

Effect of Different Indigenous Shade Trees on the Quality of Wild Arabica Coffee in the Afromontane Rainforests of Ethiopia *

A. YADESSA^{1*}, J. BURKHARDT², M. DENICH¹, T. WOLDEMARIAM³, E. BEKELE³, H. GOLDBACH²

¹University of Bonn, ZEF Bonn, Walter-Flex-Str. 3, D-53113, Bonn, Germany

*Ethiopian Institute of Agricultural Research, Forestry Research Center, P.O. Box 30708, Addis Ababa, Ethiopia; e-mail: abebeyadessa@hotmail.com, ay.tarfa@gmail.com

²University of Bonn, INRES-PE, Karlrobert-Kreiten-Str. 13, 53115 Bonn, Germany.

³Addis Ababa University, P.O. Box 28513, Addis Ababa, Ethiopia.

Summary

A study on four commonly found indigenous coffee shade tree species (*Acacia abyssinica*, *Albizia gummifera*, *Albizia schimperiana*, and *Cordia africana*) was conducted in the Afromontane rainforests of Ethiopia to assess their effects on the physical and sensory quality of wild Arabica coffee. Results showed that sensorial differences in wild Arabica coffees were detected due to tree species. Tree species significantly affected beverage acidity, flavour, aftertaste and overall cup quality. This means coffee samples collected under *A. abyssinica* and *C. africana* were more acidic, with better flavour and overall cup quality as compared to those collected under both *Albizia* species. But no apparent difference in body of the brew could be detected due to tree species. Moreover, the proportion of marketable beans (screen 14 plus in Ethiopian case) was higher under *Acacia* (92.73%) and *Cordia* (91.79%) than under *A. schimperiana* (89.48%) and *A. gummifera* (88.42%). To the contrary, the proportion of very small beans (which are rejects in most cases) was significantly higher under *A. gummifera* and *A. schimperiana* than under *Acacia* or *Cordia*. Generally, coffee beverages prepared from samples under *Acacia* and *Cordia* were more appreciated by the tasters than those under both *Albizia* species. This finding coincides well with the local farmers' perception for *Acacia*, but not for *Cordia*. In Ethiopia, *C. africana* is a valuable timber tree but endangered species, and hence its positive effect on coffee quality as obtained by the present finding is an added advantage. In light of the present findings, the practical significance of the study in terms of shade coffee production and biodiversity conservation are discussed.

Introduction

The shade trees in coffee production systems provide several economic and ecological benefits. Studies elsewhere have demonstrated the multiple uses of coffee shade trees; and their role in soil fertility management (Yadessa *et al.*, 2001; Kimemia, 2007; Muleta *et al.*, 2008), biodiversity conservation (Sonto-Pinto *et al.*, 2000; Perfecto *et al.* 2005), carbon sequestration (Jong *et al.*, 1997; Harmand and Hergoualc'h, 2007), micro-climate regulation and prevention of coffee plants from damages by frost or other extreme conditions (Barradas and Fanjul, 1984; Caramori *et al.*, 1996; Lin, 2007) and cash income generation from the sale of timber and non-timber products (Beer, 1987; Beer, 1988; Vaast *et al.*, 2006) have been well documented. And there is no exception to the shade tree-coffee association in the

Afromontane rainforests of Ethiopia. In addition to providing wild coffee, the Afromontane rainforests in Ethiopia are reservoir of several products and services.

