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Original Research

Indigenous Agronomic Practices for *Coffee arabica* Production in Ethiopia

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Abstract

The main purpose of this study was to assess the best agronomic practises among coffee-producing farmers in Ethiopia. The study employed a cross-sectional design. Data were collected from farmers and experts through questionnaire, interview and observation in coffee-producing areas of the country. Respondents were selected using criterion-based techniques, and a total of 160 respondents were included in the study. The collected data were organised in a table using percentages. The result showed that there are indigenous practises unique to Ethiopia for coffee production. 94% of farmers in the country have been using organic fertilisers made from the decomposition of coffee bean husks, and 82% of the farmers harvest coffee beans by handpicking. The result also indicates that coffee beans are sufficiently washed to remove waste, and drying has been taking place in direct sunlight on a mashed bed. Almost all farmers used to store beans in cool and dry areas. It was also recommended that during coffee processing, each stage be undertaken in the right manner, with sequential procedures and appropriate local facilities. Besides, since a decade, mixed farming of crops with coffee and pruning of aged coffee trees have been widely practised traditionally. Therefore, the best indigenous knowledge and practises among coffee farmers in Ethiopia shall be institutionalised, and experience sharing among coffee farmers shall be encouraged.

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INTRODUCTION

The definition of "coffee" is often associated with the product, which means the beverage made from roasted seeds obtained from the coffee plant. Therefore, the word coffee stands for the beverage as well as the plant in the context of Ethiopia. "Coffee" is a drink made from the roasted ground beans of the coffee tree. The name "coffee" was coined from the name of the area where coffee originated in Ethiopia around Kaffa (South West Part of the Country). There are several species of the genus Coffee identified so far; two of these varieties are economically and commercially important: Coffee arabica (Arabica coffee) and Coffee acanephora (Robusta coffee). Both coffee varieties differ mutually from a botanical perspective and in terms of quality features

(Barbin et al., 2014). The species found in Ethiopia is Coffee Arabica, which got its name during its journey to Arabia, from where it is disseminated to the rest of the world (Asfaw Tessema, 2014).

Coffee is the second-most valuable commodity in the world, next to petroleum (Bae et al., 2014). In 2007, coffee farming was assumed to involve 25 million farmers and coffee workers in over fifty countries around the world (Petit, 2007), which could be increased by threefold in 2022. The crop is grown in tropical and subtropical climates around the world, where over 10.2 million hectares of land in more than 80 countries are covered by the plant. Ethiopia is considered one of the major coffee producers, consumers, and exporters of coffee in the world. It was estimated that about 15 million people in Ethiopia will be involved in some aspect of the coffee economy through farming, distribution, or sales in 2020 (Mekonnen et al., 2020). The major coffee-growing areas in Ethiopia include the western, north- and south-western, southern, and eastern parts of the country, with a total land coverage of half a billion hectares in 2020 (Sualeh et al., 2020).

Ethiopia is the largest coffee producer in Africa, mainly Arabica coffee, which contributes 70% of the world coffee production (Vegro & Almeida, 2020). Arabica coffee is higher in quality, has lower caffeine content, and produces a more aromatic brew compared to Robusta coffee (Poltronieri & Rossi, 2016). The production of coffee in Ethiopia is showing an increasing trend; the current production is estimated to be 457,200 metric tonnes in 2022 on 725,961.2 hectares of land with an average productivity of 0.612 t ha−1 of clean coffee (USDA, 2020).In Ethiopia there is different coffee types which are named based on producing areas: Harar coffee, Limu coffee, Yirgachefe coffee, Nekemte coffee, Lage coffee and Sidama coffee, Jimma and Tepi Bebeka coffee. The coffee types vary in physical (bean size) and sensory characteristics (tests and aroma) that made it to be labelled at different levels of coffee quality in Ethiopia. A good coffee quality will have a strong and pleasant aroma that smells fresh. This is also attributed to agronomic practices of coffee production such as harvesting methods and timing, postharvest processing techniques, packing, storage conditions and transportation; all contribute to either exaltation or deterioration of coffee cup quality (Deribe, 2019). In Ethiopia, coffee producing farmers' have different practices for producing consumers demand coffee bean quality. Therefore, this study aimed to review and document the best agronomics practices adopted among coffee farmers in Ethiopia in coffee farming and harvesting processes.

