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Banana and Plantain Value Chain: West Africa
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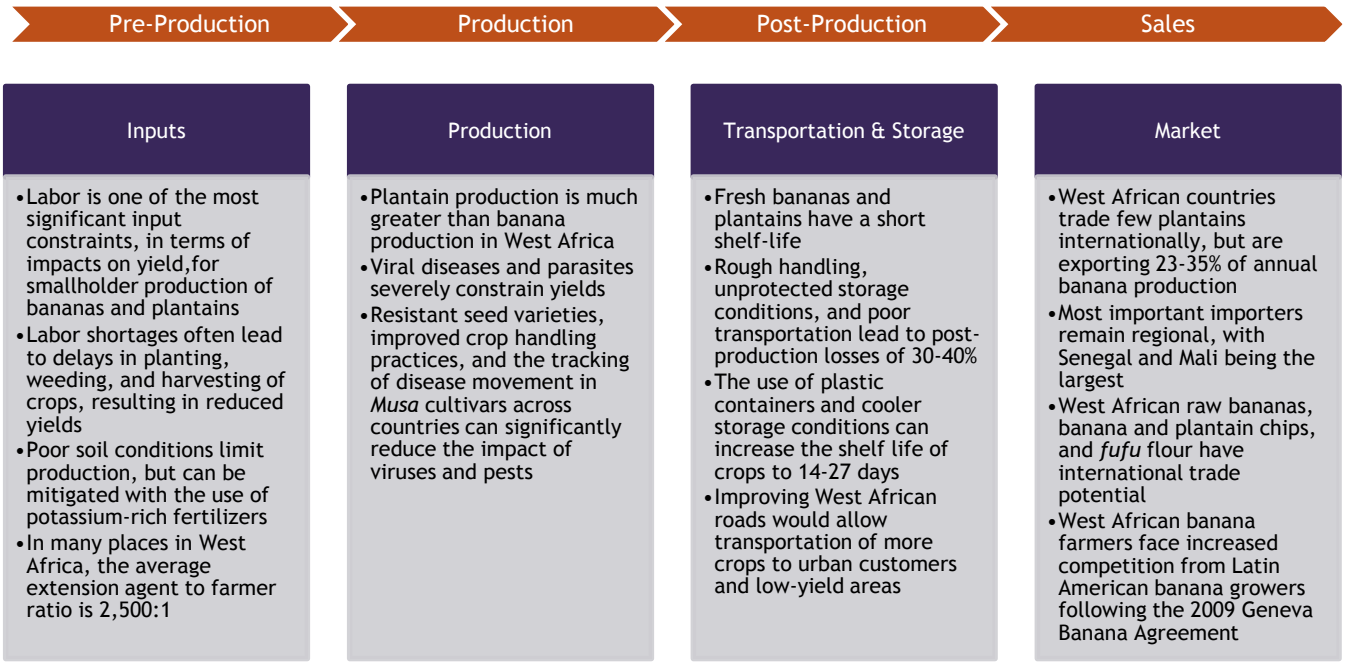
West Africa is one of the major plantain-producing regions of the world, accounting for approximately 32% of worldwide production. Plantains are an important staple crop in the region with a high nutritional content, variety of preparation methods, and a production cycle that is less labor-intensive than many other crops. In addition to plantains, bananas are also grown in West Africa, but they account for only 2.3% of worldwide production. Bananas are more likely than plantains to be grown for export rather than local consumption. Major constraints to banana and plantain production include pests and disease, short shelf life, and damage during transportation.

This research brief provides an overview of the banana and plantain value chains in West Africa. Because of the greater production and consumption of plantains than bananas in the region, the brief focuses on plantains and concentrates on the major plantain-producing countries of Ghana, Cameroon, and Nigeria. The brief is divided into the following sections: Key Statistics (trends in banana and plantain production, consumption, and trade since 1990), Production, Post-Harvest Practices and Challenges, Marketing Systems, and Importance (including household consumption and nutrition).

West Africa Banana and Plantain Value Chain Highlights

The figure below summarizes key findings along the different stages of the banana and plantain value chains in West Africa.



Note on Data and Terminology:

The distinction between bananas and plantains is a source of some confusion, both in agricultural research and in the popular imagination. All bananas and plantains belong to the same genus, *Musa*, which contains 30-40 species (Stover & Simmonds, 1987). The FAO and the International Institute of Tropical Agriculture (IITA), among other research centers, use the word "banana" to refer to *Musa* species that are sweeter and eaten raw and "plantain" to denote *Musa* species that are starchier and cooked before eating, while many researchers use "banana" to mean all *Musa* varieties, including plantains (Robinson & Sauco, 2010). This brief will follow the convention of the FAO and refer to bananas and plantains separately.

This brief focuses mainly on plantains, which have much higher production and greater nutritional importance in West Africa than bananas. Because of the difficulty of clearly distinguishing between "bananas" and "plantains," there may be discrepancies in banana and plantain statistics among countries and data sources. FAOSTAT keeps separate statistics for bananas and plantains, defining bananas as "normally eaten raw" and plantains as "generally known as a cooking banana," with example varieties of each (e.g., *Musa sapientum* for bananas, *Musa paradisiaca* for plantains). It is unclear how consistently individual countries differentiate the two groups. For instance, FAOSTAT lists no banana statistics for Nigeria, but reports that Nigeria has the sixth-highest plantain production in the world. Along with FAOSTAT, the CountrySTAT websites of Nigeria, Ghana, and Côte d'Ivoire were also checked, and in each case the data were either consistent with FAOSTAT data or not available.

A widely used classification system for bananas and plantains was developed by Simmonds and Shepherd (1955), which uses letters to represent the genetic contribution of the wild ancestral banana species *Musa acuminata* (A) and *Musa balbisiana* (B). In this system, bananas and plantains are classified into genome groups such as AA (i.e., diploid, or two sets of chromosomes, inherited from a *Musa acuminate* subspecies) and AAB (i.e., triploid, or three sets of chromosomes, inherited from both ancestral species). Plantains generally belong to the AAB group (Robinson & Sauco, 2010). When available, this brief will mention the genome groups of the bananas and plantains discussed in the literature.

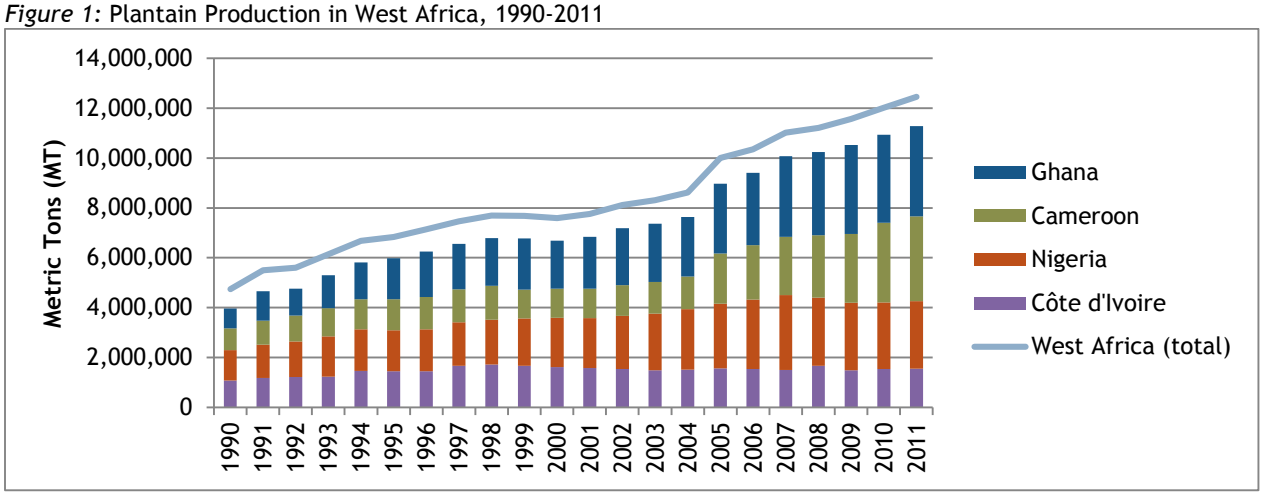
Key Statistics about Bananas and Plantains in West Africa

Production

According to FAOSTAT, plantain production in West Africa is considerably higher than banana production.[1] In 2011, 12.46 million metric tons (MT) of plantains were produced, representing 32.0% of worldwide production, compared to 2.47 million MT of bananas, representing only 2.3% of worldwide production. *Figure 1* and *Figure 2* include the highest-producing individual countries in the region along with production for West Africa as a whole. Countries are ordered on the figures from highest to lowest production in 2011. Worldwide, seven of the top ten plantain-producing countries are in Sub-Saharan Africa, including the West African countries of Ghana, Cameroon, Nigeria, and Côte d'Ivoire. The highest banana producer in West Africa, Cameroon, ranks seventeenth worldwide and fourth in Sub-Saharan Africa, far ahead of the other West African countries.