Traditionally, coffee plants grow under the shade of trees. In these tree-coffee associations, studies have demonstrated that coffee shade trees have positive impacts on coffee quality (Muschler, 2001; Vaast *et al.* 2006; Avelino *et al.*, 2007), by lengthening of the maturation period of coffee berries and hence a better bean filling and also through the modification of microclimate for the coffee plant growing underneath shade trees (Lin, 2007). Moreover, shade improves the quality of coffee by allowing the beans to accumulate greater amounts of sucrose as compared to sun grown beans (Steiman, 2003). According to Guyot *et al.* (1996: cited in Steiman 2003), bean size increased slightly with shade as did the chemical constituents: chlorogenic acids by 10%, total acidity by 16%, and caffeine by 4% and sucrose by 3%. But trigonelline content decreased by 10%, and bitterness among the organoleptic properties decreased by 18%. Muschler (1998) also observed the effects of various shade regimes on two coffee varieties (Caturra and Catimor). Both varieties exhibited a substantial bean size increase as well as improvement in visual appearance. The total amount of defects was less under shade for both varieties. Acidity and body improved with shade but aroma was slightly negatively affected in Catimor (Steiman, 2003). These studies suggest that shade positively affects coffee quality. However, due to the interaction of shade with the environment and genetic composition, the effects might be site specific.

Indigenous shade trees are very common features of the coffee production systems in Ethiopia, although currently the existing valuable shade tree species are being depleted from the Afromontane rainforest ecosystem by selective cutting for timber (e.g. *Cordia*). Jotie (2005) have listed the major important indigenous shade tree species in the coffee production systems of SW Ethiopia, and this was supplemented by field observation and reconnaissance survey during the study. The effects of some of these shade trees on yield and agronomic traits of coffee have been documented in Ethiopia (Kufa, 2007; Shimber *et al.*, 2002). But their effects on coffee quality, notably under natural forest coffee ecosystem is scarce. The present study, therefore, focused on the effect of the four most common indigenous coffee shade tree species (*Acacia abyssinica*, *Albizia gummifera*, *Albizia schimperiana*, and *Cordia africana*) on the physical and sensory quality of wild arabica coffee in the Afromontane rainforests of SW Ethiopia.

Materials and methods

The study was carried out in Yayu coffee forest, Illubabor Zone of Oromia Regional State in south western Ethiopia. The shade trees were selected based on farmers' ranking of the major shade trees for suitability, field observations and reconnaissance survey and available literature. Accordingly, the four major species were *Acacia abyssinica* (local name Sondii), *Albizia gummifera* (local name Hambabeessa), *Albizia schemperiana* (local name Alalee), and *Cordia africana* (local name Waddeessa) in order of farmers' preference ranking for suitability as shade for coffee. Coffee cherries were harvested both under the canopies of different shade trees and also outside the canopies of respective trees (tree species and sub-habitat) in November 2007 when they were at full maturity. This means two factors were involved, namely: tree species and sub-habitats (under tree canopy vs. outside canopy). Red cherries were selectively hand-picked and dry-processed with careful handling at Jimma Agricultural Research Center with close supervision of the Coffee Quality and Processing Division staffs. The dried cherries were manually depulped and the beans were made ready for cup tasting. The coffee samples

were medium roasted and medium ground. Sensory evaluation was then assessed using the major cup quality criteria: fragrance, aroma, flavour, acidity, body, aftertaste and overall quality; and scoring was based on a scale of 1-10, corresponding to the total absence or presence of the criterion in the coffee beverage, respectively. The beverage was prepared by brewing 9 g of roasted coffee in 180 millilitres of hot water. The coffee brews were evaluated by a panel of four experienced tasters at Robera Coffee Cup Tasting Laboratory (<http://www.roberacoffee.com/qualitycon.html>) in Addis Ababa, Ethiopia. For the statistical tests, the means of the values attributed by all the tasters were used.

Results and Discussion

Results showed that there were significant differences in organoleptic properties of wild Arabica coffees collected under different indigenous shade tree species. Tree species significantly affected beverage acidity, flavour, aftertaste and overall cup quality. But the tasters could not detect significant differences in some of the organoleptic properties the coffee brews, especially for the body (Figures 1 and 2). According to the present findings, coffee samples collected under *A. abyssinica* and *C. africana* were more acidic, with better flavour and good overall cup quality as compared to those collected under both *Albizia* species. But no apparent difference in the body of the coffee beverage could be detected due to tree species, which may be related to other factors such as soil properties (Yadessa *et al.*, 2008). Generally, coffees under *A. abyssinica* tree were best, followed by those under *C. africana*. Coffees under both *Albizia* species were less preferred by a panel of tasters (Figure 2). This is especially interesting for *Cordia* as it is not a leguminous species. This might be due to the fact that nitrogen might be less important for cup quality as compared to other soil properties like available P and K (Yadessa *et al.*, 2008).

