Banana:
The history and socio-economics of cultivation

Sedeer El-Showk

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Contents

1 Introduction

Banana is one of the world's major crops: it is cultivated in over 100 countries on over 10 million hectares producing nearly 90 million metric tons annually [Marin et al., 2003]. The produce is mainly consumed locally, with a daily *per capita* consumption in some producing countries of over 4kg [Samson, 1986]; only around 12 million metrics tons are produced annually for the export market [Marin et al., 2003]. While production is widely distributed, 44% of total production is accounted for by India, Uganda, Ecuador, Brazil and Colombia [Marin et al., 2003]. The ability to produce a crop without regard to season (in the tropics) is quite valuable to subsistence and smallhold farmers, while the option to synchronize a harvest is useful for larger scale commercial growers, who may need to match their production with peak demands in target markets.

As a result of banana's antiquity, wide geographical range (including Africa, Asia, Central & South America and Australia), diversity of cultivars and wide range of uses, there are some complications with nomenclature which should be addressed. Simmonds, for example, lists many of the local names for banana [Simmonds, 1959]; there is often little similarity in names within a region, which may be specific to preferred cultivars in particular localities. The issue is further complicated by the occasional use of the word 'plantain'. While the English word is generally used to refer to a certain group of starchy cooking bananas, in Spanish it is used as a general collective term for bananas of any kind; furthermore, the English usage is often inconsistent, with 'plantain' sometimes being applied to sweet (rather than starchy) bananas simply because they

are cooked and, in parts of India, being applied to sweet-fruited cultivars while 'banana' is used for certain starchy, cooked cultivars [Simmonds, 1959]. To avoid such confusion, 'banana' will be used here as a general term, with a distinction being made between 'subsistence' or 'local' banana, whether consumed raw or cooked, and 'dessert' or 'export' banana, which is produced for external consumption.[1]

The banana plant is a perennial, tree-like herb between two and six meters in height. The "tree" consists of a pseudo-trunk made up of leaf sheaths; the petioles form the "branches" and the blade of leaf (which may be between one and three meters in length) is the "leaf". Although the plant is perennial, each "tree" is monocarpic; after a fixed number of leaves, a terminal inflorescence will be formed which will push up through the stem and bear fruit. A new shoot (called a 'sucker') will grow from the rhizome ('corm'), thus perpetuating the plant [Samson, 1986].

As a tropical crop, banana requires a good deal of moisture and thrives between 25°C and 30°C [Samson, 1986]. Although most banana cultivation takes place in the tropics, one cultivar (Dwarf Cavendish) can be grown in open fields in sub-tropical climates [Samson, 1986] and other cultivars are successfully cultivated in greenhouses. Banana has historically been propagated by the removal and multiplication of suckers. While this practice continues in subsistence farming, tissue culture propagation has gained popularity in commercial plantations since the planting material is guaranteed to be clean and resulting plantations are uniform, allowing for easier management.

2 History of Domestication

Domesticaion of *Musa* first took place in South East Asia, probably in the Malay peninsula [Smartt and Simmonds, 1995]. Although our first record of banana is from an Indian epic dating from 600-500 B.C. [Simmonds, 1959], it seems likely that the domestication of banana in South East Asia occurred at least several millenia ago, though a firm date has not been reliably determined [Smartt and Simmonds, 1995]. In fact, it has even been argued that banana may have been one of the first crops domesticated during the independent development of agriculture from a South East Asian center ([Sauer, 1952] in [Simmonds, 1959]).

Wild banana plants produce trilocular berries containing mostly seeds surrounded by some inedible, sweetish, acidic, starchy pulp, the growth of which depends on a stimulus from the seeds. Durng domestication, the pulp has become less acidic and pulp growth became autonomous; fruit from domesticated banana plants are seedless and rich in pulp. [Simmonds, 1959]. Furthermore, domesticated banana is a triploid plant, a hybrid descendant of *Musa acuminata* and *Musa balbisiana*. Cultivars are classified according to the proportion of the two genotypes (A = *M. acuminata*, B = *M. balbisiana*), with AAA, AAB and ABB being the most common while diploid (AB) and tetraploid (AAAB, AABB, ABBB) clones are rare [Smartt and Simmonds, 1995].