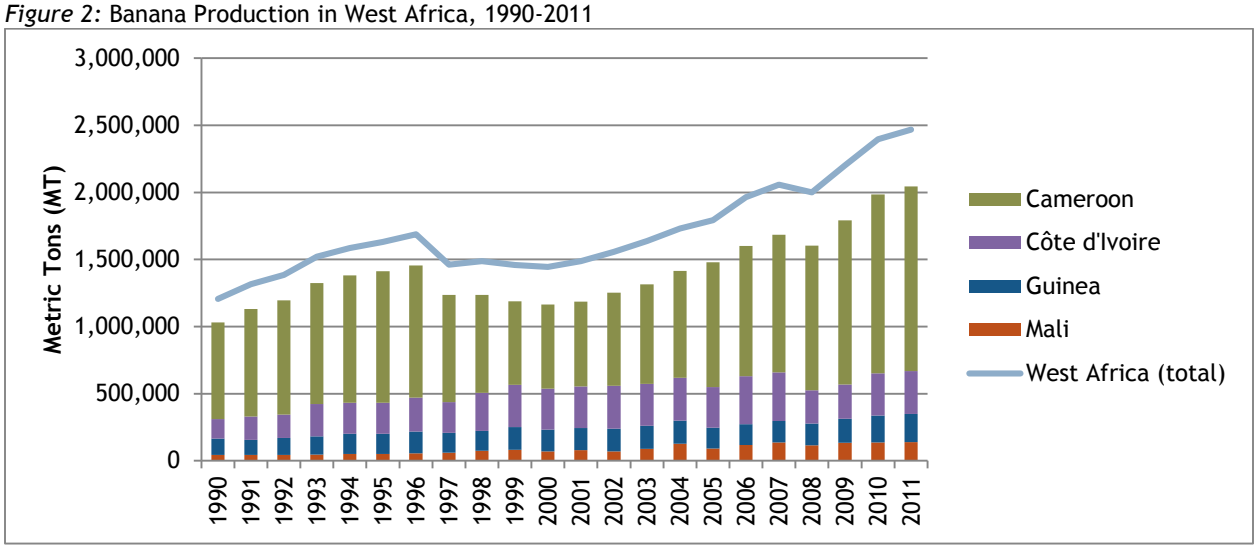
[1] The FAOSTAT definition of "West Africa" does not extend further east than Nigeria, but the regional banana and plantain-producing belt continues into Cameroon, and to a lesser extent Equatorial Guinea, Gabon, and the Republic of the Congo (Congo-Brazzaville). For the purposes of this brief, "West Africa" includes those four countries in addition to the FAOSTAT definition (which stretches from Nigeria to Senegal, including Mauritania, Mali, Niger, and Burkina Faso). All FAOSTAT figures for "West Africa" include the four additional countries.

Figure 1: Plantain Production in West Africa, 1990-2011



Source: FAOSTAT

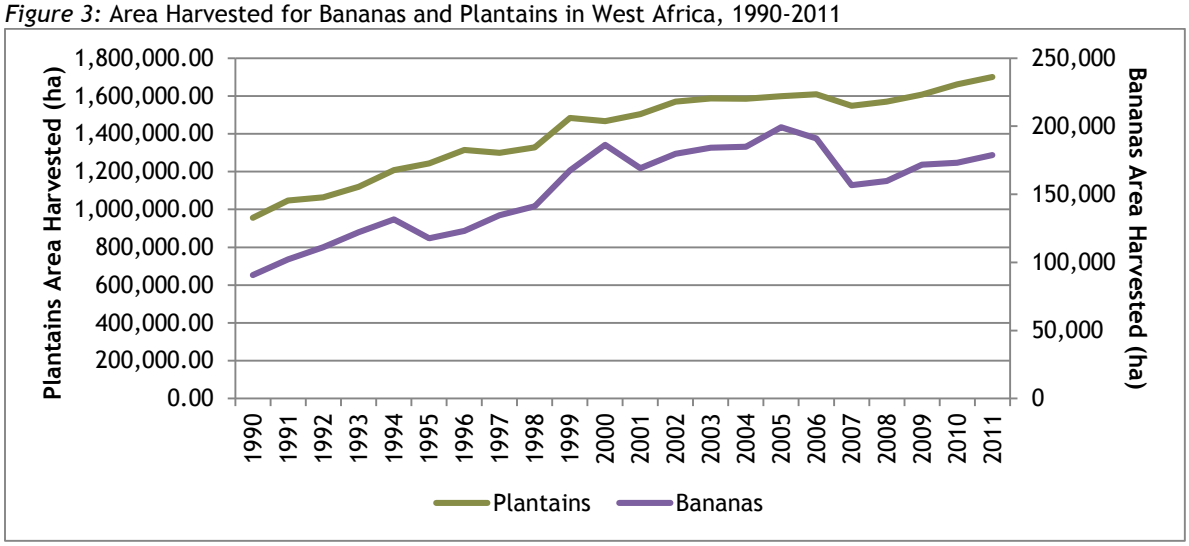
Figure 2: Banana Production in West Africa, 1990-2011



Source: FAOSTAT

The area harvested of plantains in West Africa increased fairly steadily and nearly doubled between 1990 and 2011, from approximately 955,000 hectares (ha) to 1,700,000 ha. The area harvested of bananas, while increasing overall from approximately 91,000 ha in 1990 to 199,000 ha in 2005, actually fell to 157,000 ha in 2007 and has been slowly increasing since (see *Figure 3*; note the different scales for bananas and plantains).

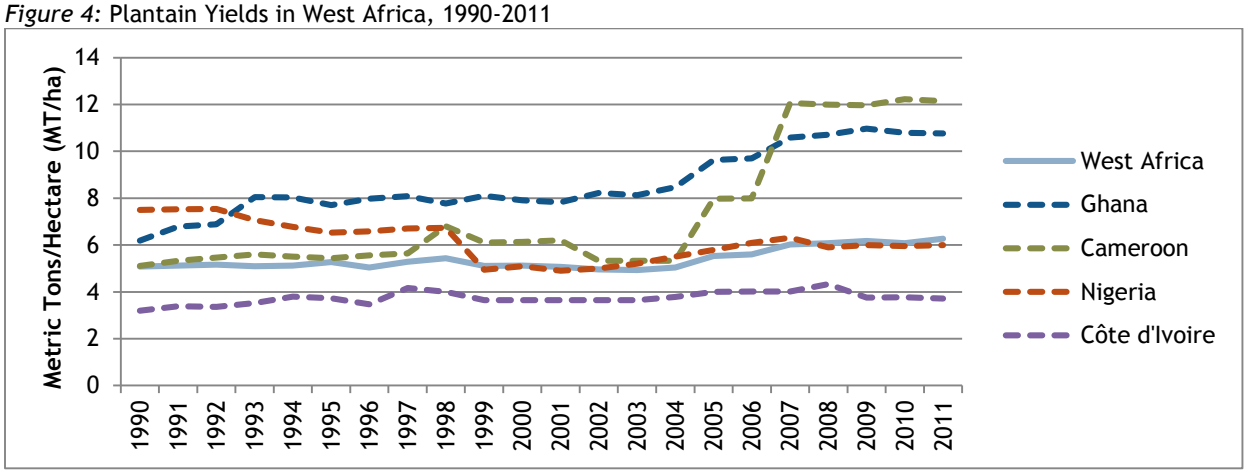
Figure 3: Area Harvested for Bananas and Plantains in West Africa, 1990-2011



Source: FAOSTAT

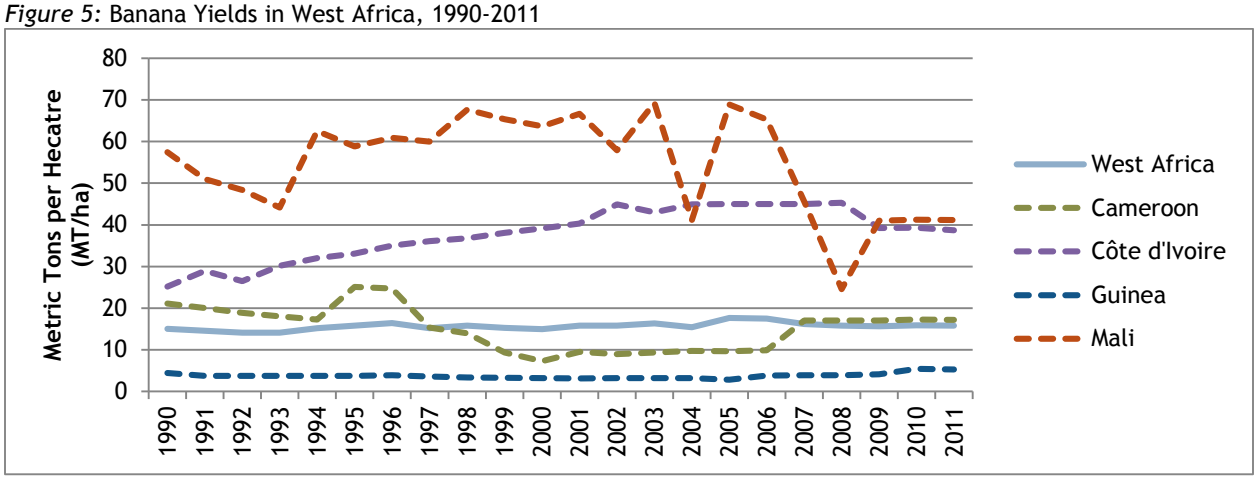
Yields for plantains in West Africa have increased slightly since 2004 overall, with large increases in Ghana and especially Cameroon (see *Figure 4*). Yields for bananas vary widely. While the average yield for bananas in West Africa as a whole was 15.8 MT/ha in 2011, Mali and Côte d'Ivoire both reported significantly higher yields, averaging around 40 MT/ha (see *Figure 5*). Neither the available data nor the literature provide an explanation for the high yields in Mali and Côte d'Ivoire or the increasing yields in Ghana and Cameroon.

Figure 4: Plantain Yields in West Africa, 1990-2011



Source: FAOSTAT

Figure 5: Banana Yields in West Africa, 1990-2011

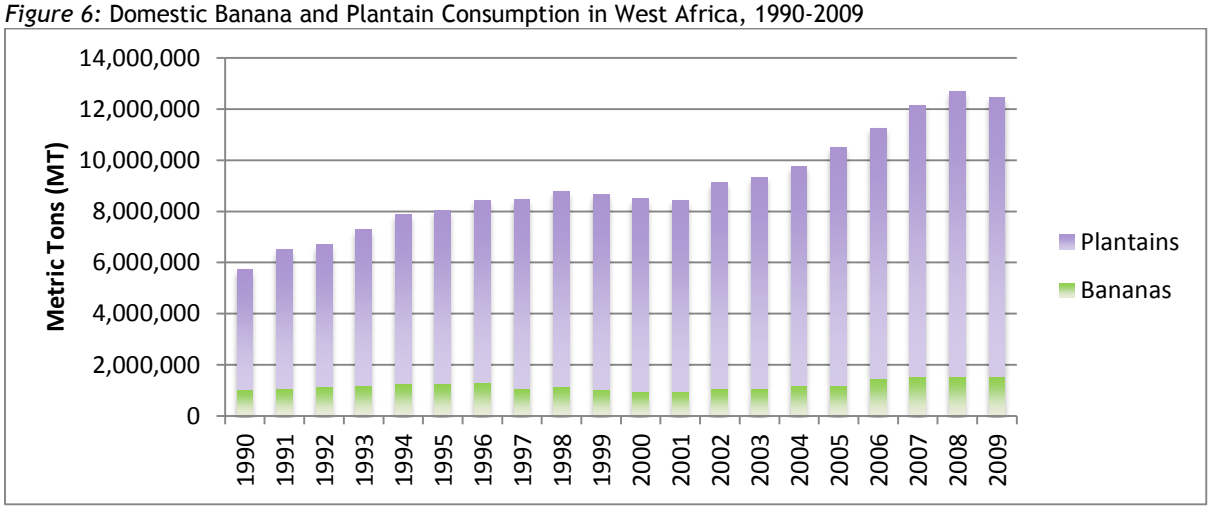


Source: FAOSTAT

Consumption

Consumption of bananas and plantains in West Africa has risen steadily in recent decades, from 5.7 million MT in 1990 to 12.5 million MT in 2009 (see *Figure 6*). According to FAOSTAT figures, anywhere from 86 to 91% of that amount is consumed in the domestic food supply, with the remainder either used for processing or wasted during production, storage, or transportation.

