Asian Journal of Agricultural and Horticultural Research

3(2): 1-14, 2019; Article no.AJAHR.47083
ISSN: 2581-4478

Coffee Production Challenges and Opportunities in Tanzania: The Case Study of Coffee Farmers in Iwindi, Msia and Lwati Villages in Mbeya Region

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Authors' contributions

This work was carried out in collaboration between all authors. Author HMOO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author BAA managed the literature searches. Author OOO helped in the review. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAHR/2019/v3i229993
Editor(s):
(1) Dr. Paola A. Deligios, Department of Agriculture, University of Sassari, Italy.
Reviewers:
(1) John Walsh, School of Business and Management, RMIT, Vietnam.
(2) Binh Phan Thanh, Western Highlands Agriculture and Forestry Science Institute, Vietnam.
Complete Peer review History: http://www.sdiarticle3.com/review-history/47083

Review Article

Received 15 November 2018
Accepted 31 January 2019
Published 20 February 2019

ABSTRACT

Coffee is one of the most popular cash crops grown in Tanzania. However, its productivity has remained low due to various biotic, abiotic and socio-economic factors prevailing in Mbeya Region. These production challenges have never been properly and intensively documented for better decision making. Therefore, this study was set to assess and provide a better understanding of the current production situation and available technologies and practices for enhancing coffee production in the region.

The research was carried out in Iwindi, Msia and Lwati villages located in Mbeya Region. Two sources of data were used; (a) primary data collected through focus group discussion; and (b) secondary data collected through a systematic and intensive process that involved searching and collecting relevant publications.

From the research, farmers were found to grow very old trees that were more than 20 years. The soils were found to have low levels of nutrients and organic matter. Soils are also acidic, a pH

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below 5.5. High prevalence of pests such as coffee berry and stem borers and diseases like coffee leaf rust, *Fusarium* spp., bacterial blight, and red blister were reported in the region. Poor agronomic practices involving intensive intercropping of coffee with trees, other food crops like banana, beans and using generally low tree densities per hectare was observed. Poor extension services due to unbalanced extension agent to farmer ratio (about 1:1800) were found to be one of the causes for poor adoption of best coffee agronomy. Lack of market information and low coffee prices were found to demoralize farmers as it leads to a low return on investment. When asked about their 'priority training and input support requirements', all farmers mentioned best coffee agronomy and fertilizer use training. They also mentioned fertilizers (especially Urea or Yara Mila Java blend products) and pesticides (for berry borer, stem borer, Coffee berry disease, and coffee leaf rust) inputs as key for better yields. All these inputs and training require money and service provider. Bundling of training and inputs together could make it easier for any service provider to help farmers increase their yields.

Keywords: Coffee; coffee stem and berry borer; coffee berry disease; coffee leaf rust disease; production challenges; Mbeya Region; soil fertility management; pest and disease management.

1. BACKGROUND INFORMATION

Coffee is one of the most popular cash crops grown in Tanzania. Nationally, the crop accounts for about 5% of total exports (generating export earnings averaging US$ 100 million per annum) and provide employment to more than 400,000 farmers [1,2]. Mbeya region, located in the southern highlands, is among the leading producers of Arabica coffee in terms of area and yields (Fig. 1). Despite the importance of the crop to the economy, its productivity is still low at 200-750 kg/ha compared to the potential yield of over 3 t/ha of most varieties under best management practices [3]. Fig. 2 shows the current coffee production figures in Tanzania. Such low yields coupled with highly regulated prices have left farmers running into losses in coffee business. Low coffee yields and poor return on crop investment could be attributed to climatic, edaphic, biotic and socio-economic related constrains [4]. Despite many available technologies existing in the coffee world that could be adapted for better production in Mbeya Region, farmers have poor access to such information and hence continuing to produce using local technologies that reduce yields. This could be because of poor agricultural extension service not capable of disseminating information. It is reported that extensional service only reaches 10% of Tanzanian farmers [5]. The level of illiteracy is also high among farmers making it difficult to synthesize, adapt and adopt available information and technologies. Based on this background, there is a compelling need to have an in-depth assessment into what the current coffee farming conditions look like, how much yield gap exists and what are the management bets with low complexities for dissemination and adoption.