MATERIALS AND METHODS

Description of the study Area

The assessment was conducted in major coffee-producing areas of Ethiopia, named Yirgachafe, Harar, Gimbi, Jimma, Lage, Sasiga, and Limmu. These areas exist in all Oromia regional states except Yirgachafe. These areas are characterised by altitudes, annual rainfall, and temperatures in the range of 1,300–1,800 m.a.s.l., 1,500–2,500 mm. and 15–25 oC, respectively. Since the precipitation is less in the eastern part of the country (about 1,000 mm), the water requirement for coffee plants is supplemented with irrigation. The coffee-producing areas are characterised by relatively dense forests that make the area a cool and shady environment, which is favourable for the growth of Arabica coffee. Arabica coffee requires fertile, fairly acidic, loamy soils with a depth of at least 1.5m and a relatively high water-holding capacity. The soil fertility of these areas is naturally maintained through organic recycling of

litters fall from coffee and shade trees (Alemayehu, 2015).

Data collection method

A cross-sectional study design was employed using both a quantitative and qualitative approach. The population for this study comprises all coffee-producing households in the areas of Yirgachafe, Harar, Gimbi, Jimma, Lage, Sasiga, and Limmu coffee-producing districts. Then, three administrative villages were selected purposefully based on coffee production potential, from which 130 "coffee-producing model farmers" were identified for data collection using a structured interview. Thirty key informants were drawn purposefully from extension workers (development agents) and Woreda and zonal-level experts. A total of 160 respondents participated in the study. The quantitative data were converted into percentages, and the qualitative information was evidenced with real images.

RESULTS AND DISCUSSIONS

Demographic characteristics of Respondents

As indicated in Table 1, 43% of the respondents were female, and 64% of the total respondents were greater than 40 years old, which indicates the labour force engaged in coffee production in the study area has sufficient life experience. Besides, 86% of the key informants had greater than ten years of work experience related to coffee farming activities.

Table-1

Characteristics of Respondents

Variables	Characteristics	Total	
		N	Percentage
Sex	Male	69	43.13
	Female	91	56.87
	Total	160	100
Age	≥29	13	8.12
	30-39	45	28.13
	40-49	72	45.0
	50 & above	30	18.75
	Total	160	100
Year of work experience (key informants)	1-9	4	13.33
	10-19	11	36.66
	20-29	10	33.33
	≥30	5	16.66
	Total	30	100
Level of Education (key informants)	Certificates	5	16.66
	Diploma	11	36.66
	BA/BsC	12	40.00
	MA/MsC	2	6.66
	Total	30	100

Source**:** *Survey data*

Most of them served as development agents and coffee development experts. From these data, it would be possible to say that such a relatively longer year of work experience in

the system might help them to possess adequate experience and a better understanding of coffee agronomic practises. Furthermore, 76% of the key informants have a diploma or bachelor degree qualification level in agronomy, horticulture, plant science, or general agriculture (Table 1).

Selection of Coffee Germplasm and Its Storage

Quality coffee beverage depends on the health status of the coffee plant, which means heavy and green coffee plants are one of the parameters to forecast quality coffee beans. This is in turn influenced by the quality of the plant germ plasma. The quality of coffee seedlings depends on the stage of cherry harvest and processing mechanisms (Netsere et al., 2015). In line with this, indigenous knowledge among coffee farmers in Ethiopia showed that selection of coffee germplasm starts with selection of the "Mother Tree" during the fruiting season. Farmers have been selecting "Coffee Mother Tree" based on the following parameters: (i) The age of the plant shall be between 5 and 10 years of its plantation. (ii), "Mother tree "shall be healthy, vigorous, and green and produce the most cherries compared to the other trees. (iii) Mature cherries that are identified by their red colour shall be collected by hand picking from the middle of the branches during the middle of harvesting time (Figures 1a, b). (iv) Cherries that contain healthy seeds are identified by soaking in water, in which cherries that contain defective seeds float on the surface that can be screened during decantation, as shown in Figure 1c. After pulping the wet cherries, the seeds are mixed with a sufficient amount of ash with a strong hand massage to control fungal infection (Figure 1d). On the other hand, some researchers reported enhanced germination of seeds when ripe cherries were dried with intact parchment under shaded and ventilated conditions (Dawit and Daba, 2020). However, this method is criticised for its inability to screen unhealthy and infected seeds.