Figure 6: Domestic Banana and Plantain Consumption in West Africa, 1990-2009



Source: FAOSTAT

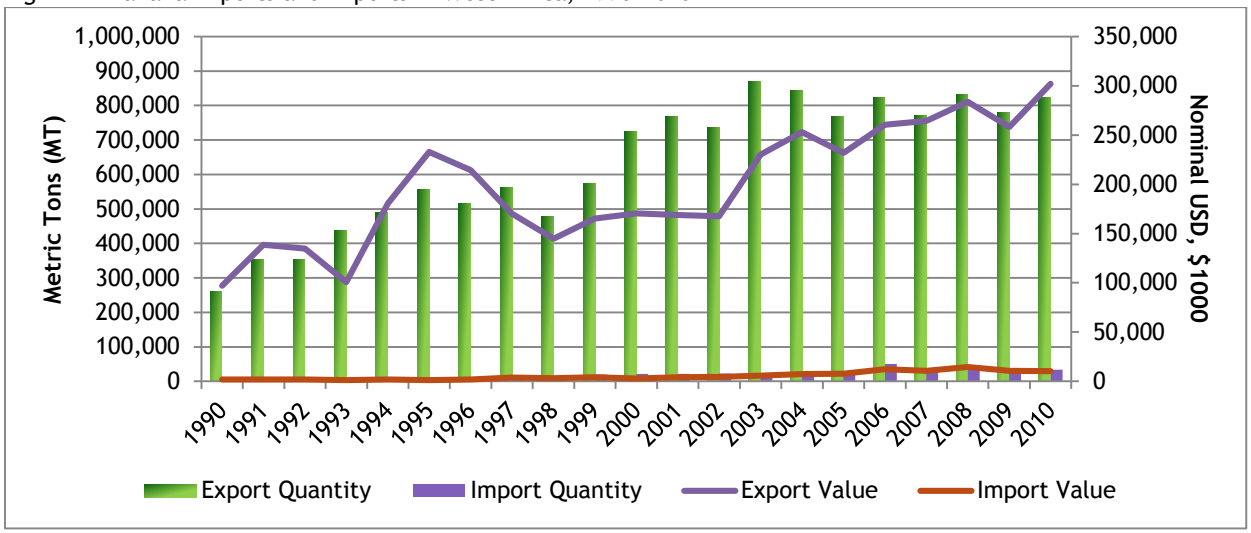
Trade

Although plantain production in West Africa is much higher than banana production, only bananas are a significant source of imports and exports, according to the FAO data. The percentage of bananas grown in West Africa that are exported increased from 22% in 1990 to 53% in 2003, but this figure has since steadily declined to 34% in 2010 (FAOSTAT). FAOSTAT data do not specify which countries or regions the bananas were exported to. See *Figure 7* for the quantity and value (amount paid by the importing country) of banana imports and exports. Plantains were

not included in the graph due to their low import and export numbers.[2] Banana exports are primarily from Côte d'Ivoire (335,593 MT in 2010), Cameroon (237,942 MT in 2010), and Ghana (11,030 MT in 2010).

Worldwide, the primary import markets for bananas are North America, Europe, and Japan (Arias, 2003). Several West African countries import bananas on a small scale. In 2010, the top importers in West Africa were Senegal with 16,450 MT, Mali with 7,939 MT, and Liberia with 3,929 MT. It is likely that the import numbers reflect regional trade within West Africa, but the FAOSTAT data did not specify whether that is the case.

Figure 7: Banana Imports and Exports in West Africa, 1990-2010



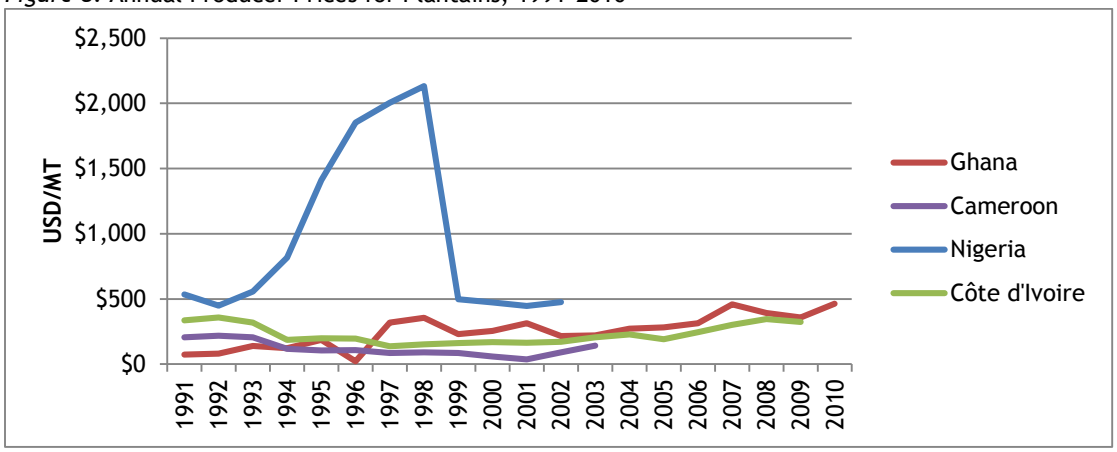
Source: FAOSTAT

Prices

Annual prices for the top plantain-producing countries in West Africa are shown in *Figure 8*. The sudden rise in plantain prices in Nigeria during the 1990s is consistent with the rise in price in other agricultural commodities and with a large rise in inflation during this time in Nigeria (FAOSTAT; IMF). This inflation in Nigeria was largely caused by expansionary fiscal policy in the country at the time (Moser, 1995).

[2] FAOSTAT records between zero and 5,000 MT of plantain exports for West Africa most years, and even fewer imports. However, the year 2001 records over 255,000 MT of plantain exports. It is unclear from the data why only one year contains significant plantain exports.

Figure 8: Annual Producer Prices for Plantains, 1991-2010[3]



Source: FAOSTAT

Overview of Banana and Plantain Production in West Africa

Propagation and Production Cycle

Bananas and plantains are planted at the onset of the rainy season, which coincides with the planting period of several other crops (rice, cassava, maize, etc.) in most of West Africa. Fruits are produced year-round in a variety of environments, yet the major harvest comes in the dry season (November to February) when most other starchy staples are unavailable or difficult to harvest, thus playing a key role in providing food security in food-scare months (Chandler, 1995 in Sharrock & Frison, 1998; Akinyemi et al., 2010). Labor shortages, often caused by concurrent planting and harvesting with other crops, make cultivation of large farms especially difficult, resulting in delayed planting, weeding, and harvesting and reduced yields (Akinyemi et al., 2010). Despite potential constraints posed by labor, plantain cultivation is attractive to farmers due to relatively lower labor requirements for production compared to cassava, maize, rice and yam (Marriott and Lancaster, 1983 in Kayode et al., 2013; Chandler, 1995 in Sharrock & Frison, 1998).

In banana and plantain, fruits develop on a single "spike" or raceme, arranged on the central stalk of the spike in 5-20 clusters or "hands" with each hand containing up to 20 fruits or "fingers" (Davey et al., 2007). Bananas and plantains follow similar growth patterns, requiring about two and a half to four months after shooting before the fruit becomes ready for harvesting, or a total of approximately eight to twelve months after planting. At maturity, the fruit maintains a constant weight for two to four days, then the weight starts to decrease with changes in the peel color from green to yellow and then to black. The maturity of the fruit may be determined by the weight of the pulp to peel ratio, brittleness of floral ends and disappearance of angularity of the fingers (Dzomeku et al., 2011, pg. 93).

Smallholder banana and plantain cultivation is carried out using a variety of techniques, including several intercropping methods. Intercropping is a preferred production method in West Africa due to the potential for improved profit margins from the cultivation of multiple crops (Fonsah and Chidebelu, 2011). From the literature, it is unclear whether intercropping also addresses production constraints caused by labor shortages. Banana and plantain also play a secondary role as a ground shade and nurse crop for other food crop species (Bayeri et al., 2004; Akinyemi et al., 2010; Tijani et al., 2009). Various cultivation methods include:

1. **The Banana or Plantain/Cocoa Intercrop:** In this system, plantain is planted alongside cocoa (*Theobroma cacao*), where it serves as a nurse crop during the early stages of development. This is common in the Western states of Nigeria and in the Ikom area of Cross River state, where cocoa is an important cash crop. In most instances, plantain production increases with expansion of the cocoa plantation. This system is expected to expand with a recent cocoa rehabilitation program being embarked on by the government (Bayeri et al., 2004; Akinyemi et al., 2010, p. 212). Banana/Cocoa intercropping is one of the most common banana cultivation methods in

[3] Producer prices for Ghana and Cameroon from the past decade were not found through FAOSTAT, CountrySTAT, or relevant government websites. No data were available to explain the rise in prices in Ghana and Côte d'Ivoire. Producer prices do not appear to be adjusted for inflation, but the FAOSTAT metadata did not confirm whether this is the case.

West Africa, and is frequently utilized in non-plantation farming in Cameroon and other countries in the region.