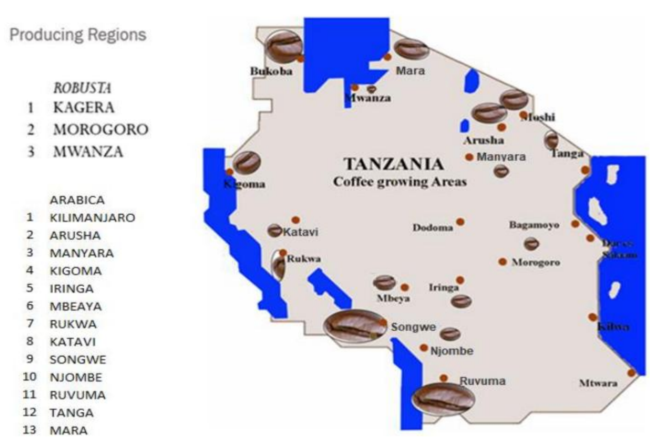

Fig. 1. Coffee producing areas in Tanzania. Source: Tanzania Coffee Business Directory

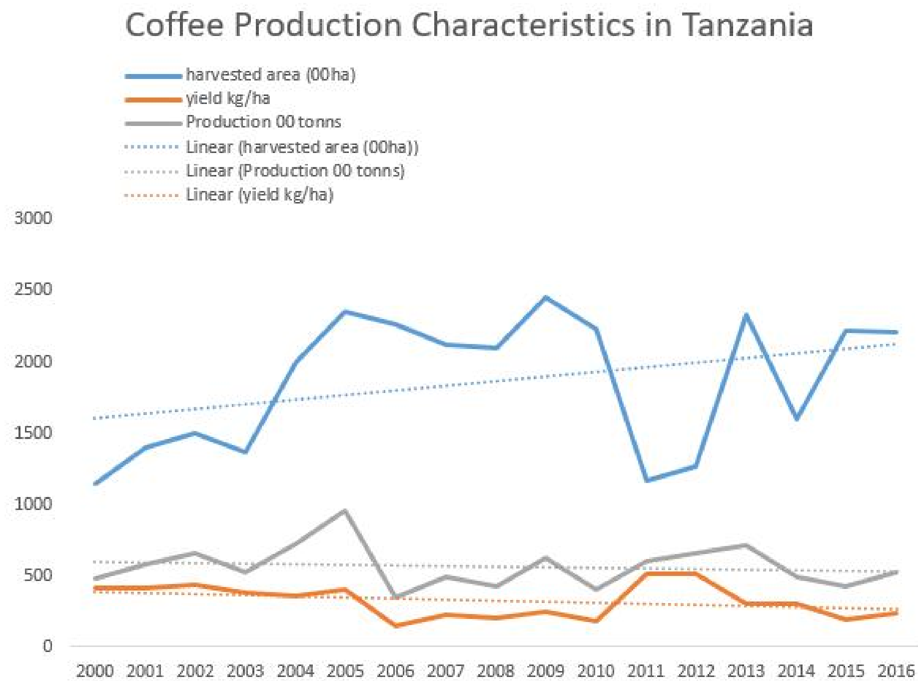

Fig. 2. Harvested area (hectares), production (tons) and productivity (t/ha) trends of coffee in Tanzania. Adapted from: FAOSTAT, 2018

1.1 Research Objectives

1.1.1 General objective

To understand the current status of coffee production and identify potential technologies and practices for enhancing crop productivity in Mbeya Region.

1.1.2 Specific objectives

(i) Assess the current coffee production situation among smallholder farmers.
(ii) Provide an in-depth assessment and understanding of key production constraints accounting for the current coffee yield gap.
(iii) Provide scalable science-based recommendations with high potential to increase coffee yields.

2. RESEARCH METHODS AND DATA SOURCING

2.1 Description of the Study Site

This research was carried out in Mbeya Region in Tanzania covering three wards; Iwindi, Msia, and Lwati. Mbeya is in South West Corner of the Southern Highlands of Tanzania and shares borders with Zambia and Malawi to the South, Rukwa Region to the West; Tabora and Singida Regions to the North; and Iringa Region to the East. The Region is located at Latitude 7.9875°S and longitude 33.4384°E; altitude range of 500-2,981 meters above sea level; annual rainfall ranges between 650 and 2,600 mm while temperature ranges from 16-25°C; and a range of soil types with volcanic origin [6,7,8,9]. Mbeya is among the leading Arabica coffee producing regions in the country. Farming is the main economic activity of the people and accounts for over 40% of the region's Gross Domestic Product (GDP) [10].