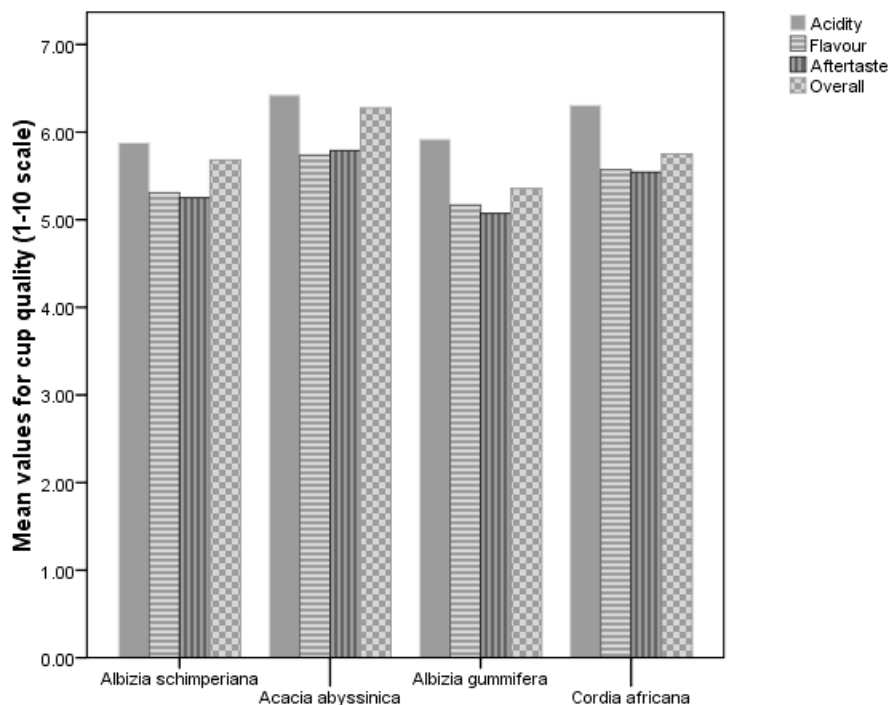


Figure 1. Organoleptic properties of wild arabica coffee as influenced by indigenous shade tree species, averaged over tasters.

As indicated in Figure 3, the proportion of marketable beans (screen 14 plus in Ethiopian case) was higher under *Acacia* (92.73%) and *Cordia* (91.79%) than under *A. schimperiana* (89.48%) and *A. gummifera* (88.42%). The proportion of very small beans (which are rejects in most cases) was significantly higher under *A. gummifera* and *A. schimperiana* than under *Acacia* or *Cordia*. But farmers' preference ranking of shade trees for improving coffee quality was in the order of *A. abyssinica* > *A. gummifera* > *A. schimperiana* > *C. africana*.

The results of the present study thus coincide well with the local farmers' perception for *Acacia*, but not for *Cordia*. In Ethiopia, *C. africana* is a valuable timber tree species, but it is an endangered species. And cutting of *Cordia* is banned by proclamation in the country (TGE, 1994.), although selective cutting of the tree from the forest ecosystem and elsewhere is unabated. Hence, the positive impact of *Cordia* on coffee quality as obtained by the present finding could be an added advantage. And this may help to boost the conservation efforts of the species as coffee shade.