2. **The Bush Banana or Plantain**: This is a complex mixture in which bananas or plantains are intercropped with many field crops such as cassava, egusi melon (*Citrullus spp*), cocoyam (*Colocasia esculentus*), coconuts, rice, cereals, sorghum, sugar cane, maize, and taro. It is common in the more humid area of West Africa's rainforest belt (Akinyemi and Tijani Eniola, 2000; Akinyemi et al., 2010; Aiyelaagbe et al., 2001; Fonsah and Chidebelu, 2011).

3. **The Taungya Farming System**: Plantains and bananas are grown with forestry species. Here the *Musa* spp. serve as a means of taking care of the trees and secondly as well as a means of income before the maturity of the trees. The crops are phased out once the trees are established. This is commonly practiced in Ogun, Ondo and Edo states in Nigeria. The prevalence of this system in the last twenty years has been low, but it accounts for about 10% of total banana and plantain production in Nigeria (Wilson, 1986; Akinyemi et al., 2010, p. 212).

4. **The Compound Production System**: Bananas and plantains are grown in various convenient points around a compound or homestead. Plant and yield sizes depend on how much space is available in the compound and the need of the household for numerous other possible compound tree crops. Bunch yield is usually high in this system and could be attributed to the application of organic matter from household wastes (Robinson, 1996; Bayeri et al., 2004). This system is more predominant in the Southeastern part of Nigeria, where most compounds are within land limited areas owing to high population pressure. This system accounts for 15–25% of total plantain production in Nigeria (Eboh and Lamechi, 1994; Akinyemi et al., 2010, pg. 212), and in the case of both bananas and plantains, this method is typically used for local consumption (Fonsah and Chidebelu, 2011).

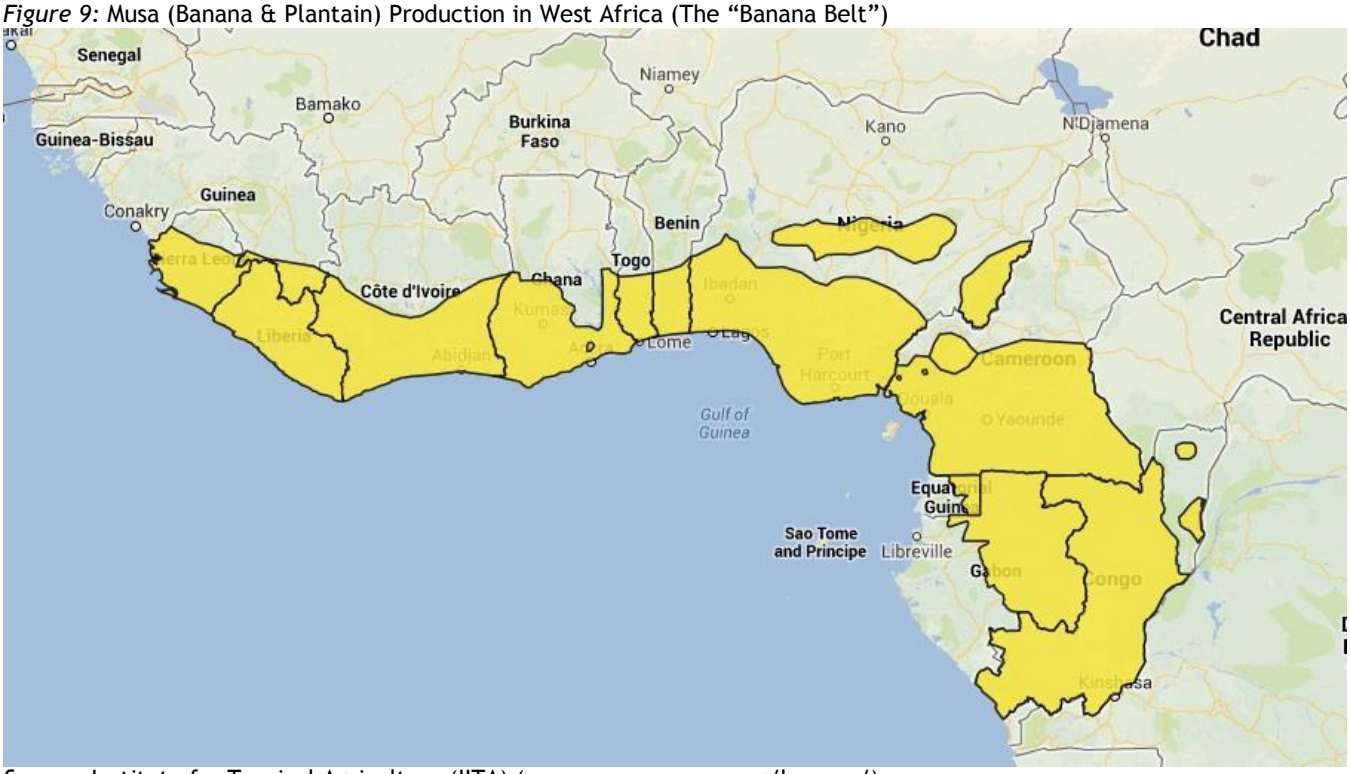
5. **Plantation Farming and Contract Farming Methods**: In Cameroon, bananas are primarily produced in plantation systems, or by smallholders contracted by larger firms who are then given access to the firm's packaging and transportation systems (Fonsah and Chidebelu, 2011). In Cameroon, plantation farming is typically a mono-cropping system. Principal producers in this system are multi-national corporations (MNCs), government-owned firms, and both foreign and domestic private firms (Fonsah and Chidebelu, 2011). Some of Cameroon's largest banana producing firms are those owned and heavily subsidized by the Cameroon government (Fonsah and Chidebelu, 2011).

Harvesting periods are largely influenced by external factors such as strong winds and rainfall. These production movements in turn cause upward and downward price trends according to supply and demand volumes. During April and May the plants become dehydrated as a result of the five-month dry season, leading to reduced yields. Plantains are scarce on the market from May to August due to strong winds experienced during the initial months of the rainy season, which can cause significant damage plantain and banana crops and significantly reduce yields. Plantains become abundant on the market from September to March with a peak in December or January (Dzomeku et al., 2011, pg. 269).

Areas Grown

Banana and plantain cultivars are grown in largely separate ecological regions in Sub-Saharan Africa. The AAB plantains are predominantly cultivated in the humid lowlands of West and Central Africa, while AAA cooking and beer bananas are the prevailing *Musa* cultivars in the East African highlands (Swennen and Vuylsteke 1991). Although the crop originally came to Africa from Asia (Simmonds 1966), the wide array of cultivar variability found in Africa suggests a long and intense history of cultivation (De Langhe 1961, 1964; Swennen et al., 1995). The humid forest zone of West and Central Africa (see *Figure 9*) is a secondary center of plantain diversification, while the East African highlands are a secondary center of diversity for bananas of the *Musa* AAA group (Swennen et al., 1995).

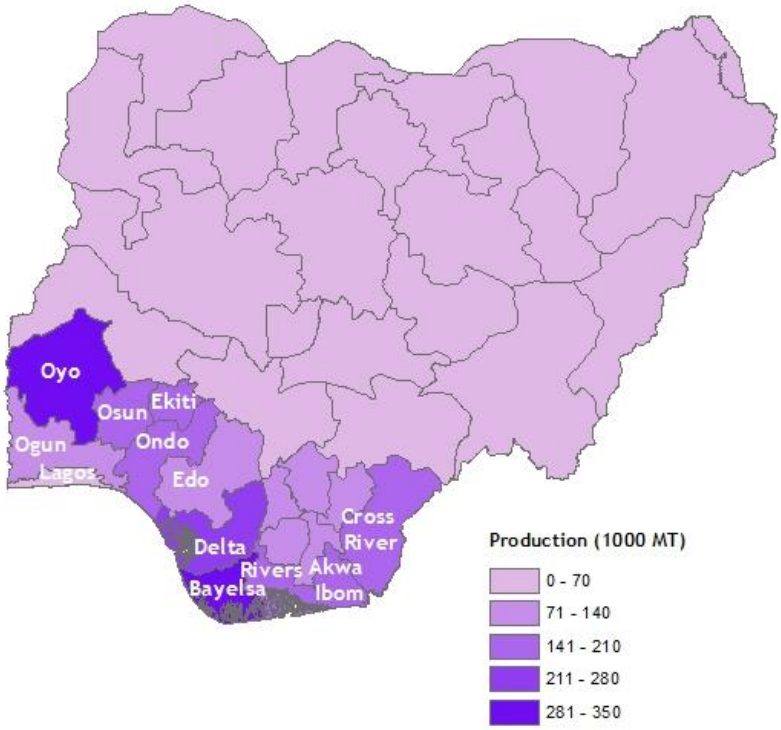
Figure 9: Musa (Banana & Plantain) Production in West Africa (The "Banana Belt")



Source: Institute for Tropical Agriculture (IITA) (www.crop-mapper.org/banana/)

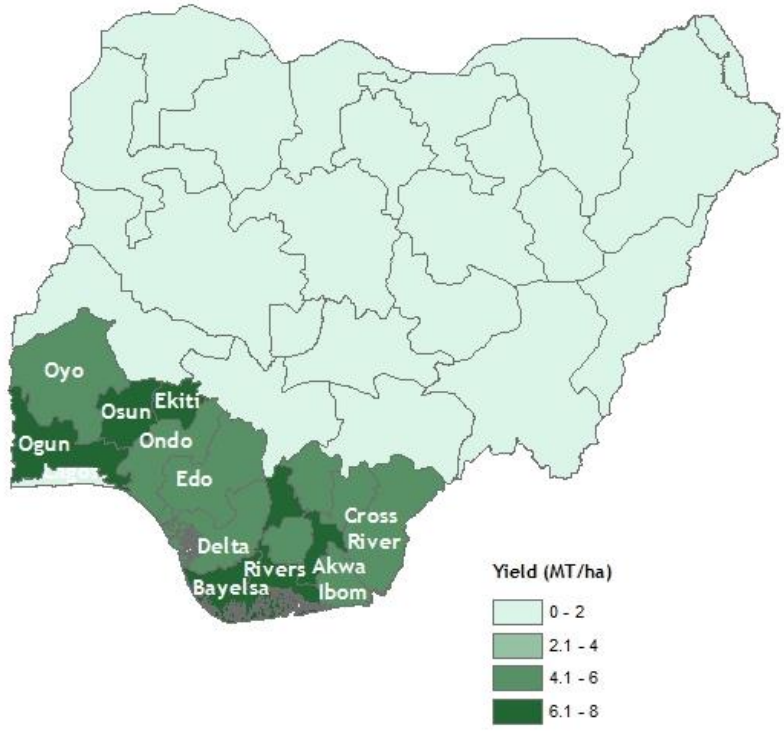
In Nigeria, plantain and banana production is concentrated in the nation's southern regions, which contain fertile forest and laterite soils conducive to plantain and banana growth (see *Figure 10* and *Figure 11*). The highest production levels are in the states of Akwa-Ibom, Anambra, Benue, Cross River, Akwa-Ibom, Imo, Kwara, Enugu, Plateau, Kogi, Rivers, Edo, Delta, Lagos, Ogun, Osun and Oyo (Ekunwe & Ajayi, 2010; Akinyemi et al., 2010). Annual rainfall in these areas is usually above 1,000 mm per year (Akinyemi et al., 2010, p.212). Regional plantain or banana production statistics for Nigeria were not available at the time of writing.