2.2 Primary Data Sourcing

The primary data was obtained through focus group discussions (FGD) held in the three wards. A total of 28 participants were involved: 9 from Msia village; 9 from Iwindi village; and 10 from Lwati village. The discussions were guided by a set of questions: (a) Causes of yield loss on the farm; (b) Perceived opportunities for yield increase; (c) Barriers of getting access to these opportunities; (d) Current input purchase (and use) behavior; and (e) Priority of coffee inputs if farmers were to be given access.

2.3 Secondary Data Sourcing

The secondary data used were sourced from various scientific publications from recognized and credible journals and research institutions. Other credible websites were also used. Important criteria such as: Coffee varieties and availability; Cropping systems (e.g. coffee spacing, mono-cropping, intercropping); Fertilizer use (e.g. rate, blend, timing and placement); Soil fertility management under coffee plantation (e.g. soil acidity, organic matter, erosion, soil structure); Coffee stress management (e.g. disease, pest, weeds, drought, flooding); and Post-Harvest (e.g. drying, storage, market access) were used. The sourced materials were then downloaded, read and cited as a best practice.

2.4 Data Analysis and Presentation

Both primary and secondary data were analyzed and validated against each other for better recommendations. Excel 2016 version was used for all the analysis and presentation of figures.

3. RESULTS AND DISCUSSION

3.1 Characteristics of Coffee Production in Mbeya Region

This research confirmed that Coffee is still the most important cash crops accounting for about 39% of land under permanent crops and cultivated by over 80% of farmers in Mbeya Region [11]. From the field visit, it was confirmed that most farmers grow mainly the Arabica variety. The crop is produced under intensive mixed cropping with maize, beans, and banana dominating the system [12]. Some farmers also practice coffee mono-cropping system, especially those who own large tracts of land. Land under cultivation varied with an average of 0.63 (that vary between 0 and 0.8 hectares) hectares dedicated for coffee production [13]. It was also confirmed that farmers had few but very old trees (averaging 22 years) with varying coffee tree numbers (389-1962 plants) in the western and southern parts [14]. The use of soil fertility inputs is not uniform, low and varying depending on the type (organic versus inorganic sources) across the region. A survey by Tanzania Coffee Research Institute reported that only 40% in the south and 2% in west coffee growing zones use inorganic fertilizer. According to our observation, no form of irrigation was reported to be used for coffee production within the surveyed villages. As a result, the yields were low (about 200-750 kg/ha) under small scale farms [15,16,17].

3.2 Current Production Challenges and Associated Yield Losses

From the research, coffee farmers in Mbeya were found to face myriad of production challenges that could be largely grouped as policy, climatic, edaphic and socio-economic related.

3.2.1 Low adoption of improved varieties and old coffee trees

The research showed that farmers depend on old trees for production. According to Hella et al. [18], coffee farmers across the country have trees that are up to 40 years old with slightly younger ones (about 22 years on average) found in the Southern and Western blocks. The old varieties like Bourbon (N.39) and Kents (KP 423) currently grown by the majority of farmers do not only represent the low yielding old types but also have lost the genetic potential to yield better and resist diseases, pests, and other climatic conditions [19]. According to the Tanzania Coffee Board [20], production using coffee trees that are older than 20 years is no longer profitable. Again, where farmers source their planting materials was highly questioned during this research. Hella and others again reported that only 1-15% of the coffee farmers were obtaining their seedlings from Research Stations, Estates, Cooperative Unions and Primary Societies. Other sources are highly questioned in terms of quality since no much control is being done. Production of old trees and low adoption of better varieties by farmers could be, in parts, due to low access. Again, poor extension service and lack of proper campaign to sensitize farmers on these new varieties seriously hinder production.