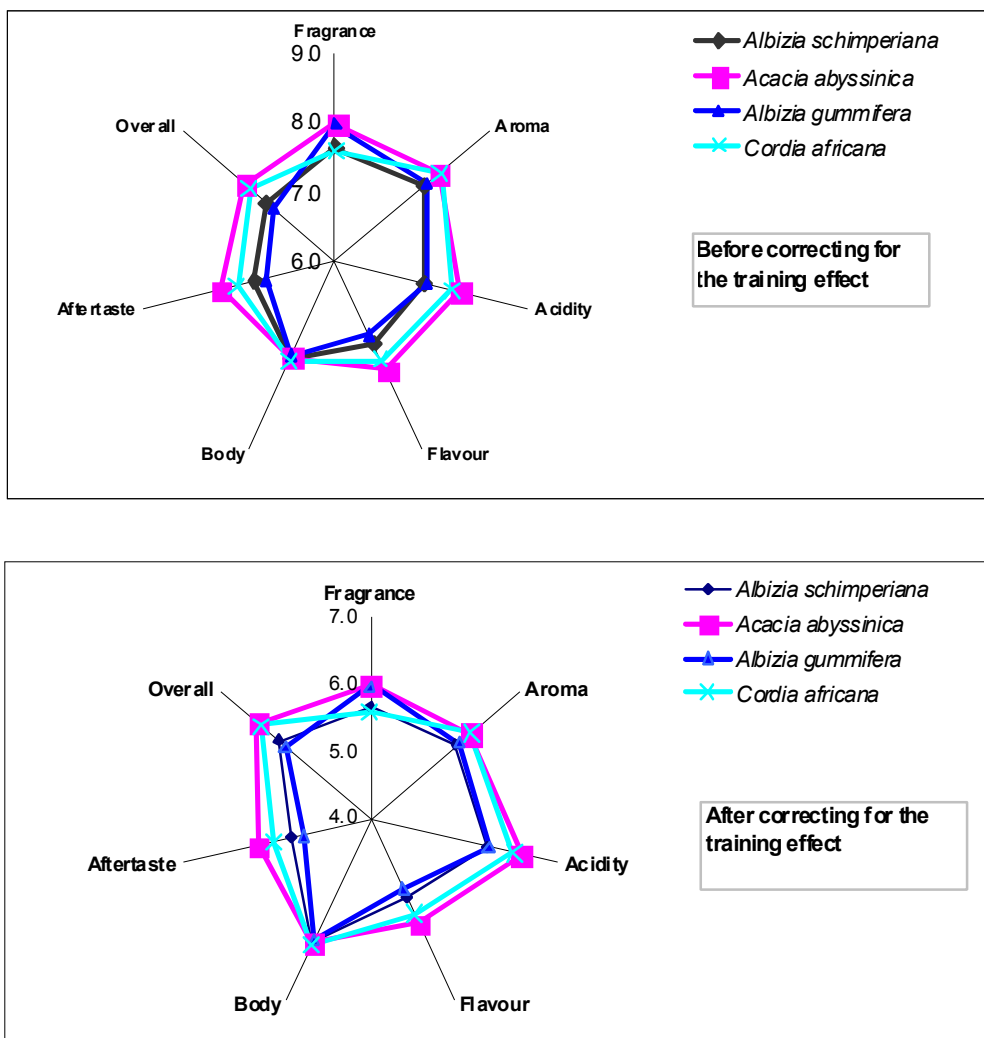


Figure.2. Organoleptic properties of coffees collected under different shade trees (the trend was similar in both cases).

Studies also show that shaded coffee plantations have been proposed as refuges for biodiversity conservation since they can potentially preserve high diversity of organisms (Perfecto *et al.*, 2005). Promotion of indigenous shade trees in coffee production systems should be considered as a strategy for *in situ* conservation of biodiversity and valuable species in the area. Study by Derero *et al* (2007) revealed that the scattered *Cordia* trees on farmlands also harbor substantial genetic diversity comparable to the continuous populations, and hence shade trees can be used as sources of genetic materials as well. *Cordia* is also a good soil ameliorator; higher concentrations of soil nutrients such as available P were reported under the canopies of *Cordia* trees as compared to its nearby open area (Yadessa *et al.*, 2001).