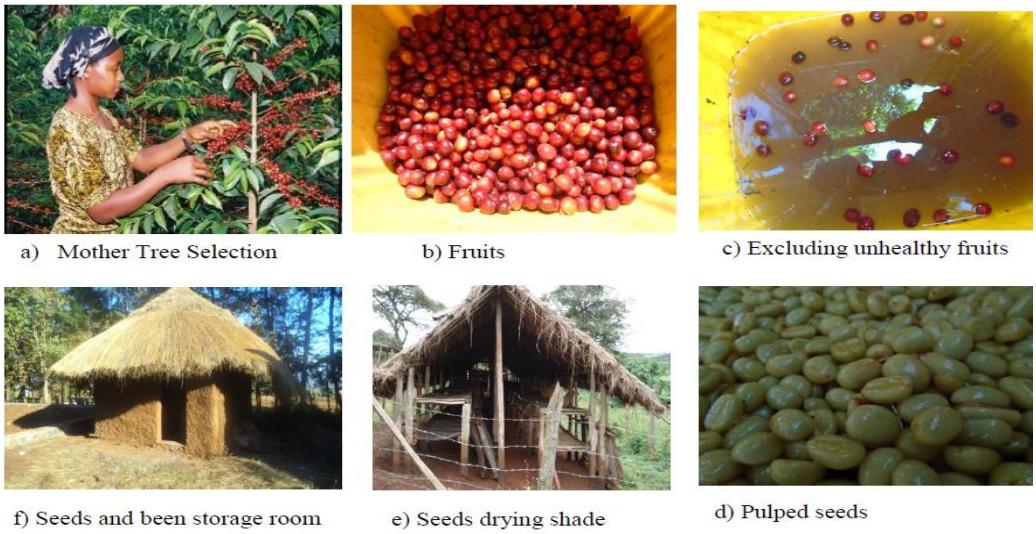

Figure 1 *Indigenous Practice in Coffee Seed Preparation and Storage*

The other factors that affect the germination of coffee germplasm are the drying method and seed storage conditions. According to Netsere et al. (2015), coffee seeds with moisture content greater than 12% retain their viability and vigour for a longer period of time. The experience of the coffee farmers in Ethiopia showed that seeds that are dried on raised beds under shade (made from grasses) during the sunny season do not lose their moisture rapidly. Besides, the viability of coffee seeds is improved when they are stored in a house made from a clay soil wall and a grassy roof (Figure 2 a-f). However, most coffee farmers recommend the effectiveness of germination if cultivated within 3–4 months of its drying.

Seedling Media Preparation

According to Netsere et al. (2015), a seedbed is defined as uniformly firm, with soil moisture near the surface, free from competing vegetation, and well-packed underneath with small surface clods or a light mulch of residue to prevent soil erosion. Coffee seedlings can be grown on beds or in polythene tubes (10–12 cm in diameter and 22–25 cm in height) filled with forest soil collected from the top 5–10 cm deep (Netsere et al., 2015). However, in the absence of forest soil, the use of blended top soil and compost, coffee pulp, or manure in a ratio of 4:1 has been used as organic fertiliser in coffee seedling production (Taye et al., 2001). The proportion of combinations for seedbed and polythene tubes is the same, although seedling production using the latter is easy in transportation and fast in adaptation during transplantation.

The seedbed can be raised or sunken, depending on the level of rainfall. The sunken type of seedbed is prepared in areas with low rainfall (Nesper et al., 2017). In Ethiopia, most of the coffee seedbeds are raised, with a height of 20 cm and a length of 120cm, that are laid from east to west (Figure 2a), and the space between plots is recommended to be 75 cm, according to coffee expertise in Ethiopia.