3.2.2 Poor coffee agronomy and ineffective agricultural extension services

From the conversations with farmers and visits to various fields, we noticed that most farmers include more than two intercrops with coffee - shade trees and crops like bananas, maize, and beans dominated the list. This observation is not unique as other researchers have also reported a similar situation [21]. Such intensive intercropping has been linked with increased disease attack, high nutrient mining and slow soil warming [22,23]. For instance, banana is considered an important host for coffee nematode (*Pratylenchus coffeae*) that significantly reduces coffee yields if left uncontrolled. Also, farmers have low plant densities. For instance, in the Southern and Western parts of the country, farmers are reported to have 389-1962 trees [24]. This is low compared to the recommended optimum range of 3000-4000 trees/ha [25]. All these inadequacies in coffee production could be attributed to the poor and ineffective agricultural extension services in the region. As reported by URoT [26], only about 41% of farming families in the Mbeya Region receive extension services. The larger population is left to learn on their own and apply ineffective practices that could be negatively impacting on coffee yields. It was also reported that most of the extension agents offering the services were not trained on Coffee production- some were trained to offer livestock services. This could be a justification as to why most farmers rated low the quality of extension services received in the region [27]. Issues around extension service are governance-related: Inadequate budget allocation to hire more extension officers and fuel cars for movement around during service delivery in the Region. Currently, the extension agent to farmer ratio is about 1:1800 [73].

3.2.3 Frequent drought and increasing temperatures that are unfavorable for coffee production

The declining rainfall amounts received and unpredictable rainfall patterns in Mbeya region and the country as a whole has greatly affected crop production. Farmers are experiencing low rainfall and sometimes droughts that occur during main seasons leading to premature fall of flowers and beans. When asked about the experience, all farmers mentioned drought as a key production challenge in the region (Fig. 3). This is majorly a climate change aspect which has caused shrinkage and redistribution of coffee zones towards the mountain tops [28]. Such low rainfalls are also accompanied by increasing temperatures of +0.30°C/decade within the producing areas in Tanzania [29]. According to Craparo and others, coffee yield loss of about 137 ± 16.87 kg/ha is expected per every 1°C rise in minimum temperature in Tanzania. Also, under low rainfall and high temperatures, soil moisture becomes inadequate to allow for proper uptake and utilization of nutrients resulting in high inefficiencies and low yields. Fig. 4 provides a summary of rainfall and temperature characteristics for the last 10 years in Mbeya Region.

3.2.4 Pest and disease attack

This research has revealed that stem borer (*Monochamus leuconotus*) and berry borer (*Hypothenemus hampei*), Green scale (*Coccus* spp), Antestia bugs (*Antestiopsis* spp) and Mealybug (*Planococcus kenyae*) are among the most important pests of coffee in the Region. These pests cause significant yield losses under heavy attack due to direct feeding on coffee stems, flowers, berry and apical parts and transmission of diseases. During this research, farmers could not quantify yield losses due to the identified pests. However, yield losses of up to 25% due to stem borer; and 50-100% due to Coffee berry borer [74,75]; and 15-27% due to Antenstia bugs [76] have been reported. We observed the attack and 93% of all farmers also reported these pests to be problematic in the region (Fig. 5).

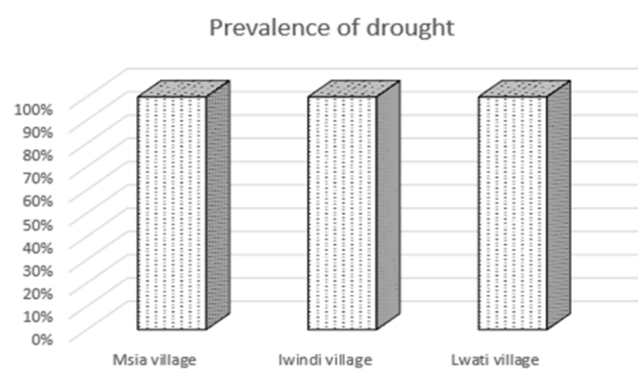

Fig. 3. Percentage of farmers who have reported drought as one of the main challenges to coffee production in Mbeya Region