A crucial step in the domestication of banana is thought to have been the development of *parthenocarpy*, the decoupling of pulp formation from a seed-based stimulus; parthenocarpic, seeded (*i.e.*, fertile) diploid banana can still be found today, lending support to this hypothesis. Parthenocarpy, and thus edibility, is likely to have occured initially in diploid *M. acuminata* and to have preceded the evolution of sterility. The first ripe[2] banana fruit consumed was probably rich in pulp

[1] I note in passing that the formal, Latin nomenclature of banana seems to be in little better state: while Linnaeus originally distinguished between *Musa sapientum* ("banana") and *M. paradisiaca* ("plantain"), both names were based on hybrids between *M. acuminata* and *M. balbisiana* and therefore could not be used; later names are also dubious [Samson, 1986]. Simmonds is cited in [Samson, 1986] as proposing to abandon specific Latin names altogether, using instead a genus name followed by a group indication and cultivar name.

[2] Banana may have been consumed 'unripe' for some time before domestication or the development of edibility; the immature fruit, as well as the male buds & flowers and the inner sheaths are all still consumed as a vegetable in part of South East Asia [Simmonds, 1962]. Furthermore, early settlers of the Malay peninsula may have valued the plant for its non-food uses; banana leaves are still used as wrapping, thatch and a source of fiber [Simmonds, 1959].

but seeded nevertheless.

Sterility, which followed parthenocarpy in the process of domestication, is also believed to have developed in a diploid *M. acuminata*. Most bananas are female-sterile, but this seems to be coupled with high levels of male fertility. In addition, the sterility is incomplete: a (very) small proportion of seeded fruit is produced in certain cultivars. It is therefore considered likely that the various forms of triploidy arose from several crossings between "sterile", parthenocarpic plants [Simmonds, 1962].

Hybridization with *M. balbisiana* is likely to have taken place on the periphery of the range of domesticated banana; *M. acuminata* is well adapted to the conditions around the center of domestication, where the climate is more equable, but may have benefited from the hardiness conferred by *M. balbisiana* in drier climates [Smartt and Simmonds, 1995].

3 History of Cropping

Following its domestication in South East Asia, banana was most likely introduced to eastern Africa by Indo-Malay sailors via the Great Lakes region, making its way west across the continent from there [Smartt and Simmonds, 1995]. It was introduced to Europe via the conquest of Africa, and thence to the New World [Smartt and Simmonds, 1995]. It was during the 19th century in Central and South America that banana trade developed into an industry [Simmonds, 1959]. The peculiar risks and requirements of banana cultivation resulted in banana companies needing to manage risk by spreading the plantations across several countries and to invest heavily in transport infrastructure, particularly railways; coupled with the enormous role banana production (and agriculture in general) often played in the role of these countries, this led to banana trading companies often wielding excessive influence with the governments of these countries, resulting in the moniker "banana republics". The largest and most powerful of these companies were the United Fruit Company, formed by the merger of several smaller companies in the early part of the twentieth century, and the Standard Fruit & Steamship Company [Simmonds, 1959][Stover and Simmonds, 1987]. Both companies remain active in banana trading: the United Fruit Company is now known as Chiquite Brands International and the Standard Fruit & Steamship Company has become Dole Food Company.

4 Banana: The Crop

Despite its role as a subsistence crop throughout the tropics, banana is, nevertheless, a demanding plant. Water requirements are high and nutrient use is considerable; wind damage, pests and diseases pose very real risks to the banana farmer. These factors will be of varying importance depending on the scale and type of cultivation being practiced; subsistence and small scale growers will respond differently than larger, commercial growers as a result of differences in both their capacity and their concerns.

4.1 Cultivation

Banana cultivation requires a good deal of water. In tropical areas, this is often provided by rainfall; in sub-tropical growing regions, irrigation is required. A Dwarf Cavendish plant may use between 15 and 25 liters of water per day [Samson, 1986]; at a planting density of 2000 - 2500 plants/ha, each hectare will need, on average, $40m^3$ of water per day. Optimal rainfall levels have been estimate and 200-300mm per month [Samson, 1986]. For a respectable yield of over 40 tonnes/ha, Samson cites the removal of 80kg N, 20kg P_2O_5 and 240kg of K_2O from each hectare

[Samson, 1986]. Organic matter may also be added, usually in the form of farmyard manure or mulch. While neither is required on healthy soils, the addition of both has a significant effect on yields [Samson, 1986].