Seed Plantation

Seed plantation rate depends on the type of nursery media: either a seedbed or polythene tubes. Most of the time, indigenous coffee farming communities adapted to seedbeds due to the limited availability of polythene tubes. Plantation of seeds on the seedbed depends on whether the site is used for either "germination bed" (Figure 2a) or "direct sowing" (Figure 2b). However, most of the time nursery seedbeds are used as dissemination centres for seedlings for transplantation; hence, usually a direct sawing method is used in Ethiopia. Experience also showed that plantation of pre-germinated seeds results in seedlings with deformed roots (Netsere et al., 2015). Nursery sites in Ethiopia are selected based on the availability of irrigation systems and land escape to protect leaching. For maximum germination, the seedbeds shall be watered at least once a day before planting. Coffee seeds should be sown at a depth of 1 cm with the grooved side of the seed down and the embryo tip up (Kudama, 2019). Seeds are planted in a street line with spacing between seeds and rows of 15cm and 20cm, respectively (Figure 2a, b). Before planting, it is recommended to soak

seeds in water for at least 24 hours for a fast germination rate at the nursery site.

Mulching and Watering the Seedbed

Experiences are showing the importance of covering the seedbed with 3–5 cm of dried grass immediately after the sowing of seeds for a fast and high germination percentage. The covered seedbed needs to be watered at a 2-day interval until seedling emergence during the dry season (Figure 2c). After the emergence of seedlings, removing mulch and providing overhead shade of 75cm height is important to protect seedlings from direct sun rays and decrease the pressure of water during watering (Figure 2d). After germination, water seedbeds twice a week until the seedlings produce 2–4 pairs of true leaves, and then after watering at weekly intervals (Tesfaye et al., 2013).

Figure 2 *Seedling Preparation and Transfer to Permanent Site*

Site selection for coffee Seedling Transfer

During the plantation of the coffee seedlings, an important and primary factor that should be considered is the selection of appropriate farmland. Forest lands that have sufficient head trees and clay loam soil types are assumed to be the most appropriate sites, according to coffee experts in Ethiopia. Ethiopian coffee farmers have experience using canopy trees of Acacia, Albizia, and Millettia, Cordia Africana, and Croton macrostachyus for coffee production. In a forest, the specific site for coffee planting should be at least two metres away from the base of the shade tree. The planting area must be cleared and ploughed, except for shade trees.

Hall Preparation for Coffee Seedling Plantation

Experiences showed that coffee should be planted at a spacing of 2m and 1.5m between rows and plants, respectively, although it depends on elevation, climate type, coffee variety, and soil fertility status. Thus, farmers are expected to prepare the pits in advance to loosen up the soil before transplanting the coffee seedlings into the main field. These pits shall be dug two months before transplanting the seedlings. The dimensions of the pit are recommended to be 50 cm x 50 cm in size (Figure 3 a-e, i). The excavated soil shall be mixed with manure or compost, refilled, and watered until the date of planting. Most of the time, transplantation of seedlings is recommended in the middle of the rainy season in Ethiopia.

Soil Conservations of Coffee Farms

Agricultural activities, especially coffee production, in Ethiopia are hurt by land degradation such as soil erosion and nutrient depletion. Of course, land degradation depends on the agro-ecology of the growing areas because coffee grows in wide ranges of temperature and rainfall. This is greatly affecting the early survival of transplanted coffee seedlings in Ethiopia. However, research done on coffee farm land in Ethiopia showed that on-farm mulching, cultivation of cover crops, application of organic fertiliser, and shade management have improved soil moisture holding capacity, depressed weed growth, added organic matter to soil and improved soil structure, and regulated coffee tree overbearing and overbearing branch die-off (Kebede, 2012). Particularly, legume cover crops such as crotalaria, desmodium, dolichos, and mucuna intercropped with coffee are known to improve soil moisture content, plant macronutrients, and significantly suppress weeds on farmland (Kiseve, 2012). For instance, research done in Ethiopia showed that the use of Desmodium sp. as a cover crop increased coffee yield by about 30% and conserved soil moisture considerably as compared to sole coffee plots (Kebede, 2012).