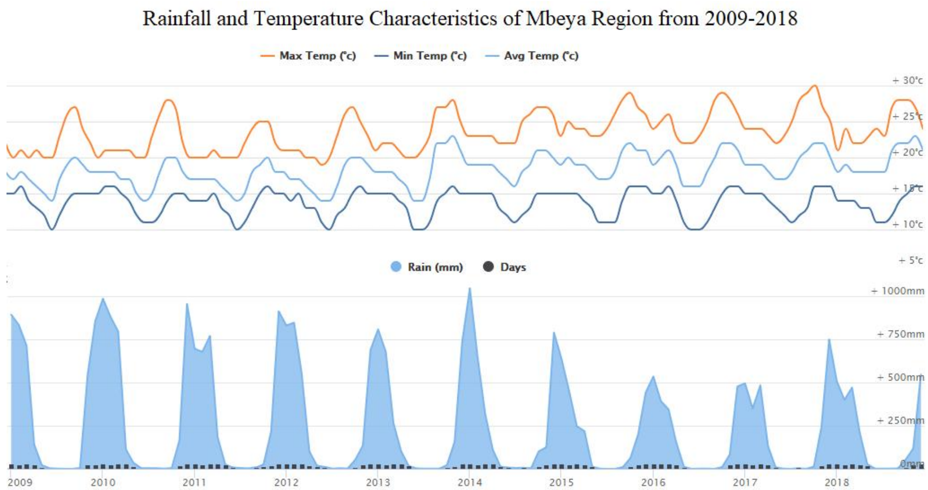

Fig. 4. Climatic characteristics of Mbeya Region: Rainfall (mm) and temperature (°C) from 2009 to 2018

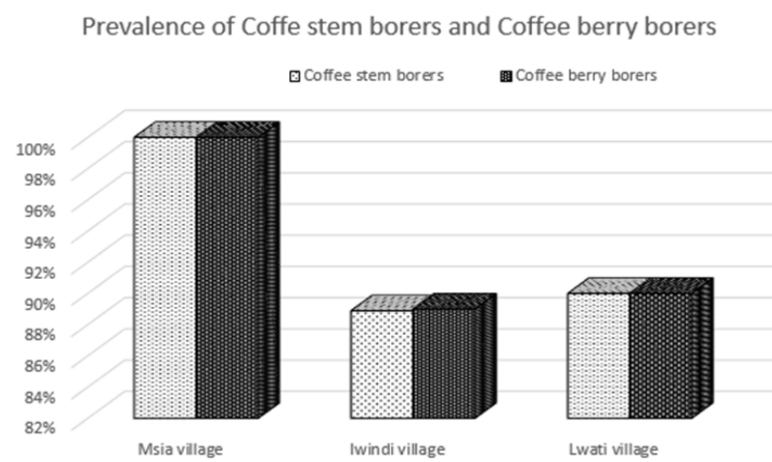

Fig. 5. Percentages of coffee farmers reporting the presence of coffee stem borer and Coffee berry borer pests on their farms in Mbeya Region

On the other hand, our research revealed high disease attacks. Out of the interviewed farmers, 86% and 100% reported serious yield losses due to Coffee leaf rust and coffee berry disease respectively (Fig. 6). Other diseases observed include *Fusarium* spp., bacterial blight, and red blister. These diseases cause considerable yield losses in lake zone, south highlands (Iringa, Mbeya, and Rukwa), Ruvuma region and northern zone [30,31]. Yield losses of 35% and 60% due to Coffee leaf rust and Coffeeberry diseases respectively have been reported [77,78]. Production of less tolerant coffee varieties could be one of the reasons behind the reported yield losses. Lack of credit access and poor coffee agronomic practices hinder proper management of these pests and diseases.

3.2.5 Soil infertility and low fertilizer use in the coffee zones

Serious depletion of soil nutrients and deficiencies has been reported in Mbeya Region: Nitrogen, Phosphorus, Calcium, and Zinc [32], calcium, Magnesium, and Potassium [33], Copper and zinc [34]. Deficiency of these important nutrients cannot allow for optimal production of coffee in the region. The soils are also acidic, pH <5.5 [35]. Such low pH conditions fix the already deficient nutrients in the form that is unavailable for plant use. The high cost of fertility inputs hinders farmers' capacity to apply the recommended amounts of fertilizer and soil amendments for better coffee yields. On average, farmers apply about 50 kg of fertilizer per hectare. When asked about fertilizer accessibility and use, all farmers reported that they either use low rates (averaging 1 bag per hectare) or apply nothing at all for coffee production since the available fertilizers are very expensive. Coffee trees extract a lot of nutrients. It has been reported that for every 1 ton of green coffee beans, the plants extract about 40 kg nitrogen, 2.2 kg phosphorus and 53 kg potassium [36,37]. These nutrients must be replaced yearly to guarantee better production.

3.2.6 Poverty and low access to agricultural credit

Farmers lack access to farm-based financial support to acquire already highly priced coffee inputs like fungicides, insecticides, and fertilizers. For instance, 97% of farmers in Kigoma mentioned high prices as a bottleneck to production [38]. Our research confirmed this as all of the farmers mentioned high fertilizer prices (currently at about Tshs. 65, 000 to Tshs. 90,000 per 50 kg bag) as a challenge to production (Fig. 7). This is probably due to low income and high poverty levels. Also, agricultural markets are dominated by a few private traders who are free to practice unfair competition thus burdening farmers with high prices.