Although large scale, commercial banana for export is usually produced in monoculture plantations, a great deal of banana is produced on smaller scale farms, often as a subsistence crop [Simmonds, 1959]. On these smaller farms, banana may be used for intercropping and crop rotation: the shade provided by its canopy, coupled with a short cylce time and good response to mulching & fertilization make it an ideal crop for such endeavours [Ruthenberg, 1980]. In Bukoba, Tanzania, for example, banana is intercropped with coffee and maize [Baijukya et al., 2005]; in Kenya banana is mainly grown by smallhold farmers, predominanly women, and is usually intercropped [Wambugu et al., 2002]. Although intercropping may reduce the yield of both crops, it can still be a favoured practice if the combined yield increases the total income or if one of the crops (*e.g.*, banana) is consumed and the other(s) used as a cash crop [Stover and Simmonds, 1987].

Banana plantations are quite susceptible to wind damage; this is unfortunate, since many major plantations are in areas at risk of high winds. A wind velocity of 25-30km/h is sufficient to cause significant damage to banana plants; wind speeds of 65km/h will cause considerable loss and higher speeds to a complete crop failure [Samson, 1986]. This problem is mitigated somewhat in some sub-tropical cultivations, since banana may be grown under greenhouses in these areas; although entire greenhouses may be lost as a result of high velocity winds, they protect the banana plants from damage from slower winds.

Several pests and diseases pose a serious problem for banana growers. Perhaps the most significant, from a historical perspective, is 'Panama disease' (or banana wilt), caused by *Fusarium oxysporm*, forma *cubense*. There is no known treatment for Panama disease; if a cultivar is not resistant, the wilt will progress quite rapidly until the pseudostem splits and the plant dies. The disease is spread by infected soil, tools and water and all chemical and sanitary efforts at control have failed; because of the rapid spread and high level of fatality, it has been described by one scholar as "one of the world's most catastrophic plant diseases" [Samson, 1986]. After the appearance of Panama disease at the end of the 19th century, whole plantations were lost in many South and Central American countries, often with a serious impact on the national economy; the replacement of the susceptiblie cultivar 'Gros Michel', once the most popular banana for the export market, by various cultivars of the 'Cavendish' group is thanks to the latter's resistance to Panama disease (in fact, many growers initially refused to abandon Gros Michel, acceding only in the face of devastating losses from *Fusarium* wilt) [Smartt and Simmonds, 1995]. The Cavendish subgroup, however, has proven susceptible to a variant of Panama disease (*Fusarium oxysporum*, forma *cubense*, tropical race 4); the development of improved, resistant varieties has been a priority of banana research for some time [Smith et al., 2006].

Black Sigatoka is, without a doubt, the most serious disease currently affecting banana plantations. First described in Fiji in 1963, it is caused by the fungus *Mycosphaerella fijiensis* Morelet. Symptoms include chlorosis of the leaves followed by the development of necrotic spots and, finally, necrosis. If uncontrolled, Black Sigatoka can result in a yield loss of up to 38% in plantains and higher in export banana; in addition to being the most damaging disease of banana, it is also the most costly: attempts to control Black Sigatoka may account for a quarter of the production cost [Marin et al., 2003].

Other diseases and pests of banana include Yellow Sigatoka (another leaf cholorosis disease, caused by *Mycosphaerella musicol*a, which is much less damaging and more easily controlled than Black Sigatoka) [Marin et al., 2003], Moko disease (similar to Panama disease but susceptible to control) [Samson, 1986], Bunchy Top Virus (leading to stunted, rosetted, chlorotic growth, but susceptible to control by elimination of the aphid host vector and removal of infected plants) [Stover and Simmonds, 1987], nematode infestations (primarily *Radopholus similis* and controllable

through fumigation and other soil treatments) [Stover and Simmonds, 1987] and the banana borer weevil (*Cosmopolites sordidus*, which tunnels into the corm and feeds, causing rot and the eventual collapse of the plant, but which can be controlled by removing harvested stems from the field, using clean planting material and applying an insecticide around the base when planting) [Samson, 1986]. While none of these problems should be described as 'minor', they certainly pose less of a threat to banana than Black Sigatoka and are more easily controlled. Nevertheless, they can have a serious impact on the yield of a plantation.