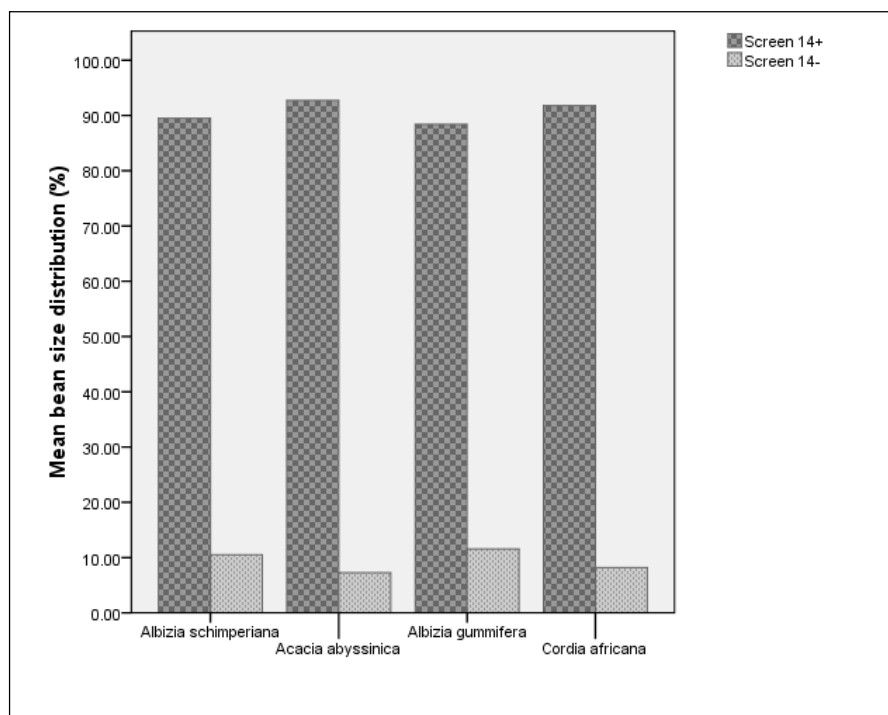


Figure 3. Bean size distribution of wild arabica coffee as influenced by indigenous shade tree species.

However, there was no significant difference in coffee quality between samples collected under the canopy of shade trees and ‘outside’ the canopy of shade trees although the difference was significant for the tree species. This might be due to the fact that in forest or semi-forest coffee systems the presence of purely open coffee is less likely because of the density of shade trees. There is no proper ‘open area’ or ‘full sun’ in forest or semi-forest coffee production systems of the Afromontane rainforests in Ethiopia. The density of upper canopy trees in the Afromontane rainforests of Ethiopia was reported in detail by Senbeta (2006). This could be the probable reason for lack of significant difference in the beverage quality of coffees collected from different sub-habitats (under canopy versus outside canopy) although significant differences were reported in literature in coffee plantations (Muschler, 2001; Vaast *et al.* 2006; Avelino *et al.*, 2007).

Conclusion

The present results revealed that indigenous shade trees considerably influenced the organoleptic properties of wild Arabica coffee in the Afromontane rainforests of SW Ethiopia, especially beverage acidity, flavour, aftertaste, and overall cup quality. The taste of the coffee brew was relatively best under *Acacia*, followed by *Cordia*, but lower under both *Albizia* species. Coffee samples collected under *A. abyssinica* and *C. africana* were more acidic, with better flavour than those collected under both *Albizia* species. Generally, coffees under *Acacia* and *Cordia* were more appreciated by the tasters than those under *Albizia* species. This finding coincides well with the local farmers' perception for *Acacia*, but not for *Cordia*. This could be an added economic advantage for *Cordia* as it also provides other economically useful products (e.g. timber) for the local people and ecologically important services (e.g. soil amelioration) for the ecosystem. These economic and ecological benefits of shade trees in the Afromontane rainforests of Ethiopia thus presents a good opportunity to develop programs for sustainable natural resources management by combining conservation and economic goals. Similar scenarios were also reported in Central America in coffee plantations (Perfecto *et al.*, 2005). And thus in coffee trading, shade coffee certification has recently emerged as a conservation-oriented marketing strategy. There is also an increasing demand for shade coffee among consumers (CEC, 1999; Steiman, 2003). It is therefore advantageous and economically sound to promote shade trees in coffee production systems, and certification programs that relate biodiversity or environment and coffee quality should be considered in the future.