3.2.7 Coffee market monopoly and low prices

This is government related issue. The coffee production is highly regulated by the national government who set the prices. The price set is sometimes influenced by the middlemen leading to low prices. Prices that are as low as 50-70% of the auction prices have been experienced [39]. When asked about market and price related challenges, 97% of farmers confirmed that price fluctuations and the monopoly of the market actually hinder coffee profitability (Fig. 8). This could disincentivize farmers to produce more of the crop. Lack of sufficient market information and knowledge is also one of the factors leading to this level of exploitation. The high cost of transportation due to bad roads and far situated collection and pulpery centers further increase production costs incurred by the farmers.

3.3 Available Technologies and Agronomic Practices for Improving Yields and Profitability of Coffee in Mbeya Region

To manage coffee production challenges, our research focused on available simple technologies with scientific backing that are recommended and adaptable for coffee production in Mbeya Region. High priority was given to preferences mentioned by farmers as their biggest perceived opportunities for yield increase. In the order of priority, farmers listed fertilizer followed by fungicides and pesticides and lastly good quality seedlings as their most important requirements that could ensure increased yields.

3.3.1 Adoption of improved coffee varieties

Adoption of improved varieties that are ag-zone specific, more tolerant to pests and diseases and

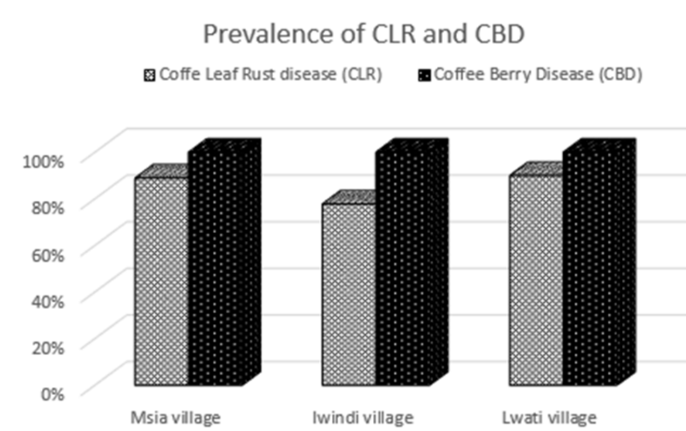

Fig. 6. Prevalence of coffee leaf rust and coffee berry diseases as reported by the sampled farmers in Mbeya Region

Fig. 7. Percentage number of farmers reporting low access and high prices on inputs as one of the main challenges affecting coffee production in Mbeya Region

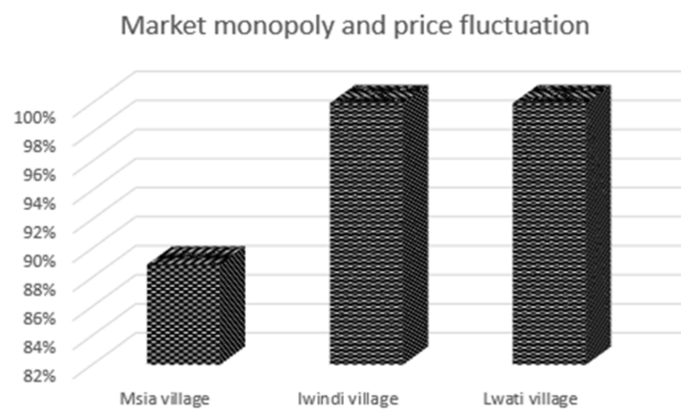

Fig. 8. Percentage of farmers who reported that market monopoly and price fluctuation are key factors affecting coffee production in the Mbeya Region

have higher yield potential compared to the current old types grown by farmers should be given priority. Production of improved coffee varieties would increase the profitability of the sub-sector. New varieties like Batian and Ruiru 11 that are fast maturing, high yielding, and tolerant to CBD, CLR and *Fusarium* spp. are available for adoption- more varieties have also been released [40,41]. The government should also invest in media campaign and organize region-wide coffee field days to sensitize farmers on the newly released coffee varieties and benefits of changing their current trees.