Figure 10: Plantain Production in Nigeria by Region, 2011



Source: Nigeria National Bureau of Statistics

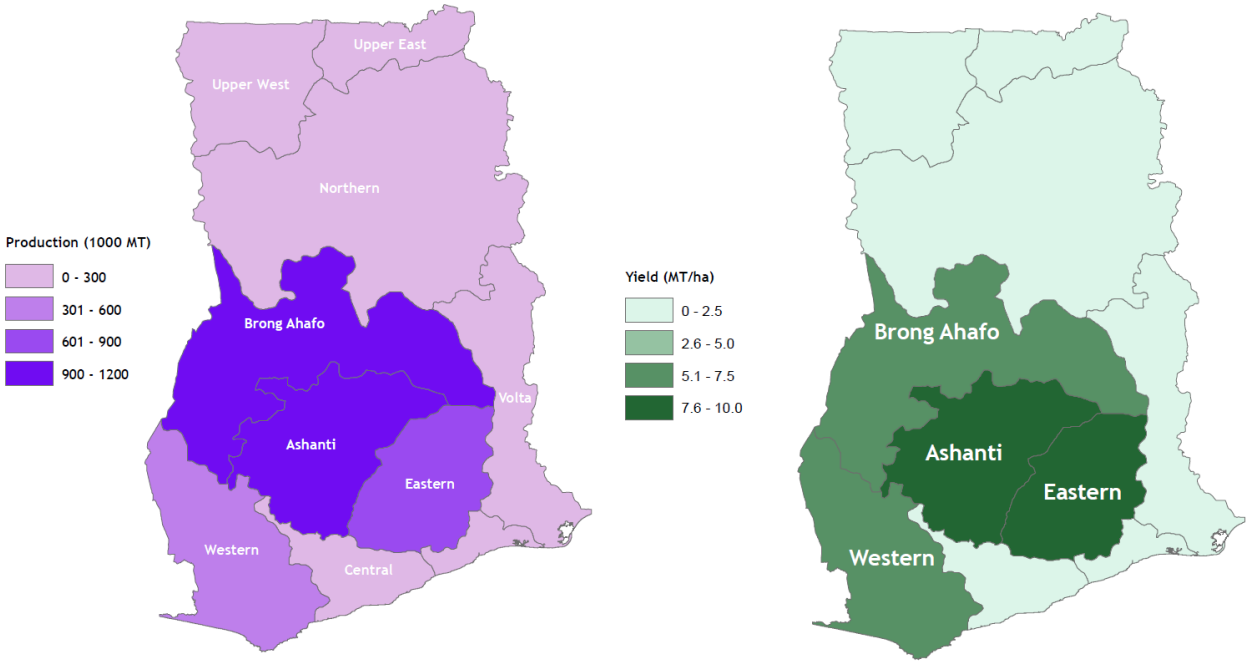
Figure 11: Plantain Yield in Nigeria by Region, 2011



Source: Nigeria National Bureau of Statistics

In Ghana, production and area planted with plantain have generally risen since 2000, with the Eastern Region enjoying the largest area volume of production since 1996 (Dzomeku et al. 2011). High production areas are also seen in the Ashanti, Western, Brong Ahafo, Central and the Volta regions, in that order. See *Figure 12* for production and yield figures from the Ghana National Bureau of Statistics, which vary somewhat from those of Dzomeku et al. (2011). The increasing production may indicate increasing importance of the crop in those regions, or may be due to the expansion of cocoa production, as banana and plantain frequently serve as shade trees for young cocoa plants (Dzomeku et al., 2011, p.269).

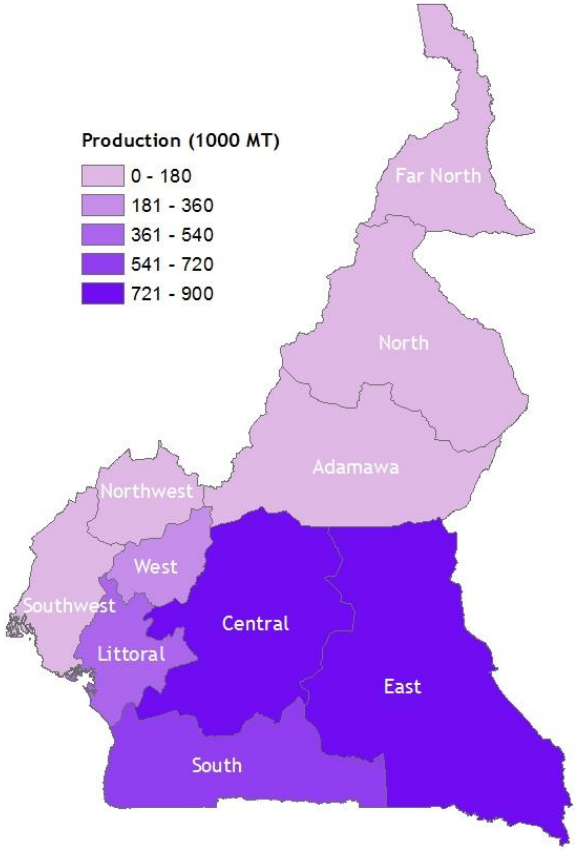
Figure 12: Plantain Production and Yield in Ghana by Region, 2012



Source: Ghana National Bureau of Statistics

In Cameroon, plantain production is highest in the Central and East Provinces (see *Figure 13*). Cameroon's banana industry is concentrated in the Mungo and Fako Divisions of the Littoral and Southwest Provinces, respectively. Banana production is conducted primarily by several large firms, most of whom are located in the Mungo Division, along the Douala/Nkongsamba road of the Littoral Province. The primary producers are: Organisation Cameronaise de la Banane (OCB), Societe de Plantation de Nyombe-Penja (SPNP), Nassif, Plantations de Houte Penja (PHP), Tiani, and Djoumo. Forty additional producers are classified as smallholders (plantations between two and fifty hectares in size) (Fonsah and Chidebelu, 2011).

Figure 13: Plantain Production in Cameroon by Region, 2010



Source: Cameroon Ministry of Agriculture and Rural Development

Farmer Demographics

Nationally representative data on farmer demographics appears largely unavailable for the countries examined. However, several studies have been conducted on banana and plantain farmers in West Africa, particularly those in Nigeria and Ghana, which include questions about socio-demographic characteristics (see *Table 1*). These studies found that plantain farmers are predominantly males between the ages of 41-60. In plantain production, labor distribution according to gender varies with producer traditions and production roles. In Cameroon, men and boys over 12 years old are generally in charge of clearing and preparing land and planting. Women and girls over 15 years old go to the planting site to monitor crop growth. Men and women both transport and sell products (Tchango et al., 1999).

Table 1: Comparison of Methods and Findings about Banana and Plantain Farmer Sociodemographics from 4 Studies

	Tijani et al., 2009	**Ekunwe & Ajayi, 2010**	**Bifarin & Folayan, 2009**	**Dzomeku et al., 2011**
Country	Nigeria	Nigeria	Nigeria	Ghana
Geographic Area	Irewole Local Government Area, Osun State	Edo State	Ondo State	Nationwide
Study Dates	2008	2010	2009	2006
Gender	78% male and 22% female	82% male and 18% female	n/a	n/a
Average Age of Farmer	Roughly half of respondents 41-60 (46%)	44	51	47.1
Average Household/	n/a	7 persons	n/a	9.4 persons

Family Size				
Average Number of Years of Education	No formal education – 40%, Primary – 20%, Modern/JSS – 18%, Secondary/SSC – 13%, Tertiary – 9%	11	n/a	8.4
Average Number of Years of Growing Plantain/Bananas	Roughly half of respondents: 11-20 years (49%)	22 years	18 years	
Average Landholding Size (ha)		1.7	5.34	.8
Cooperative Members	32% members and 68% non-members	n/a	n/a	n/a
Sampling Methods	Random sampling of 100 plantain farmers in Irewole	Random sampling of 150 plantain farmers in Edo State taken from list of Agricultural Development Programme (ADP) contact farmers	Purposive sampling of 276 plantain producers from six Local Government Areas based on intensity of plantain production	Random sampling survey of 400 farmers and 156 plantain sellers from 20 villages.

Ekunwe & Ajayi (2010) and Dzomeku et al (2011) both found that plantain farmers tend to have large households, which Dzomeku et al. (2011) suggest could be attributed to the extended family system practiced in the area, or to provide labor for plantain farming activities. The selected studies also consistently found that plantain farmers had been cultivating plantains for extended periods, most having between ten and twenty years of plantain farming experience. The studies also found low levels of formal education among respondent farmers across the populations studied, most attaining no more than primary schooling. Tijani et al. (2009) suggest that limited education combined with multiple years of farming could lead plantain farmers to rely primarily on their experience to enhance their productivity, and low levels of literacy among farmers could negatively affect their ability to access market information and understand new farming techniques provided by governments and extension agencies.