Acknowledgement

The research was sponsored by German Federal Ministry of Education and Research (BMBF). We also acknowledge Center for Development Research (ZEF) and Ethiopian Coffee Forest Forum (ECFF) for hosting and supporting the activities, Forestry Research Center and Jimma Research Center for provision of vehicles and other assistance, Addis Ababa University for different assistances, Robera Coffee PLC for assistance during the cup tasting, the professional cup tasters, and ASIC for supporting my participation in the conference.

References

- Avelino, J., Barбора, B., Davrieux, F., and Guyot. 2007. Shade effects on sensory and chemical characteristics of coffee from very high altitude plantation in Costa Rica. *In: Second International Symposium on Multi-Strata agroforestry systems with perennial crops: Making ecosystem services count for farmers, consumers and the environment*, September 17-21, 2007 Turrialba, Costa Rica.
- Barradas, V.L. and Fanjul, L., 1986. Microclimatic characterization of shaded and open grown coffee (*Coffea arabica* L.) plantations in Mexico. *Agricultural and Forest Meteorology*, 38: 101-112.
- Beer, J., 1987. Advantages, disadvantages and desirable characteristics of shade trees for coffee, cacao and tea. *Agroforestry Systems*, 5: 3-13.
- Beer, J., Muschler, R., Kass, D., Somarriba, E., 1998. Shade management in coffee and cacao plantations. *Agroforestry Systems*, 38: 139-164.

- Caramori, P.H., Filho, A.A., and A. C. Leal, A.C. 1996. Coffee shade with *Mimosa scabrella* Benth. for frost protection in southern Brazil. *Agroforestry Systems*, 33: 205-214.
- CEC (Commission for Environmental Cooperation). 1999. Measuring consumer interest in Mexican shade-grown coffee: an assessment of the Canadian, Mexican and USA markets. <http://www.cec.org/filespdf/ECONOMY/shade-eEN.pdf>
- Derero, A. Gailing, O., Finkeldey, R., 2007. Comparative Genetic Variation in *Cordia africana* between Trees in Traditional Agroforestry Systems and Continuous Populations in Ethiopia. Tropentag 2007.
- Harmand, J.M. and Hergoualc'h, K. 2007. Carbon sequestration in aerial biomass and derived products from coffee agroforestry systems in Central America. In: Second International Symposium on Multi-Strata agroforestry systems with perennial crops: Making ecosystem services count for farmers, consumers and the environment, September 17-21, 2007 Turrialba, Costa Rica. web.catie.ac.cr/cd_multiestrata/Poster/session2/Carbon_sequestration.pdf
- Jong, B.H., Soto-Pinto, M.L., Montoya-Gómez, G., Nelson, K., Taylor J., Tipper, R., 1997. Forestry and agroforestry land-use systems for carbon mitigation: an analysis in Chiapas, Mexico. In: Adger, W.N., Pettenella, D., Whitby, M. (Eds.), Climate-Change Mitigation and European Land-Use Policies. CAB International, pp. 269 - 246.
- Jotte, Z. 2005. The influence of indigenous institutions in the conservation and use of *Coffea arabica*. The case of Yayo Forest in Ilu Abba Bora Zone, Southwest Ethiopia. MSc thesis from Addis Ababa University, School of graduate studies, Department of Sociology and Social Anthropology, Addis Ababa, Ethiopia.
- Kimemia, J.K. 2007. Influence of an *Albizia* shade tree on soil chemical properties, coffee plant growth and yields in Kenya, pp.1199-1202. In: 21th ASIC Proceedings, Montpellier, France.
- Kufa, T., Yilma, A., Shimber, T., Nestere, A., and Taye, E., 2007. Yield performance of *Coffea arabica* cultivars under different shade trees at Jimma Research Center, southwest Ethiopia. In: Second International Symposium on Multi-Strata agroforestry systems with perennial crops: Making ecosystem services count for farmers, consumers and the environment, September 17-21, 2007 Turrialba, Costa Rica.
- Lin, B.B. 2007. Agroforestry management as an adaptive strategy against potential microclimate extremes in coffee agriculture. *Agricultural and Forest Meteorology*, 144: 85-94
- Muleta, D., Assefa, F., Nemomissa, S., and Granhall, U. 2008. Distribution of arbuscular mycorrhizal fungi spores in soils of smallholder agroforestry and monocultural coffee systems in southwestern Ethiopia. *Biology and Fertility of Soils*, 44: 653-659.
- Muschler R. 2001. Shade improves coffee quality in a sub-optimal coffee zone of Costa Rica. *Agroforestry Systems*, 85: 131-139.
- Muschler, R. 1998. Tree crop compatibility in agroforestry: production and quality of coffee grown under managed tree shade in Costa Rica. Ph.D. Dissertation, University of Florida. 219 pp.
- Perfecto, I. Vandermeer, J., Mas, A. and Soto Pinto, L.S. 2005. Biodiversity, yield, and shade coffee certification. *Ecological Economics*, 54: 435– 446.
- Senbeta, F. 2006. Biodiversity and ecology of Afromontane rainforests with wild *Coffea arabica* L. populations in Ethiopia. Ecology and Development Series No. 38, 2006.
- Soto-Pinto, L., Perfecto, I., Castillo-Hernandez, J. and Caballero-Nieto, J. 2000. Shade effect on coffee production at the northern Tzeltal zone of the state of Chiapas, Mexico. *Agriculture, Ecosystems and Environment*, 80: 61–69

