Potatoes were introduced primarily by British farmers and colonial officials to Kenya and other areas of East Africa during the 1880s. As early as 1909, European farmers in Kenya were attempting to export potatoes to South Africa. The initial effort was frustrated by the fungal infection *Nectarius solani*, but some export of potatoes occurred successfully over the next decade. The British colonial government encouraged potato cultivation during the First World War, as a means to feed troops stationed in East Africa. Seed imports for research purposes and formal variety trials date from this period (Waithaka 1976).

After 1918, agronomic research on potatoes expanded, and African farmers began to grow the crop for home consumption. B. Laufer (1938), citing the Handbook of Kenya Colony (of 1920), noted that the crop was even by then rapidly becoming popular with Kenyans in the highlands on land recently cleared of forest, with typical yields of nine tons per acre (approximately four tons per hectare). In the 1920s grading standards were established, and exports of potatoes began to assume economic importance to both African and European farmers (Waithaka 1976). During the 1930s, Kenyan potato production suffered both from economic problems associated with the global depression and from pests and disease (Waithaka 1976).

During the Second World War, production was maintained to meet the needs of the British Army. Processing plants were established to dehydrate potatoes and other vegetables, but the longer term investments in extension and research were severely reduced. From the end of the war in 1945 until Kenya’s independence in 1963, potato research expanded with the establishment of the post of Colony Potato Officer in 1958 and the Potato Research Advisory Committee in 1961. This period saw increased efforts in seed production and screening, plant breeding for disease resistance, and potato pathology studies (Waithaka 1976).

In 1967, a potato development project was established by the Kenyan Government with a mandate to establish programs in variety screening, plant breeding, seed multiplication, and agronomy (Durr and Lorenzel 1980). In 1970 a government seed bulking station was established at Tigoni, which was expanded by 1979 into a full potato research station. In the 1970s the Faculty of Agriculture, University of Nairobi, and the International Potato Center (CIP) began a cooperative effort with the national potato program in conducting and promoting research and extension for potato production (Nkanya 1984; Kabira and Njoroge 1982).

Over the 1970s and 1980s, the potato grew in importance as a food crop for home consumption and for income generation through local markets, though international exports declined. In the early 1990s potato production began a rapid expansion that has made the crop Kenya’s second most important food, in terms of tons production, after maize. From 1994 to 2003, area planted nearly tripled, from 47,000 to 120,000 hectares. Yields have likewise increased over this period, from a national average of less than 4 to approximately 7.5 tons per hectare, although the trend has not been stable. The combined effects of more cultivation and higher yields have resulted in a nearly five-fold increase in total production over a decade, from 184,000 to 900,000 tons (FAOSTAT 2004).

This rapid increase in potato production has occurred simultaneously with a stagnation or decline in cereals and other staple crops, principally maize, largely attributable to low average rainfall in areas of cereal production (Kenya Ministry of Agriculture (KMoA) 1998). The decline in maize is especially notable given action taken by the Kenyan government to encourage maize production, primarily via tariffs on imported maize that might otherwise be more cheaply available to consumers (Nyoro 2002).

The potato in Kenya remains predominately a crop of smaller scale independent and diversified farmers, many of them women, although some larger-scale growers have specialized in commercial production to meet the demands of urban areas, where the potato has become a very popular food item. Marketing is likewise undertaken mostly by smaller scale independent traders and shippers (Lutaladio et. al. 1995, p. 555).

**GEOGRAPHY AND PRODUCTION ZONES**

**Physical Geography and Climate**

From the Indian Ocean coast, the land of Kenya rises gradually through dry bush to the more humid arable highlands on which the agricultural economy is based (UK Trade and Investment). Kenya's classification into agro-climatic zones, based on annual rainfall expressed as a percentage of potential evapotranspiration, provides a rough estimate of land that is potentially productive for agriculture, generally areas with an index greater than 50 percent. By such classification, only 12 percent of Kenya's land area is suitable for agricultural production (Orodho). The majority of the country, especially to the east and north, is characterized by arid and semi-arid rangelands, including extensive areas of very arid desert to the north.
The exception is the Central Highlands, where fertile volcanic soils and annual rainfall often above 1,000 millimeters (mm) allow for productive agriculture, although intensive cultivation, especially on steeply sloping land, has led to serious soil erosion in many areas. One symptom of erosion is potassium depletion, reported as a worsening problem (Henao and Baanante 1999).