The use of mulch in coffee farming is an important traditional method used to conserve soil moisture-holding capacity. Mulching is the covering of the soil with different materials (e.g., grass, compost, manure) that is not only to preserve soil moisture and decrease soil temperature (reducing evapotranspiration), but also to increase soil fertility, suppress weeds, and improve rainfall penetration into the ground, as shown in Figure 3a. Mulch is common, especially during the first few years after transplantation of coffee seedlings (Ahmed et al., 2020).

Application of Organic Fertilizer in Coffee farm

Organic fertilisers are important in the buildup of the soil's organic matter and the conditioning of the soil's physical and chemical properties. It is also a food source for various microorganisms that play an active role in the quality of the topsoil. In Ethiopia, the application of chemical fertiliser on coffee farms is nonexistent. Coffee pulp and husk are by-products of coffee processing that have been used as organic fertiliser after composting in coffee farms in Ethiopia, as shown in figure 3b. Particularly, the combination of coffee husk or pulp with manures or residues of leguminous plants accelerates the composting process and improves nutritional composition (Dawid, 2018). The majority of farmers (91.45%) in Ethiopia apply 5–10 kg of compost per coffee tree per year in split application forms (March and September).

Small-scale coffee farmers usually grow different species of trees as an integral part of the production system (e.g., fruit and nut trees). This in turn has manifold ecological benefits by serving as windbreaks and shelterbelts, for aesthetic value in residential areas, and more importantly, to protect the coffee plants from excessive sun and high temperatures that result in premature death (Belayneh & Molla, 2020). Some coffee shade trees, like Sesbania *sesbania*, are planted at a spacing of 4 m. The permanent and predominant coffee tree shades in Ethiopia, such as Albizia, Millettia, Acacia, Erytriana, and Cordia, are planted in a strip planting pattern among the coffee plants, as shown in Figure 3c-e.

Figure 3 *Soil and Water conservation strategies in Coffee farms*

Integrated crop management practices/ Mixed Farming

Coffee farmers in Ethiopia use integrated crop management practises on their coffee farms. This is also a diversified source of income. Crops such as beans, maize, sweet potatoes, bananas, and papaya have been traditionally intercropped with coffee in Ethiopia. The farmers and extension officers reported that coffee produced on intercropped fields has good quality and a high yield. Besides, traditionally, coffee farmers in Ethiopia involve themselves in honey production using local beehives made of the available local materials under the coffee shade trees (Figure 4). It also helps to protect the environment, landscape, and vulnerable habitats (Mukadasi, 2018). Thus, in a mixed farming system, farmers can get income from multiple sources year-round as it consists of different agricultural activities. Employment is generated, and household labour work is done throughout the year.

Figure 4 *Integrated farming system among Small Holder Coffee Farmers*

Therefore, intercropping crops within coffee trees is an important activity to overcome the famine that could happen among smallholder coffee farmers until the pruned coffee starts yielding.

Coffee Tree Pruning

Pruning is the systematic removal of coffee stems so that they rejuvenate multiple new branches. Pruning a coffee tree produces a new plant from an old one, which is an essential management practise in coffee production. It helps to achieve the desired plant shape and contributes to sustainable, higher yields. The majority (86.70%) of Ethiopian farmers reported that more than 30% of their coffee plantations became old. Key informants revealed that there were challenges for the farmer to totally prune aged coffee from their farm; this may be due to a lack of input needed for pruning. One of the coffee-producing farmers said that:

> *Many producers do not prune their coffee plants and if they do, it has been generally inadequate due to a lack of knowledge on how to encourage growth of new plant tissue on their coffee trees.*

Thus, pruning is not commonly practised by the majority of coffee farmers in Ethiopia (Figure 5). However, some coffee farmers in Ethiopia adopt pruning practises because many coffee trees in the study area are old. A pruned coffee tree starts to produce cherries within 2–3 years, depending on their management. Pruning coffee plants is an important activity that ensures the growth of new plant tissue, good harvests, increased yields, and quality. To this end, another interview farmer responded to the advantage of pruning, saying:

> *When we prune trees and new growth occurs, the production of coffee is stable, has enhanced seed production, and the plant is resistant to plant diseases such as coffee rust.*

Besides, for pruning to be effective, it must be practised in coordination with other good farming practises such as shade management, application of organic fertilising, pest and disease control, weed management, and conservation of soil and water.