The majority of plantain farmers in Nigeria are smallholders, and most own less than 10 hectares. In addition, most farmers are not members of cooperatives (Bifarin & Folayan, 2009, p. 903; Ekunwe & Ajayi, 2010, p. 31). While not as involved in plantain cultivation, women were found to play a predominant role in plantain processing and marketing (Tijani et al., 2009). Similar to the studies on Nigeria, most plantain farmers in Ghana are not cooperative members, suggesting that a majority do not have direct access to regional markets or credit facilities, which would presumably limit farmers' ability to access production inputs and reduce potential yields (Dzomeku et al., 2011, p. 268).

Factors Constraining Production and Yields

Legal and Cultural Norms

There has been little or no change in the production practices surrounding plantain cultivation in West Africa over the past two decades. Inadequate knowledge of improved cultural practices around plantain production, coupled with inefficient government extension services and the limited scope of plantain research are believed partially responsible for continued low yields in Nigeria (NAERLS, 2005, Akinyemi et al., 2010). The average farmer to extension agent ratio in Nigeria is 2500:1 (NAERLS, 2005, Akinyemi et al., 2010).

Local customs and legal issues surrounding land rights also constrain production. The type of land tenure and inheritance system practiced in most plantain-producing regions does not allow adequate space for expansion (Akinyemi et al., 2010). For example, in Nigeria a large portion of the land is communally owned, and private land is allocated by community members only for the purpose of establishing a residence. In this system, customary rules of tenure restrict smallholders to communal land access sufficient to feed and support their families (Arua & Okorji, 1998).

Inputs

Despite lower labor requirements relative to other crops, labor is one of the most significant input constraints on banana and plantain production, driven by high labor costs and shortages due to overlapping planting and harvesting seasons with other crops. Farmers in oil-producing countries like Nigeria face high labor costs due to competition with higher paying jobs at oil companies (Akinyemi et al., 2010, pg. 214). In banana-producing countries like Cameroon, modern banana production practices require highly trained personnel, particularly at the managerial level (Fonsah and Chidebelu, 2011). Shortages of highly trained personnel lead to delays in production and higher post-harvest losses.

In two surveys of plantain production conducted in Nigeria farmers indicated transportation problems (e.g., lack of good roads, lack of vehicle access, high transportation costs) as one of the most significant constraints to plantain production and marketing (Ekunwe & Ajayi, 2010; Bifarin & Folayan, 2009).

Improving banana and plantain yields requires chemical inputs such as fertilizers, pesticides, and herbicides. In countries such as Cameroon, where the country is a net importer of these goods, production costs are driven ever higher by the rising costs of these inputs (Fonsah and Chidebelu, 2011). Despite evidence suggesting that fertilizers could increase yields and indications that access to fertilizer is limited, survey respondents did not indicate that access to fertilizers or chemicals are major barriers to plantain production (Ayanlaja et al., 2010; Ekunwe & Ajayi, 2010; Tijani et al., 2009). Although the use of pesticide and other chemical inputs can increase yields more effectively than non-chemical alternatives, they can also increase negative environmental and health impacts in the area (Viljoen, 2010).

Pests/Diseases

Black leaf streak, burrowing nematodes and banana weevils are the major disease and pest constraints affecting banana and plantain production in West Africa (Bifarin & Folayan, 2009; Banful et al., 2000). Black leaf streak, also known as black sigatoka, is a leaf spot disease of banana and plantain plants cause by ascomycete fungus *Mycosphaerella fijiensis*. The disease causes necrotic lesions on the leaves of many *Musa* cultivars, reducing their photosynthetic ability, prematurely ripening the fruit, and leading to yield reductions of 30-50% and in some cases as high as 80% (Marin D. H. et al., 2003). All the landraces in Ghana were found to be susceptible; therefore new resistant landraces were introduced in 1994 to supplement the available landraces (Dzomeku et al., 2006). Observations in plantain-producing regions showed that the disease occurred more in distant fields than in home gardens.

Cucumber mosaic virus (*Cucumovirus*) is primarily transmitted by aphids, but can also be spread through human cultivation by touching healthy plants after handling infected crops. The disease has a wide range of symptoms, including narrowing leaves and necrotic lesions on leaves and fruit, and leaf, flower, and fruit distortion (Moorman, 2013).

Until recently, Cucumber mosaic virus and black leaf streak virus were the only viruses reported in *Musa* species in West Africa. In 2011, an outbreak of Banana Bunchy Top Virus (BBTV; *Babuvirus Nanoviridae*) was reported in in the Republic of Benin, and studies in 2012 suggest that the virus is also affecting banana and plantain crops in Ogun State, Nigeria (Adegbolo et al., 2013). BBTV is one of the most economically important pathogens of Musa cultivars. It is well established in Central Africa and also in Angola, Malawi, and Zambia in Southern Africa. Plants infected at early growth stages are severely dwarfed and do not bear fruit. BBTV is transmitted by the banana aphid *Pentalonia nigronervosa*, which is widespread in Africa (Adegbolo et al., 2013).

The burrowing nematode (multiple species) and the banana weevil (*C. sordidus*) are known in virtually all *Musa*-cultivating countries in the world. Nematode species attack the plant's roots, resulting in whole plant toppling (Banful et al., 2000). The banana weevil damages plants primarily by burrowing through the corm and rootstock, weakening the plant and causing stem breakage (Gold and Messiaen, 2000). Banana weevils cause snapping of fruit bearing plants, which forces farmers to give continuous attention to the pest. These risks have been partially mitigated by the introduction of resistant cultivars and better cultural practices (Akinyemi et al., 2010).

Environmental Factors

Wind damage is a major problem for banana producers worldwide. Wind speeds above 40km/hr can completely destroy a banana plantation (Stover and Simmonds, 1987 in Fonsah and Chidebelu, 2011). In 1960 and 1964, 1,600,000 plants were destroyed in the Cameroon Development Corporation (CDC) plantation (Lecoq, 1972 in Fonsah and Chidebelu, 2011), and more recent observations showed average annual losses of more than 200,000 plants in 1991 and 1992 (Lecoq, 1972 in Fonsah and Chidebelu, 2011).

Soil analysis carried out in Nigeria's plantain growing regions indicate that the major constraints to plantain and banana production in the soil are the deficiency of phosphorus (P), magnesium (Mg), and potassium (K). Plantain crops require high soil potassium levels for the formation of fruits, and pervasive deficiency of potassium makes the soil unsuitable for plantain production. However, given Nigeria's soil organic carbon content, cation exchange capacity (CEC),[4] and optimum pH and total nitrogen (N), the soil has a high potential suitability for plantain if issues with soil fertility can be mitigated (Ayanlaja et al., 2010, pg. 22).

To increase and sustain productivity of bananas and plantains, mulching has been advocated as the suitable method to overcome the problems of both moisture stress and nematode damage (Banful et al., 2000). The application of K and N require timeliness for successful and maximum uptake. Improper timing results in lower effectiveness, wasting inputs and manpower and further driving up the costs of production (Fonsah and Chidebelu, 2011). In tests using a variety of manure placement methods, placement of half the fertilizer dose of poultry manure as a bottom dressing and half on the surface as a top dressing was the most effective fertilizer treatment (Baiyeri, Ndukwe, & Tenkouano, 2013).

Irrigation

Lack of adequate drainage and irrigation are major constraints to banana and plantain production, often due to the high cost involved. Even when adopted, the maintenance of irrigation systems presents major challenges for smallholders, typically due to the absence of spare parts and adequate expertise (Fonsah and Chidebelu, 2011).

Post-Harvest Practices and Challenges for Plantain and Banana Farmers

Post-Harvest Losses

Post-harvest losses for plantains have a number of causes, including rough handling, harvesting at maturity just before the fruit ripens, lack of processing options, contamination from spoiled fruits, and inadequate storage and transportation (Adeniji et al., 2010; Tchango et al., 2009; Zhang et al., 2005). Rough handling and transport cause splitting, abrasion, and other types of damage in the plantains. High temperatures and humidity in West Africa combined with poor storage options also shorten the shelf life of plantains, leading to increased rot and waste (Akinyemi et al., 2010). Estimated post-harvest losses are as high as 40% in Nigeria (Olorunda, 1996 in Odemero, 2013), or approximately 35% for developing countries as a whole (FAO, 1987 in Adeniji et al., 2010a).

Similarly high rates of post-harvest loss are seen in West Africa's banana-producing countries. In Cameroon, studies have estimated that 30% of post-harvest losses of bananas are incurred during wholesale and about 70% during retailing (Wills et al., 1998 in Eyabi et al., 2000, Liu and Ma, 1983 in Eyabi et al., 2000).

Storage and Transportation Practices

Storage

Plantains in West Africa are generally stored simply by piling them on the ground. Certain precautions are sometimes taken to maintain freshness and reduce damage, such as storing bananas in the shade or covering the piles with banana leaves or bags that are frequently moistened with water (Tchango et al., 1999). To improve shelf life, researchers have recommended packaging plantains in plastic bags to reduce air circulation and storing them at 12 to 14 degrees Celsius, based on studies of the shelf life of plantains harvested at maturity in Côte d'Ivoire (Marchal, 1990, Collin & Dalnic, 1991 in Tchango et al., 1999, Agbo et al. 1996, in Tchango et al., 1999). Plantains wrapped in plastic bags mixed with dry cocoa leaf powder or rice husk had a shelf life of 14 to 27 days depending on the temperature. However, traditional plantain producers and traders generally do not use plastic bags or any form of refrigeration due to the cost (Tchango et al., 1999).

Transportation

In most West African nations, plantain transportation is by road, typically in open or partially open vehicles, where they are stacked without protection and may travel hundreds of miles to large distribution centers. In addition to trucks and taxis, small-scale wholesalers and local retailers also transport plantains by bicycle, wheelbarrow, motorcycle, rickshaw, or on baskets carried on top of the head (Akinyemi et al., 2010; Tchango et al., 1999). Studies on plantain marketing have shown that plantains are often subjected to poor conditions during handling

[4] The maximum quantity of total cations, of any class, that a soil is capable of holding, at a given pH value, available for exchange with the soil.

and transport. Rough handling, typically leading to splitting, abrasion, vibration and compression, coupled with late delivery, often affects plantain quality during distribution (Adesope et al., 2004, Akinyemi et al., 2010). Generally, post-harvest distribution and marketing of plantain in the last twenty years has not been very efficient, as there are no established quality and quantity standards for plantain transportation and marketing (Akinyemi et al., 2010, pg. 213-14).