In the Meru District, on the eastern edge of Kenya’s potato zone (but historically a major producer), soil types include (Durr and Lorenzl 1980):

- Dark brown loams derived from volcanic tuffs and ash, most common at 2,000 to 3,000 meters above sea level (masl);
- Dark red friable soils at elevations of 1,500 to 2,000 masl, well drained but often containing iron and aluminum oxides which combine with phosphorous and limit its availability to plants;
- Black cotton soils at lower elevations with a typically clay texture and high plasticity that limits drainage, where potato cultivation becomes less common.

In the Central Highlands, temperature regimes are dominated more by altitude than by latitude. Since Kenya is bisected by the equator, seasonal temperature variation is very minimal. Areas of cooler temperatures at higher altitudes (but below altitudes subject to frost) are especially well suited to potatoes.

Local latitude and topography influence precipitation patterns, sometimes very locally, but generally for the Central Highlands, two rainy seasons occur: March through May (traditionally called the “short rains”) and November through December (the “long rains”). In Nairobi, the highest month of precipitation is usually April of the short rains, (roughly around 500 mm) with the peak of the long rains in November (roughly 200 mm). (Please see the http://www.bbc.co.uk/weather/world/city_guides/city.shtml?tt=TT000300 for climatic graphs from Nairobi.)

Regional Distribution of Potato Production

The distribution of Kenya’s potato crop is typical for a tropical country: concentrated at mid elevations and highland areas (roughly from 1,200 to 3,000 masl), where population density is high, farms are small, and agricultural productivity is challenged to meet the demands of a growing population (Lutaladio et al. 1995, p. 555).

The main potato growing areas by province include (KMoA, 1998, p. 10):

- Central Province: produces most of the national crop, with some cultivation of potatoes in nearly all districts; Nyandarua District, along the Aberdare Range, being the largest and most diversified region;
- Eastern Province: main growing area is Meru District around the slopes of Mount Kenya;
- Rift Valley Province: potatoes grown in the Mau Escarpment region in Dundori, Mau Narok, and Molo, and in the western highlands of Kericho, Bomet, and Uasin Gishu.

PRODUCTION SYSTEMS AND CONSTRAINTS

Cropping Calendar

Planting for the long rains is undertaken in October and November, for harvesting in January and February. The short rains crop is planted in March and April, for harvesting in July and August. It is very common, at least in Meru, for farmers to plant two potato crops annually (KMoA, 1998, pp. 10-11).

Farmers who have invested in irrigation systems, usually relying on gravity-fed lines tapped from streams, typically plant in January and February for harvests in April and May, and again in August and September for harvests in November and December (ibid). With the minimal seasonal temperature variation of Kenya’s equatorial latitudes, irrigated potatoes can be planted at any time, but this pattern coincides with lower market supplies, hence higher prices. Further investment in irrigation is often limited by lack of clear title deeds to land.

As can be seen from the table below from data gathered at Meru, intervals between harvests are at most three months, although harvests from irrigated crops are likely lower.
Cropping Patterns and Fertility Management

Potatoes are usually planted as pure stands on ridges, at a seeding rate reported as eight to ten bags per acre (KMoA 1998, pp. 10-11). The bag is a standard measure of potatoes in Kenya, generally the equivalent of 100 kilograms (kg), although this can vary, at least for marketing transactions. At this rate, eight bags (800 kg) per acre would be the equivalent of almost two tons per hectare (t/ha), the seeding rate recommended by extension services. Earlier reports indicate that in most areas, a much lower seeding rate of 1.3 to 1.6 tons per hectare is more common, the higher rate of two tons per hectare being more common in the Meru area (Durr and Lorenzl 1980).