Figure 5 *Coffee Tree Pruning (left) and Application of Organic Fertilizer (right)*

Coffee Bean Harvest

Harvesting is the process of collecting red coffee cherries from coffee trees. In Ethiopia, harvesting is performed by selective handpicking of the mature cherries. Most farmers use this method to selectively pick the mature cherries, leaving the unripe coffee cherries to be harvested at their maturity. Handpicking improves coffee quality and reduces postharvest losses that could be caused by a mix of mature and premature beans. However, harvesting by handpicking is time-consuming and expensive because it requires excessive manpower to finish the harvest on time (Figure 6).

Some farmers (28%) also use another manual method to harvest coffee cherries called strip picking. The strip-picking method involves taking hold of a branch of the coffee tree and using a single motion to pull off all of the coffee cherries on the branch at once. Some farmers prefer this method because it's quick and convenient. On the other hand, some unripe cherries are being included in the

harvest, which needs further sorting. The decision on which harvesting method to use will depend on the manpower, land, and budget of the producers.

Figure 6 *Hand Picking Method of Coffee Cherries Harvest Process*

One of the biggest challenges facing coffee today is poor harvesting. Farmers harvest immature coffee cherries and mix them with mature coffee cherries. A district coffee expert in one of the study areas says: This severely affects the quality of coffee production. The expert advised to pick off only the ripe bean and leave the unripe for later harvest". In addition, another district coffee expert advised the coffee bean harvesting method as follows:

> *When picking coffee cherries, carefully pick up only the mature red ones, leaving the green ones on the tree to ripen further. Always pick; do not strip. Understand that when you pick immature coffee cherries, you lose on two sides. On one side, you lose at least 30% of the weight you would have to gain if you harvested it while it was immature, since immature coffee weighs less. On the other hand, you also lose customers if they discover that you harvest immature coffee. Besides, exclude leaves, twigs, and foreign matter from harvested beans that can affect the quality of the beans.*

During interview session, zonal level coffee development experts associated the immature cherries with poor quality coffee. They explained that:

> *Beans from immature cherries are prone to blackening during the drying process, and liquid coffee made from immature cherries has undesirable taste characteristics. Furthermore, the wet processing of coffee requires uniformly ripe cherries, as immature fruit is poorly pulped.*

Some researchers also advise using the traditional hand-picking and husbandry labour methods of coffee harvest to get green coffee quality (Behailu et al., 2008). Furthermore, Ameyu (2017) associated the insufficient

caffeine content of coffee beans with the harvest of unripe coffee cherries. Therefore, coffee beans need a careful harvesting process. A good harvesting process ensures the optimum quality of the beans. According to Haile and Kang (2019), the basic good harvest requirements are: (i) harvest ripe cherries only (no green or overripe beans); (ii) harvest beans from plants without imperfections or disease; and (iii) collect cherries at the peak of the harvest season.

Most small-scale coffee farmers in Ethiopia (71%) harvest the cherries, dry them, and sell them to coffee collectors. However, some small-scale coffee producers sell the red cherries to the trader on the farm while they are on the tree. The trader harvests, dries, and hulls the cherries. The large-scale private farmers harvest coffee cherries and pulp them using machines (either the dry or wet pulping process).

