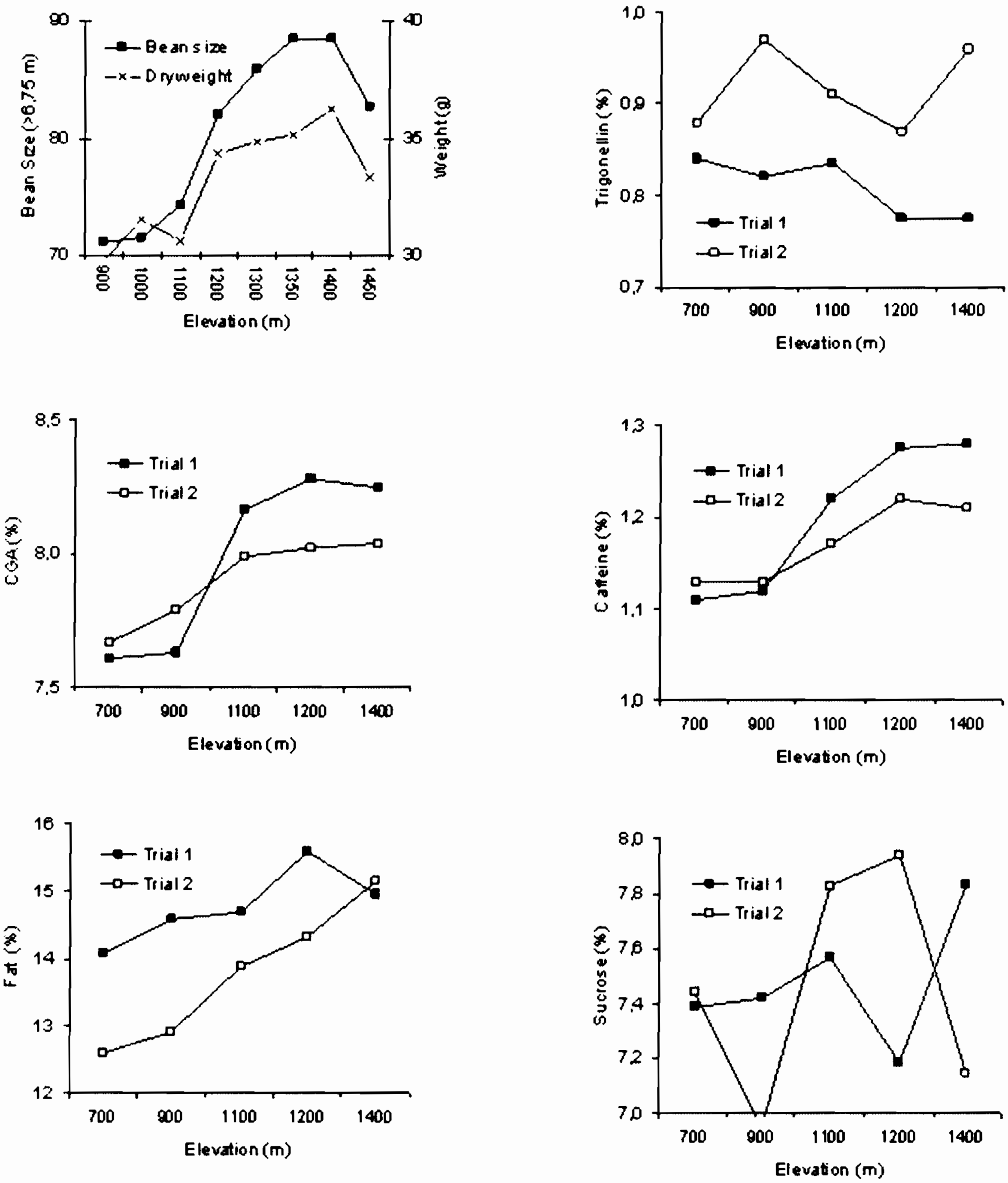

Figure 1. Elevation effect on bean size for Trial 1, and chemical composition for Trials 1 and 2.

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