On independent small farms where most of Kenya’s potatoes are grown, the crop is often intercropped, most often with maize and beans. Potatoes grown on larger commercial operations are more frequently monocropped (Lutaladio et al. 1995, p. 555). Where potatoes are grown as a monocrop, they are usually rotated sequentially with other crops. However, some farmers with very small areas of land who are dependent on regular sales of potatoes may not be able to rotate their potato crop regularly, especially in areas too cold for other crops (KMoA, 1998, p. 11). To the extent that land and food constraints are forcing farmers to cultivate potatoes at higher altitudes where that is possible, intensified potato cultivation without rotations might become more common, but this has not yet been reported.

Di-Ammonium-Phosphate (DAP) is a common fertilizer, applied at the rate of 100 kg per acre (or roughly 247 kg per hectare). Farmers who keep livestock also apply farmyard manure prior to planting (KMoA, 1998, p. 11).

The use of mechanical equipment has been fairly common for several decades. Durr and Lorenzl (1980) estimated that roughly half of all farmers specializing in potatoes used tractor-drawn plows to prepare land for planting. Tractors are not widely owned, but larger-scale farmers who own equipment often rent it to other local farmers.

Yields of potato, though overall increasing, are extremely variable by locality and management practices. Meru has been cited for some years as an area where potatoes are more intensively managed and yields are higher, though current and specific data are lacking. Durr and Lorenzl (1980) cited a survey of six areas which revealed a national average of five t/ha, but over nine t/ha in Meru. Data reported by the United Nations Food and Agriculture Organization (FAO) for 2003, as noted above, indicate a national average yield of 7.5 t/ha (900,000 tons produced on 120,000 hectares) (FAOSTAT).

Occurrence and Control of Potato Diseases and Pests

Late Blight (LB) (Phytophthora infestans) is reported as the most widespread and destructive pathogen affecting potato production in Kenya. Surveys of farmers elsewhere in the region (including Rwanda, Burundi, and Uganda) have indicated that susceptibility to LB ranks as high as market acceptance and general eating and cooking quality as a factor for farmers to abandon a particular variety (Lutaladio et al. 1995, p. 556).

For general information about LB, please see several sites posted by the International Potato Center:

- Global Initiative on Late Blight (GILB) Home Page with links under “General Information;”
- International Potato Center’s Late Blight Overview
- GILB Kenya Profile.

The possibility of tomato and potato serving as alternate hosts for \textit{P. infestans} in Kenya and Uganda has been investigated, but so far with no evidence of occurrence. Please see "Host Specificity of \textit{P. infestans} on Potato and Tomato in Uganda and Kenya."

The development of LB resistant varieties has been a focus of the Kenya Potato Programme under the direction of the Kenya Agricultural Research Institute (KARI), leading to the release of the Tigoni and Asante varieties in 1996 (based on material provided by CIP) and the identification of several promising clones. The programme has also evaluated several cultivars under a variety of fungicide treatments to determine relative responses. Screening for LB resistance has been
underway using two populations, A (with vertical resistance based on R-genes) and B (a newer breeding population where horizontal resistance to LB has been improved in the absence of major R-genes) (KARI 2000, p. 81).

KARI has also conducted studies to evaluate lower cost measures used by farmers to control LB, including the application of a mixture made of stinging nettle (apparently *Urtica massaica*, though not indicated) and Omo (presumably the commercial brand of laundry detergent). Although this treatment was not as effective as a commercial fungicide, Ridomil, blight scores were nevertheless lower and yields higher than observed for the control of no treatment. On a benefit to cost basis, the stinging nettle treatment was impressive, at over two to one (KARI 2000, p. 83). This treatment is apparently not a common practice in the region, at least not yet, but an example of an association of stinging nettle (likely a different species) with potato in Sweden is found at Ecology and Society.

**Viral Diseases** are becoming a serious constraint given the very intensified production system in Kenya and the lack of “certified seed,” free of viral infection. Most potatoes are grown from tubers retained by farmers from previous harvests or acquired from markets or neighbors, which induces the gradual debilitation of tubers via viral infection. Khurana and Garg (2003) report that commercially sold tubers are frequently infected.