- Steiman, S. 2003. Shade versus sun coffee: a review.
<http://www.grayskies.net/honeybear/shade.htm>
- Shimber, T., Kufa, T., and Yilma, A. 2002. The effect of established shade trees on the growth and yield of arabica coffee in two planting patterns. Proceedings of the International Conference on Coffee Science (ASIC), May 14th-18th, 2001, Trieste, Italy.
- TGE (Transitional Government of Ethiopia), House of Representatives. 1994. NEGARIT GAZETA of The Transitional Government of Ethiopia, 53rd Year - No. 80, Proclamation No. 94/1994. Forestry Conservation, Development and Utilization Proclamation, p.372.
- Vaast, P., Van Kanten, R., Siles, P., Dzib, B., Franck, N., and Harmand, J.M. 2006. Shade: a key factor for coffee sustainability and quality, 887-896. ASIC 2006, Montpellier, France.
- Yadessa, A., Burkhardt, J., Denich, M., Woldemariam T. G., Bekele, E., Goldbach, H. 2008. Influence of soil properties on cup quality of wild Arabica coffee in coffee forest ecosystem of SW Ethiopia. Paper presented at 22nd International Conference on Coffee Science (ASIC), held between 14-19 September 2008, Campinas, SP, Brazil.
- Yadessa, A., Itanna, F. and Olsson, M. 2001. Contribution of indigenous trees to soil properties: the case of scattered trees of *Cordia africana* Lam. in croplands of western Oromia. *Ethiopian Journal of Natural Resources*, 3: 245-270.

*** Citation**

Yadessa, A., Burkhardt, J., Denich, M., Gole, T.W., Bekele, B., and Goldbach, H. 2008. Effect of Different Indigenous Shade Trees on the Quality of Wild Arabica Coffee in the Afromontane Rainforests of Ethiopia. Poster presented at 22nd International Conference on Coffee Science (ASIC), held between 14-19 September 2008, Campinas, SP, Brazil.
(See http://www.asic-cafe.org/pdf/abstract/PA544_2008.pdf)