Washing of Coffee Cherries and Beans

After being harvested, the coffee cherries are brought to a processing mill, where they are soaked in water. The unripe or over-mature cherries immediately float, and they are prevented from getting to the next stage of the process (Figure 8a). This eliminates the majority of the defective cherries. The ripe cherries will then be put into a de-pulping machine that separates the cherries from the beans. At this point, the beans are still covered in their parchment and fruit mucilage. It is important to get rid of any mucilage. To do this, the beans are fermented in fermentation tanks for 24-36 hours, until the mucilage can be easily washed off. When the beans are clean, they are laid on the sun to dry to reduce water content and remove their parchments (Figure 7b, c).

a. Soaking Cherries in water b. Fermenting the pulped bean c. Washing the coffee beans

Figure 7 Coffee cherries brought to a processing mill,where they are soaked in water

According to the information obtained from key informants (traders, zonal and district coffee experts), there are agents (associations, unions, and individual traders) in Ethiopia that buy coffee from collectors and sell it to either exporters or international importers. These suppliers usually collect red coffee cherries from producers or local collectors and process the cherries before bringing them to auction. These agents usually have their own coffee

processing plant that hulls and washes. Most of the machines have wet and dry processing compartments.

In the case of wet processing, the harvested coffee cherries were immediately pulped, fermented in tanks, and then finally washed with clean water to remove the mucilage. It was then dried in the sun on raised tables and sorted at the proper moisture content. After drying to the proper moisture content, the outer layer of the cherries is removed by hulling, and the green bean obtained is ready for marketing (Figure 7). The value addition at this level is totally related to processing activities.

On the other hand, zonal coffee experts revealed that the "primary cooperatives (plc)" in Ethiopia are important participants in coffee bean processing. The organisation produces coffee, processes coffee beans, and sells them to their respective "farmers' unions (PLCs). Finally, the "medium farmers' union (PLC)" packs coffee beans, transports them to their warehouse, and prepares them for the international market. Here, the "unions" have different alternatives to sell their products. They can sell directly to the international importer or to the domestic exporter through the Ethiopian Commodity Exchange (ECX) Authority. The coffee unions contact ECX to grade coffee beans following the rules and regulations of the Ethiopian government.

Drying of Coffee Cherries or Beans

After washing the pulped coffee beans, a very important step is drying the beans. Although there are different methods of coffee bean drying, in Ethiopia, sun drying is predominantly used by producers, organisations, and cooperatives by laying the bean on mesh tables or locally made beds for about two weeks in sunny days until it fully dries. On the other hand, after coffee cherries have been collected, coffee producers allow the cherries to dry in the sun on large patios or raised drying beds (Figure 8). The cherries are turned occasionally to ensure even drying. After sufficient drying, it is hulled to remove all the parchment and husk that cover the beans. Finally, the beans are packed for transportation.

Figure 8 Coffee beans spread out in the sun to dry on large drying beds (after washing)

The drying of cherries on the tree or the drying of cherries without pulping is called natural drying. In the natural drying process, it is impossible to identify and ensure that the coffee dries at the same rate. Due to this, there may be a high risk of inconsistency. To this end, one of the zonal development experts said that "naturally processed coffees result in strong acidity and a poor brew aroma, which results in a low coffee grade.

The drying operation is one of the most important steps in the post-harvest processing of coffee that influences the quality of the coffee (Corrêa et al., 2006). Research indicated that drying can affect the physical appearance, the yield at hulling, and the taste of the beverage (Menya & Komakech, 2013). According to Tesfa (2019), drying is one part of the post-harvest process that is responsible for the removal of excess moisture to a level that is safe for long-term storage without any impact on the aroma or taste of the final beverage.

Several factors affect the coffee drying process, including the drying method, drying air temperature, relative humidity, drying air velocity, and drying time (Corrêa et al., 2006). In whole cherry drying, the pulp and the parchment are removed in a single operation. This method is simple and can be completed with less labour.

Drying is considered an important step in quality coffee production since moisture levels higher than 12% can promote microbial growth and mycotoxin formation (Haile and Kang, 2019). The main purpose of drying is to maintain the moisture content of the parchment for optimal storage. Freshly pulped coffee has a moisture content of about 55%, and that has to be reduced to about 12%. This is the ideal level of moisture content required for proper storage, hulling, and roasting.

Coffee Beans Storage

Coffee bean storage is an important step since dried coffee can easily absorb bad flavours or moisture that degrades quality coffee. Regarding this, one of the coffee development experts in the study area advised farmers, "Farmers or traders should store coffee beans in a cool, dry area away from potential contaminants, such as cow dung, soil, chickens, and smoke sources". During the survey, the majority (94.6%) of smallholder farmers had knowledge of coffee storage, and they reported that they don't expose the beans to moisture and that they always keep the storage room dry, clean, and well-ventilated.