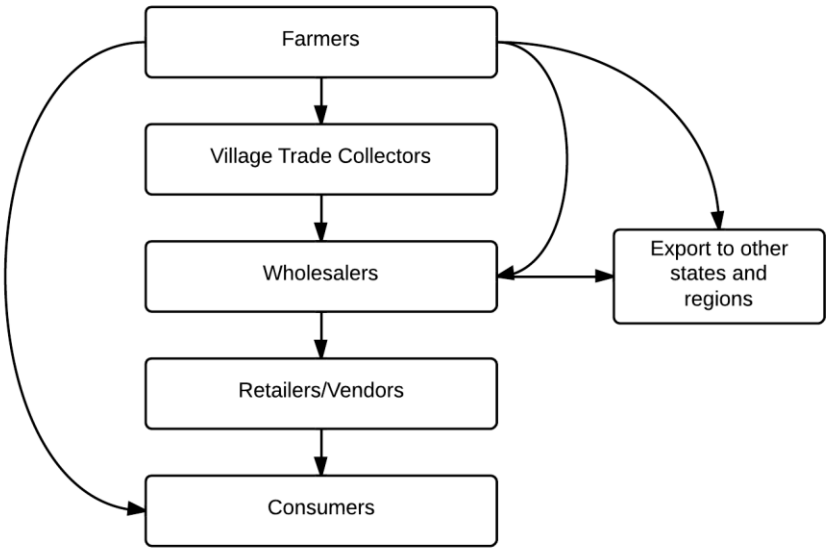
Survey data indicate that Ghanaian farmers are using multiple means to transport their plantains to market. Some are harvesting and transporting their crops from Brong-Ahafo and Western regions to Accra themselves, while in other areas farmers are organized into groups and pool resources to cover transportation costs. Since most plantain producers are scattered smallholders, plantains are often sold at the farm gate, either to middlemen or directly to consumers (Dzomeku et al., 2011, pg. 271).

In Cameroon, packing and transportation of bananas are typically the responsibility of each individual farmer. In the cases of smallholders who are unable to afford their own packing stations, major banana producers, such as Organisation Cameronaise de la Banane (OCB), allow access to their packaging facilities and facilitate farm to market or farm to port transportation via truck or rail, typically as part of a contracted-smallholder arrangement. The use of larger firms in the banana transportation process generally leads to reduced product damage during transport (Fonsah and Chidebelu, 2011).

Marketing Systems

Bananas and plantains are highly perishable and, in the absence of modern technology and advanced harvesting practices, must be consumed within three weeks post-harvest, requiring rapid distribution and marketing (Fonsah and Chidebelu, 2011). Plantain distribution in West Africa is carried out through a variety of interactions between farmers, collectors, wholesalers, and vendors (see *Figure 14*). Since banana production is far more focused on export than plantain production, large wholesalers and vendors, and even multinational corporations (MNCs) such as the Del Monte Fruit Corporation in Cameroon, often play a larger role in banana marketing (Fonsah and Chidebelu, 2011).

Figure 14: Typical Banana and Plantain Value Chain in West Africa



Source: Akinyemi et al., 2010

Plantain distribution in Nigeria is complex. Farmers whose land lies nearer to major roads harvest the crop at the mature green stage and display it at the roadside or transport the crop to nearby markets, allowing small-scale wholesalers, retailers and consumers to purchase directly. In other cases, trade collectors move around farms, collect the produce from farmers and transport it to the cities where they hand them over to wholesalers, who in turn pass the produce on to retailers or vendors for sale to customers. Movement and distribution to major cities and other non-producing regions is usually performed by wholesalers (Akinyemi et al., 2010, pg. 213).

Similarly in Ghana, the marketing of plantains involves a large number of producers and a few wholesalers who distribute plantains to consumers on a large scale. A nationwide survey of 400 plantain farmers and 156 sellers conducted in Ghana identified four main channels through which plantain reach consumers (Dzomeku et al., 2011):

- producer to wholesaler to retailer
- producer to retailer
- wholesaler to agri-industry
- producer to agri-industry

Plantain marketing is very difficult because of the dispersal of the production zones, the lack or poor conditions of the lines of communication with urban consumption centers and the irregular supply in the market by wholesalers and middlemen who set the prices. By contrast, banana marketing in places like Cameroon appears more centralized, with wholesalers and large production firms coordinating acquisition of bananas from smallholders, as well the packaging, transportation, and marketing of the produce (Fonsah and Chidebelu, 2011). Bananas and plantains have the marketing characteristics specific to all perishable foodstuffs whose production is complex and distribution difficult to organize. The process involves a large number of producers and a few wholesalers who distribute plantains and bananas to consumers on a large scale.

Women play a significant role in the marketing and sale of plantains in West Africa. In many locations female market supervisors, often known locally as "market queens," manage every market and regulate the quantity and price, and often, new entrants are not permitted to sell their produce if they do not belong to that market (Dzomeku et al., 2011). For smallholders who do not have market access through wholesalers or direct participation on local markets, marketing options are primarily limited to sale at the farm gate (Akinyemi et al., 2010; Dzomeku et al., 2011). This marketing method largely limits sales to local consumption and, in the absence of village trade collectors or larger-scale buyers, puts more isolated smallholders at a greater disadvantage.

Traders who want to sell their plantains at the ripe stage generally induce the ripening process by stocking them in baskets, drums or other containers covered with plastic bags or jute bags to maintain heat among fruits. These containers are ventilated by removing the covers after 2 to 4 days (Tchango et al., 1999).

Plantain prices are higher in European markets than in North America, mainly due to high transport costs and customs duties. Ghana's geographical location positions it to capture the European market compared to other exporting countries, which are largely located in Latin America and the Caribbean (Dzomeku et al., 2011). Export of West African bananas to European markets has been complicated by the 2009 Geneva Agreement on Trade in Bananas, in which the European Union (EU) agreed to gradually reduce its tariffs on Latin American bananas from 176 euro per ton to 114 euro per ton (The EU and the WTO, 2012). West African countries, which are not subject to EU import tariffs, will likely face more competition from Latin American banana growers in those markets.

In Cameroon, the presence of a domestic banana market predates the establishment of the first banana plantation in 1907 (Fonsah and Chidebelu, 2011). Domestic demand is driven by the banana's history as a traditional staple crop in Cameroon as well as its relatively low cost. More recently, improved road infrastructure has facilitated the shipping of bananas to areas of scarcity within Cameroon, such as the country's northern provinces where banana cultivation is essentially non-existent (Fonsah and Chidebelu, 2011).

Importance of Bananas and Plantains in West Africa

Varieties grown

The great majority of the exported bananas consumed in the developed world belong to the Cavendish subgroup (AAA), which became popular in the mid-20th century due to its resistance to Panama disease, which had devastated the previously dominant Gros Michel subgroup (Dita et al., 2010). However, this export crop accounts for less than 15% of global banana and plantain production, and there is a great deal of regional variation in locally consumed bananas (Sharrock & Frison, 1998). True plantains (AAB), which are cooked before eating, are dominant not only in West Africa, but in Central and South America as well. In East Africa, the most common varieties are highland bananas (AAA) which are steamed or used for making beer. In Southeast Asia and the Americas, cooking bananas (ABB) and dessert bananas (AAB) are the most common, while another type of cooking banana (AAB) is popular in the Pacific (*ibid*).

There is considerable variety even among plantain cultivars. Plantain cultivars are grouped by inflorescence type (the structure on the banana plant that includes that flowers that become fruits) and the number and size of their fruits. Four plantain groups have been categorized, including French, French Horn, False Horn, and Horn. Plantains are also categorized as small (less than 32 leaves on the plant), medium (between 32 and 38 leaves), or giant

(more than 38 leaves) (Swennen et al., 1995). The varieties of plantain grown in West Africa generally belong to the AAB genome group and fall under the French, Flash Horn, and Horn categories (Danso et al., 2006).

Household consumption and consumer preference

As a perennial crop with a short gestation period, bananas and plantains play an important role in West African domestic food production, and all stages of the fruit are used as a source of food. Bananas and plantains in West Africa are popular across a range of ages, genders, and socio-economic groups due to their convenience and ease of preparation. They are eaten both alone and as part of a larger meal that may include stew, vegetable sauces, fried kidney beans, roasted meat, or other dishes (Honfo et al., 2011).

Bananas and plantains can be prepared through a number of methods, including boiling, steaming, mashing, baking, drying, and pounding into *fufu* (a popular West African staple made with boiled cassava, yams, or plantains that are pounded into a dough) (FAO, 1990). In Edo State, Nigeria, plantains are commonly boiled alone, used in porridge or *fufu*, made into plantain chips or roasted on charcoal and sold by predominantly female roadside vendors (Ekunwe & Ajayi, 2010). In Cameroon, plantains are generally consumed between the green and yellow stages of ripeness after being boiled, pounded and then fried, roasted, or made into flour (Yomeni et al., 2004). Overripe plantains are processed into beer or spiced with chili powder, fried with palm oil, and served as a snack (such as "dodo-ikire" in Nigeria). The dried leaves, sheath and petioles (the stalk attaching the leaf blade to the stem) are used as tying materials, sponges and roofing material. Plantain leaves are also used for the wrapping, packaging, marketing and serving of food. The peels are used as feed for livestock, while the dried peels are used in soap production (Akinyemi et al., 2010, p.212). In Nigeria, plantain peels are used as feed for livestock, while dried peels are used for soap production. The dried leaves, sheath and petioles are used for tying materials, sponges and roofing material (Akinyema et. al, 2010).

A study comparing banana and plantain consumption in Nigeria and Cameroon during a three-day period found that banana and plantain consumption overall was higher in Cameroon (Honfo et al., 2011). They also found that raw banana consumption was higher among women and children, which according to the authors was related to a preference for sweeter food among these groups. Household members in both countries consumed bananas and plantains through a wide variety of methods (see *Table 2*). The authors also asked about the time of day when different banana and plantain products were consumed. Ripe bananas, boiled or fried plantains, and plantain porridge were consumed throughout the day, plantain chips were eaten as an afternoon snack, and pounded bananas or plantains served as a lunch or dinner (*ibid*).