3.3.2 Adoption of best coffee agronomy, cropping system, and extension service delivery

Farmers should be sensitized to adopt economically viable coffee density- 2500 to 4000 trees per hectare as the optimum which can give a better return on investment. Optimum density could be achieved by planting trees at 1.5-3 m by 1-2 m pacing. It is important to consider soil fertility levels and rainfall received when deciding on plant density to use as they significantly influence the level of competition likely to occur. Better intercropping (with fewer crops) and proper spacing should be encouraged to reduce competition for growth resources like nutrients, light, space, and water. Use of trees with the capacity to fix nitrogen and produce large quantities of mulch (like Grevillea and Lucerne) as windbreaks should be encouraged to help improve soil fertility and soil organic matter. Farmers should be careful when intercropping coffee with fruits trees like mango, macadamia, and guava as they could reduce yields [42]. To avoid over shading and possible quality reduction in coffee, the shades need to be regulated after every 3 years [43]. Famers should work towards replanting their fields with younger coffee trees that have the potential to produce more - young coffee trees yield high and are profitable compared to those that are older >20 years [44]. Pruning is a very important practice for better coffee production. For even production and steady yield in the following seasons, it is recommended to prune coffee trees after every harvest; while for changing coffee cropping cycle, pruning should be done after every 6-7 years [45].

3.3.3 Improving soil water conservation and use efficiency

To respond to frequent droughts currently experienced, farmers should start by adopting drought-tolerant varieties like Ruiru 11. Multiplication and distribution of such varieties by various players like Research Stations, Estates, Cooperative Unions and Primary Societies could ensure availability for adoption. Farmers should also be encouraged to practice soil and water conservation measures: use of herbicides to control weeds instead of manual hand hoeing helps in minimizing soil disturbances and evapotranspiration [46]. The use of herbicides should be done appropriately and follow instructions provided on the label [73]. Use of plant residues e.g. maize stovers, banana stalks and leaves after harvesting and pruned coffee branches as mulches could help farmers conserve the already limited soil moisture [47,48]. During this practice, care must be taken to void using disease infested coffee branches for mulching- they should always be buried deep or thoroughly decomposed before using back in the farmer- to avoid reintroduction of the pathogens.

3.3.4 Improving soil fertility through increased fertilizer use and soil amendments

Solving soil infertility and low fertilizer use issues should be of high priority looking at the current level of nutrient depletion across the region. Even with the adoption of improved varieties, the inadequate supply of macronutrients and micronutrients would still limit yields. Farmers should, therefore, be encouraged to apply both organic and inorganic fertilizers: Use of organic sources such as manure and compost is important not only for releasing nutrients but also for the amelioration of soil acidity which is currently high. According to Otieno and others [49], SOM form complexes with Al and Fe ions thereby creating conditions that are better for root growth and nutrient absorption. Application of wide quantities of organic materials (0.5-10 t/ha) has been recommended across coffee producing regions depending on soil fertility status, availability of manure and their quality [50,51]. Coffee pulps should not be wasted as they contain nutrients that need to be recycled back to the farms- about 60 kg of coffee pulp is said to contain 1 kg N, 0.60 kg P and 0.9 kg K and other important trace elements [52]. Use of such materials (at 2.5-20 t/ha) as soil amendments has been shown to result in 15-33% coffee yield increase [53]. Nitrogen and potassium are the most extracted nutrients from the soil [54]. Other nutrients are also important and play various crucial roles in the growth and reproduction of coffee as described by YARA International [55]. Application of these fertilizers should be based on soil analysis and targeted yields. The 4R Nutrient Stewardship principles- the right source, rate, time and method- as described by the International Plant Nutrition Institute (IPNI) provides guidance and should be considered for high nutrient use efficiency [56]. According to Hamadi [57], young coffee trees less than 5 months should be supplied with 3.26 g of Urea, 0.75 g of Triple Superphosphate and 1.5 g of Muriate of potash fertilizers per tree from the start, mid and end of the rainy season for fast generation of vegetative cover and root establishment. WASI/MARD [58] recommended that about 280 kg N, 100 kg P_2O_5 and 300 kg K_2O per hectare per year be applied to mature and producing trees (above 4 years) to realize 3.5-4 tons of green berry per hectare. For increased nutrient efficiency in fertilizer use, about 2-3 t/ha of lime should be supplied to raise the low soil pH currently experienced in Mbeya region- the rates should be site specific to avoid detrimental effects over-liming.