The data obtained through an open-ended question revealed that sometimes farmers and traders in the study area store coffee for a long period of time (greater than one year) to improve the coffee market. Thus, the length of storage may affect the quality of coffee. According to Wintegens (2004), green coffees stored for a longer period, described as aged coffee, may suffer a loss of their acidity, which is needed for a coffee to have a specialty coffee grade. Moreover, the length and condition of bean storage also affect cup quality (Yigzaw, 2005). Particularly, long-term storage under high relative humidity and warm conditions increases bean moisture content and consequently reduces quality in terms of raw and roasted appearance as well as liquor (Woelore et al., 1995).

Even under adequate or optimal storage conditions, coffee beans deteriorate with age.

This phenomenon is accelerated when the environment is hot and/or humid, which makes the bean lose flavour due to the oxidation of its own fats. If longer storage is sought, it is better to store at a temperature of 20°C and 65% relative humidity (Adam and Anwar, 2010).

Finally, key informants suggested that inappropriate harvesting methods and a lack of appropriate drying and drying places are the major factors that could affect coffee quality and reduce market value. To maintain the quality of coffee, great effort is needed in creating awareness, encouraging the use of raised beds, drying to a proper moisture level, and using suitable storage facilities that inhibit the growth of moulds. Storage facilities should be clean, cool, shaded, dry, and well ventilated.

CONCLUSIONS

The objective of this study was to review best agronomic practises among coffee producers, experts, and traders for coffee arabica production in Ethiopia. Tangible information was collected from coffee-growing areas of Ethiopia, mainly from Oromia regional states. Interviews and focus group discussions were held for farmers and coffee experts for coffee specialty producers named Yirgachafe, Harar, Gimbi, Jimma, Lage, Sasiga, and Limmu Coffee types. Actual images were collected from the particular areas. According to the data collected, coffee beans used for the production of seedlings are usually identified at the farm as "Coffee Mother Tree," a coffee tree with an age of less than eight years that is healthy, green, and produces the most cherries compared to the other trees. Red cherries were collected from the middle of the branch. The cherries are pulped when wet, mixed with ash, dried, and stored in cool and dry places. The seedling bed shall be made from soil containing compost made from coffee pulp or manure in the ratio of 4:1 as organic fertiliser. Coffee seeds shall be planted at a depth of 1 cm with the grooved side of the seed down. It is recommended to soak seeds in water for at least 24 hours before planting for fast germination. Experience showed the importance of covering the seedbed with 3–5 cm of dried grass and watering at a 2-day interval until seedling emergence. Remove the mulch and make an overhead shade 75 cm high after seed emergencies. Transplantation of coffee seedlings shall be made after it has at least four green leaves, and planting shall be made at a spacing of 2m and 1.5m between rows and plants, respectively. For the transplantation process, 50 cm x 50 cm pits shall be made 2 months in advance, and organic soil shall be prepared by mixing with manures or composts. The coffee farm shall be intercropped with leguminous crops, and it is advised to have shade trees of Albizia, Millettia, Acacia, Erytriana, and Cordia. These shade trees are usually another source of income because they can be used for timber production and, in most cases, honey production.

In Ethiopia, when coffee trees become older and diseased, the shoots are procedurally removed, called pruning, which facilitates excessive branch formation. When cherries are red, manual picking is performed, which can be pulped as either dried or wet, although the most common is the dry pulping method. However, the wet pulping is effective in maintaining the quality of coffee because the unfit cherries can be screened by soaking them in water where

they float. The coffee beans are sufficiently washed to remove waste and exclude abnormal beans. Drying takes place in direct sunlight on a mashed bed, and the sufficiently washed seeds are stored in cool and dry areas. However, the quality of a coffee beverage is also greatly affected by roasting methods, grinding size, water-to-coffee powder ratio, and duration of boiling, in spite of variations in coffee types.

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