Table 2: Banana and Plantain Preparation Methods Used During a Three-Day Survey

Preparation method	Percentage of Cameroon respondents (N=240)	Percentage of Nigeria respondents (N=240)
Boiled ripe or unripe plantain	100%	100%
Fried plantain	100%	100%
Plantain chips	95%	100%
Plantain flour paste	18%	79%
Roasted plantain	100%	100%
Banana/plantain porridge	100%	66%
Pounded banana/plantain	49%	74%
Ripe banana	100%	100%

Source: Honfo et al., 2011

In a different survey in Cameroon (Dury et al., 2002), 355 housewives were asked ''if every product (plantain, cassava and derived products, rice, cocoyam, yam, and maize) had the same price, which one would you prefer?'' Fifty-five percent of the respondents chose plantain as their first choice, and 72% included it among their top three favorite staple foods. Cassava and rice were the second and third most popular choices. However, there were regional differences, with respondents from Northern Cameroon (where cereals are the staple and plantains are not grown) less likely to choose plantain as their top choice. Plantains were also a relatively expensive staple in the region, with a price per calorie more than twice that of cassava and about 25% higher than rice. When the respondents were asked which food products they would purchase in higher quantities if they were wealthier, plantains were the top choice, followed by meat, rice, fish, and yams (*ibid*).

In Nsukka Urban, Nigeria, household surveys indicated a higher consumption rate for bananas than plantains, with most consumers accessing bananas and plantains through the local market (versus producing them themselves). Plantains were most often consumed with morning and evening meals, while bananas were principally consumed in the afternoon as a snack. Plantains were more expensive than bananas, which may explain the higher levels of

banana consumption (Ajayi and Aneke, 2002). In addition, bananas were typically purchased ripe, while plantains were typically purchased unripe. The same study estimated a higher price elasticity of demand for plantains than bananas, meaning that at prevailing prices, consumers were more responsive to changes in plantain prices than to changes in banana prices. Banana consumption changed minimally with price increases, though more respondents indicated consumption would increase more with price decreases. By contrast, more than half of respondents indicated they would consume fewer plantains in the case of increased prices and 75% would buy more if prices fell (Ajayi and Aneke, 2002). According to the survey, women were the primary decision-makers over the purchase of both bananas and plantains, and men were the primary decision-makers in regard to action taken with the peels and other inedible plant matter (Ajayi and Aneke, 2002).

Processing

Plantain chips in West Africa are created by frying slices of unripe or slightly ripe plantain pulp in vegetable oil, and are packaged in plastic or aluminum sachets. Plantain chips are the most popular plantain products in Nigeria, and are sold either by vendors on the street or by small companies which deliver them to supermarkets (Ekunwe & Ajayi, 2000). Plantains are also made into flour by peeling the plantains, cutting the pulp into pieces and air drying it, and then grinding the dried pulp in a wooden mortar or corn grinder. Plantain flour can be used to make *fufu*, bread, biscuits, baby food, or cakes (Tchango et al., 1999). The quality and characteristics of the plantain chips or flour are affected by the stage of ripeness of the plantains (Yomeni et al., 2004). One advantage of plantains in chip or flour form is a longer shelf life and easier transportation (Adeniji et al., 2010a).

In Ghana, chips are primarily for local consumption with minimal export, while plantain flour has been marketed at the African diaspora. The False Horn and True Horn plantains are the preferred cultivars for processing due to their large sizes and higher dry matter content (Dzomeku et al., 2011).

Income generation

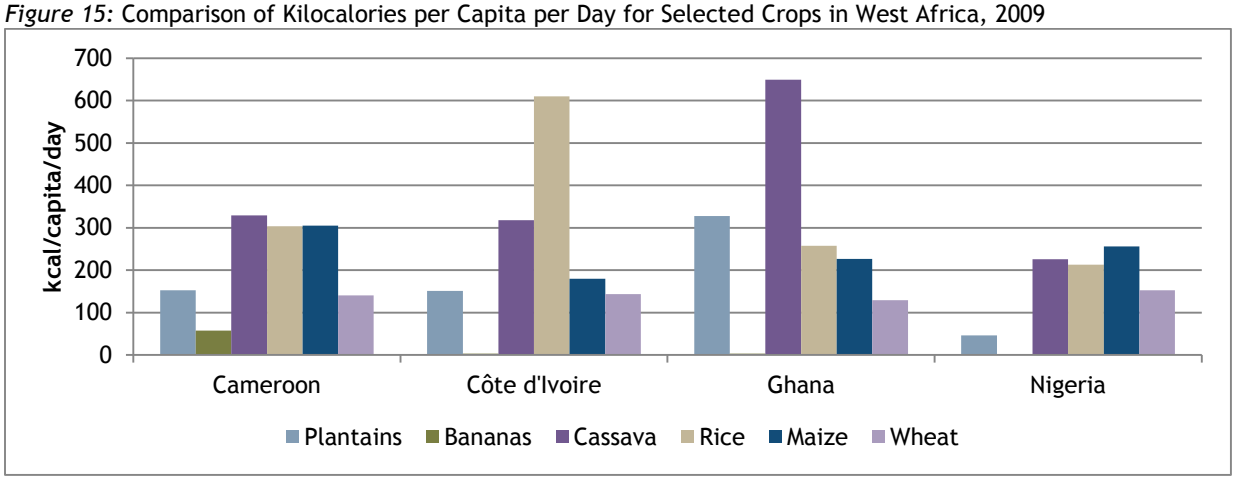
Plantains are an important source of income for smallholder farmers in West Africa, partly because of their low labor requirements for production compared to crops like cassava, rice, maize, and yams (Dzomeku et al., 2007; Lemchi et al., 2004). Akunwe and Ajayi (2010) interviewed 150 plantain farmers in Edo State, Nigeria about profitability and constraints to plantain production. They found that plantain production was profitable in the area, with a 37.7% rate of return for the original investment in planting materials, intercrops, fertilizer, chemicals, and labor.

In addition to the income opportunities for farmers, processed plantains provide employment for the vendors who sell them. In Nigeria, roadside women sell the fried plantain dish known as *dodo*, and plantain chips and other snacks are also sold by vendors (Bifarin & Folayan, 2009).

Nutrition

Plantains are an important part of the diet in West Africa and other regions of the continent, accounting for up to 25% of the carbohydrates for approximately 70 million people in Sub-Saharan Africa's humid zone (IITA, 1997 in Ekunwe & Ajayi, 2010). Plantains generally do not account for as many daily calories as other popular staples such as cassava (see *Figure 15*). According to 2009 FAOSTAT data, West Africans consumed an average of 39 kg per capita per year of plantains, compared to 76 kg of cassava and 71 kg of rice (and only 9 kg of bananas). In southwest Cameroon and other high plantain-consuming areas, plantains can account for as much as 150 kg of consumption per capita per year (Swennen et al., 1995).

Figure 15: Comparison of Kilocalories per Capita per Day for Selected Crops in West Africa, 2009



Source: FAOSTAT

Bananas and plantains are a rich source of carbohydrates, which account for approximately 22% of the dry weight for bananas and 32% of the dry weight for plantains (Honfo et al., 2011). Bananas and plantains are low in fat and sodium and contain compounds that reduce blood pressure (Sharrock & Lusty, 2000). They are also a good source of vitamins, including C, B, and A, and minerals such as potassium (K), calcium (Ca), and phosphorus (P) (Kayode et al., 2013; Swennen et al., 1995). Dark-yellow or orange-fleshed banana and especially plantain cultivars are a good source of provitamin A carotenoids, which are the primary source of vitamin A for rural farming populations affected by vitamin A deficiency (Ekesa et al., 2012; Fungo & Pillay, 2011).

As bananas and plantains ripen, their composition changes. The dry weight of unripe plantains is more than 80% starch and only 1.3% sugars, but the sugar content increases to about 17% in ripe plantains. Unripe bananas are about 20% starch, which declines to 1-2% in the ripe fruit, while the sugar content increases from less than 1% to 20%. (Zhang et al., 2005; Sharrock & Lusty, 2000). The nutritional content of bananas and plantains also varies significantly across genotypes and preparation methods (Davey et al., 2007).

One of the general differences between banana varieties and plantain varieties is the moisture content: plantains are about 65% moisture on average, compared to 83% for bananas. Because moisture enhances hydrolysis, the process that converts starches to sugars, starches become sugars more quickly in bananas, which also causes the peel to turn yellow (Sharrock & Lusty, 2000). The sugar content of ripe bananas is unusually high in a fresh fruit, providing almost double the energy of an apple and close to three times the energy of citrus fruits. The energy value of bananas and plantains is comparable to other starchy staples such as yams and cassava, but only about a third as high as dry rice, wheat flour, and maize (*ibid*).

Conclusion

Plantains are a popular and versatile staple in West Africa, providing a significant portion of the calories and nutrition of smallholder households and a wide variety of food products. Plantain consumption and production have increased steadily over time, but production and yields are constrained by pests and disease, including the black leaf streak virus and nematodes, soil degradation, limited knowledge of best practices among smallholder farmers, lack of inputs, short shelf life, and limited labor availability. Plantain production is dominated by men, but women play a key role in processing and marketing.

Bananas play a much smaller role in the domestic food supply in West Africa, but a larger one in the export business, especially in Cameroon. Whereas plantain marketing is characterized by small-scale, widely dispersed producers, banana production in Cameroon and elsewhere in West Africa is generally more centralized, involving larger production firms and a more structured marketing and transportation system.

Literature Review Methodology

Searches for banana and plantain literature were conducted primarily through Google Scholar and the University of Washington library website using combinations of the terms Africa, West Africa, Nigeria, Ghana, Cameroon, banana, plantain, production, yield, marketing, income, and trade. Other sources included the Bureau of Statistics

and Ministry of Agriculture websites for Nigeria, Ghana, and Cameroon, the International Institute of Tropical Agriculture (IITA), and ProMusa.org.

Please direct comments or questions about this research to Leigh Anderson and Mary Kay Gugerty at eparx@u.washington.edu.

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