4.2 Economics

Banana is widely grown throughout the tropics, but the mode and scale of cultivation varies widely, leading to very different problems and solutions. Simmonds has devised a classification scheme for the types of management of banana, dividing them into "peasant", "farmer", "estate" and "company" based on the use to which the fruit is put, the type of labour, the capitalization and the 'form of agriculture' practiced [Simmonds, 1959]. While this approach is nearly half a century old and was conceived primarily in the context of South & Central American plantations, it is nevertheless a useful framework for examining modern forms of cultivation of banana and elucidating some of the problems and pitfalls.

Simmonds notes that peasant growers usually consume their crop directly and make significant non-food use of the plant. Farmers, estates and companies, on the other hand, will use all (or perhaps most, in the case of farmers) of their harvest as a cash crop. Similarly, peasant labour is drawn from the family, while labour in the other three groups is hired (again, with some family labour in the case of farmers). Estates and companies will have much higher capitalization than farmers or peasants – there is a heavy investment in the plantation in terms of drainage, irrigation & spraying equipment, as well as buildings, transport infrastructure & equipment, etc. Naturally, there is also more capital available to be used, for example, in acquiring new planting material or expanding operations. The final distinction is in terms of agricultural practice: companies practice monocropping, while the groups will practice mixed or unmixed diversified cropping, with peasants usually practicing some form of intercropping [Simmonds, 1959].

In order to discuss the economics of banana production, it is also important to first understand the economics of banana itself. There are several factors which should be taken into consideration. To begin with, the banana plant grows rapidly, having a time-to-harvest of 9 - 18 months; in addition, it is a perennial crop and proudction need not be seasonal [Samson, 1986]. These characteristics help to explain the enormous popularity of banana and its use as a staple crop, particularly if one bears in mind the fact that the cost of land preparation (in the tropics) is quite low [Ruthenberg, 1980]. However, banana is quite susceptible to wind damage as a result of its herbaceous growth form; while there is little most growers can do to meet this risk, very large scale growers may spread their plantations across many regions (in several countries), thus minimizing their exposure ([Simmonds, 1959] but see also the discussion in the same source of the Banana Industry Insurance Board in Jamaica, which provides insurance against wind damage for smallhold farmers). Furthermore, the high demands with regard to soil structure and nutrition limit the amount of land available for large-scale, commercial banana plantations [Simmonds, 1959]. Finally, it should be borne in mind that the banana fruit is very perishable and requires special ships and adequate infrastructure for transport, as this will affect the economics of dessert banana production [Simmonds, 1959].

5 Social and economic impact and role

Broadly speaking, the socioeconomic impact of banana growers and the agricultural problems they face can be divided into two groups: problems faced by large-scale, commercial growers and problems faced by subsistence growers. As a result of the different priorities and capabilities of the different types of management (see above), there is little overlap between these two groups. Smaller-scale farmers (for local market consumption, for example) fall somewhere between the two: in terms of agricultural management and risk exposure, they are similar to the large-scale growers, but they may not enjoy the same influence, resources and capital and are therefore more limited in their ability to respond.

While large scale, commercial banana cultivation takes place in the tropics [Marin et al., 2003], the primary consumers of dessert banana are the United States and the European countries [Simmonds, 1959]. The highly perishable banana fruit has to be delivered to these international markets, ideally at an appropriate time to meet peak demand. Commercial growers are therefore interested in a predictable, synchronized harvest in order to be able to effectively plan and organize transportation and marketing. Fortunately, this agricultural requirement can be met with modern technology: tissue culture can provide uniform, clean planting material and large scale, mechanized farming can be used to ensure uniform growth and a synchronous harvest. There are, however, some further implications to be considered: the perishability of the produce may place growers at the mercy of the shipping and export company since fruit which cannot be exported will have to be sold on the local market, often at a reduced price [Simmonds, 1959]. An incentive is thereby created for large-scale growers to invest in non-farm infrastructure, such as cold storage and transport facilities, in order to provide themselves with a measure of flexibility; this investment, in turn, grows the company – when not being used for banana, the transport and storage facilities may generate a new revenue stream which can then be invested in increasing banana cultivation, thus requiring the further development of infrastructure. The much criticized massive banana trading companies which dominated the "Banana Republics" in the 19th century were the products of such a cycle.