3.3.5 Coffee pest and disease management

To manage pests and diseases, better practices should be adopted as early as possible- from proper land preparation and selection of tolerant varieties to direct management of pathogens and pests in the field. During production, scouting and monitoring for pests and diseases should be done regularly to enable early detection and control. Cultural practices such as field sanitation, intercropping with legumes (e.g. beans, cowpea) and insect repellents (e.g. N. *tabacum*, L. *camara*, and C. *officinalis*), proper and timely pruning of infested branches and weeding also help in controlling these pests and diseases [59].

Controlling stem and berry borers: The bored stems could be sealed with paints or sprayed with kerosene to kill borers inside. Parasitoids like *Heterospilus coffeicola* and *Prorops nasuta* provide natural control to the borers [60,61]. Chemical control method has never been reliable due to cryptic nature of the insect (i.e. protected inside the coffee berry), and the availability of coffee berries in the field allowing the survival of the pest from one generation to the next [62]. Several chemicals (including chlorantraniliprole and thiamethoxam) have been recommended for control of borers in coffee [63,64]. The use of any of these chemicals should be done cautiously and as guided by Otieno [73].

Green scale, Antesia bug, and Mealy bug insects could be controlled naturally through conserving their natural enemies like ladybirds, Tachinid flies, and parasitic wasps [65]. To help this, farmers need to plant more nectar-producing plants as live fences to attract these enemies; and avoid application of broad-spectrum insecticides that would wipe out all insects. Use of neem extract has been found effective on these pests [66].

Just like pests, control of diseases requires better field management – weed-free fields, proper and timely pruning of suckers and diseased branches. Adoption of disease-tolerant varieties would always provide the most economical strategy. A number of new varieties such as Ruiru 11, Batian, SC 3, SC 9, SC 11, SC 14 have been reported to be tolerant to most of these common diseases like CBD and CLR [67]. Use of chemicals like chlorothalonil, cyproconazole, flutriafol and cuprous oxide to control CBD, CLR and BBC and other common fungal diseases during coffee growth stages is appropriate [68,69].

3.3.6 Increased access to finance and coffee inputs

In order to effectively adopt best coffee agronomy, inputs and training must be availed to farmers. Provision of these coffee inputs could be done by microfinance institutions, agro-dealers, and the government. For instance, One Acre Fund has been successful in providing access to inputs at affordable prices across various countries in Africa [70]. Government subsidy programs could also increase access to key inputs. Formation of farmer groups is also a strategy that could help farmers access large markets and inputs from service providers [71].

3.3.7 Improved access to market information

There are various organizations buying and marketing coffee in the region- Tembo is one of the popular companies trading in coffee in the region [72]. Together with government involvement, such companies could teach farmers how to increase coffee quality (better harvesting, drying, and storage methods) for better pricing. By government setting and enacting laws on better coffee bean pricing and quality control, other non-governmental and private players are likely to comply thereby solving this challenge. Such set policies could as well work towards reducing the heavy involvement of middlemen in the industry. Organization of farmers into groups and cooperatives could ease the delivery of inputs and services like coffee quality and market information training. Through NGO, Government and private sectors partnerships, farmers could access better market prices and training.

4. CONCLUSION AND RECOMMENDATIONS

From the research, inadequate access to improved variety seedlings, poor coffee agronomy and low access to extension services, soil infertility, expensive fertilizer and other inputs, the prevalence of pests and diseases, low access to financial services and poor coffee prices are the main challenges facing coffee production in Mbeya Region. To mitigate the effect of most of these constraints, farmers need to be trained on best coffee agronomy and efficient usage of inputs. Provision of financial support was also found to be important.

To help improve coffee yields, the following support is required;

> Training on best coffee agronomy (most important soil water conservation measures, proper and timely weed control, and pruning) and proper use of farm inputs.

Increased access to farm inputs either on credit or subsidy;

a) Fertilizers- NPK blends with high N and K and urea for topdressing. The application rates of these nutrients should be based on soil analysis results.
b) Pesticides- mainly for coffee berry and stem borers.
c) Fungicides- mainly for coffee berry disease and coffee leaf rust.

Further research to establish the relationship between coffee yield loss (as may have been caused by nematode) and banana (as a potential host for these nematodes) should be prioritized for a better intercropping recommendation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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