Although diseases certainly represent a problem for any banana grower, the quality of the problem differs drastically between commercial and subsistence growers. Subsistence growers must often tolerate pests and diseases if they lack the resources to combat them; they have the luxury to ignore them, however, since plantations are often mixed and the banana need only yield enough to maintain the household, not the larger quantities needed for a profitable business. Commercial growers, on the other hand, not only strive to maximize their yield, but are also suffer a much greater exposure since their large, monocultured plantations are more vulnerable to devastation by an uncontrolled pathogen. Panama disease provides a good example of such a case: the devastation suffered by large South American plantation eventually forced commercial growers to switch to resistant cultivars while subsistence farmers in Africa have continued using susceptible cultivars to this day, simply eliminating unhealthy plants and accepting the reduced yield [Qaim, 1999].

The relatively low yields, however, do pose a problem for subsistence farmers, particularly if, as is often the case, the yield declines over time. Recent studies in Kenya and Tanzania indicate that, despite being a staple crop in both countries, banana has declined in popularity during the last few decades (by as much as 40% between the 1970s and 1990s in Tanzania) [Wambugu et al., 2002][Baijukya et al., 2005]. Poor management by subsistence farmers [Simmonds, 1959] is one factor contributing to depressed yield, as subsistence growers in Africa often do not provide sufficient nutrients to make up for those taken up by the crop [Baijukya et al., 2005], irrigate or use pesticides [Qaim, 1999]. The primary factor, however, may be the high prevalence of pests and diseases due to a lack of clean planting material [Qaim, 1999]. Resulting ields may be less than a third of the potential under favourable conditions [Qaim, 1999], even as low as 5.6 tons/ha in

some parts of Kenya (where the average is 14 tons/ha) [Wambugu et al., 2002].

The use of tissue culture plants has been suggested as a means of resolving these problems for subsistence farmers [Qaim, 1999][Wambugu et al., 2002], since it would provide guaranteed clean planting stock. An early study indicated that the use of tissue culture plants in Kenyan farms would result in increased income despite the higher cost of tissue culture plantlets; interestingly, the study claimed that the largest increase in income would be experienced by small-scale farmers (with less than 0.2 hectares) [Qaim, 1999]. A pilot project was established to test this hypothesis; the primary result was a significant increase in average bunch weight (from 15-30 kg to more than 40 kg) [Wambugu et al., 2002].

The study also highlighted a few interesting points regarding both the establishment of the program and possible follow-through effects. For example, the study showed gains in productivity could be passed on to the consumer since the surplus banana could be sold, causing prices to fall. In addition, it was found that farmers were quite reluctact to use the varieties supplied by the project; the lab was therefore forced to switch to producing the farmers' preferred varieties, a lesson which should be borne in mind for future such projects. Furthermore, the study strongly recommended that a hands-on information package about banana management be provided to farmers, particularly since tissue culture plants may need special attention during the first few months. Finally, an ingenious (and successful) micro-credit scheme was established to allow resource poor farmers to purchase the planting material: loans were offered to friendship groups of 30-50 members (with elected leaders) which were responsible for repayment as a whole. In addition to overcoming many of the difficulties inherent with credit schemes, this system also serves to promote community cohesion and facilitate information flow [Wambugu et al., 2002].

6 Conclusion

Banana is one of the world's most important crops and cultivation is widespread; nevertheless, there is an important distinction between large scale, commercial cultivation for export and cultivation for subsistence or the local market. For much of its history, banana remained a relatively small-scale crop, grown by small-holders and serving as a staple crop throughout the tropics. With the introduction of banana to the Americas, however, and the growth of the US (and, eventually European) market for dessert bananas, a new dynamic emerged in banana production, marketing and consumption; this dynamic had drastic effects on the development of the producer countries, both positive (the development of infrastructure and economic growth) and negative (excessive political influence, support for tyrannical regimes and the oppression of organized labour). While the socioeconomic role of the large banana companies has been a legitimate source of concern, more attention and research must be directed towards the needs and problems of resource-poor subsistence farmers in both Africa and the Americas; technical solutions to the production problems must not only be found, but also effectively integrating into the existing social and economic structure. As is the case with many other agricultural problems, a holistic approach is needed, taking into account production needs, market demand, social structure and environmental impact.

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