Two examples of yield reductions over time are (Khurana and Garg, 2003, p. 181):

- Viral infection PVX (Potato Virus X) reportedly decreased tuber yields in the variety Kenya Baraka by 21 percent and the variety Roslin Eburu by 10 percent;
- PLRV (Potato Leaf Roll Virus) was reported to decrease yields of Kenya Baraka by 68 percent and Roslin Eburu by 35 percent.

For general information regarding potato viruses, please see:

- UC IPM Online, from the University of California, Davis: Potato, Mosaic Diseases Caused by Potyviruses. http://www.ipm.ucdavis.edu/PMG/r607101411.html

(The sites from Cornell and Davis do not focus on Kenya, but both contain some relevant information and photos. While at the Cornell site, look for Spinning Spuds. http://vegetablemdonline.ppath.cornell.edu/PhotoPages/Spin/Pot_spin.html)

**Bacterial Wilt** (*Ralstonia solanacearum*) can be very destructive at the lower altitude, warmer extreme of the potato’s range in Kenya. Since the pathogen is transmitted through tuber seed into the soil, availability of “clean” seed and adequate rotations are the most effective control measures (Lutaladio et al. 1995, p. 555). As with other diseases, the unavailability and high cost of disease-free seed tubers is a major constraint (Kinyua et al. 2001).

For more information, please see the CIP site, Bacterial Wilt Overview

**Potato Tuber Moth (PTM)** (*Phthorimaea operculella*) is also becoming a greater hazard, possibly also due to reduced fallow periods and more intensified rotations. The moth has high reproductive potential and is apparently developing resistance to some insecticides. It can cause damage to foliage and to tubers in the field, but has especially high potential to destroy potatoes in storage, sometimes to nearly total loss (Lutaladio et al. 1995, p. 557).

Stefan Keller (2003) conducted research on the ecology of the PTM in Njabini, north of Nairobi at 2,550 masl, high enough for frost to be an occasional hazard. Annual precipitation is approximately 800 mm. Two potato crops are grown, from April to July and from October to January. PTM infestation (both foliar and tuber) over three years was highly variable, apparently due in large part to variations in rainfall, as well as temperature. A period of dry weather and frost one year caused foliar damage, leading the PTM to infest tubers, which were also more vulnerable due to cracks in the soil caused by dry conditions. Another year, of higher precipitation and earlier harvest, experienced far less PTM damage. In general, the study revealed very high potential damage from PTM infestation in Kenya (higher than reported values in Peru and Egypt). Populations of PTM often fluctuate with temperature, which in Kenya is generally a more consistent factor, rarely beyond the tolerance range of PTM. Of readily available management practices, timely harvest limited damage, as tubers left in fields for longer periods were highly infested.

KARI has conducted trials to develop Integrated Pest Management (IPM) strategies to control PTM, especially since treatment with commercial insecticides can be very dangerous. Several potentially effective components have been identified, including a mixture of *Bacillus thuringiensis* (BT) var. kurstaki and fine sand, which protected stored potatoes for three months. Other materials being evaluated in mixtures include the granulosis virus, neem tree extract, *Lantana* (shrubs and herbaceous perennials of the family Verbenaceae) and pyrethrum (a naturally occurring insecticide harvested from Chrysanthemum flowers widely grown in East Africa).
For more information on the use of the granulosis virus, please see Peruvian Virus Knocks Potato Tuber Moth, reported by Michigan State University and Rodale, based on research conducted by CIP. http://fadr.msu.ru/rodale/agsieve/txt/vol3/1/a8.html

VARIETIES AND SEED SYSTEMS

Varieties

As of around 1980, nearly all potatoes grown in Kenya and elsewhere in Africa were derived from seed tubers of European origin, and were susceptible to a wide range of viral, bacterial, and fungal diseases, as well as insect pests (Lutaladio et. al. 1995, p. 556).

Khurana and Garg (2003, p. 181) indicate that the main varieties currently cultivated in Kenya include: Kerr's Pink, Maritta, B-53, Kinongo, Ngabati, Ngorobu, Annet, Thiba, B-59, Desiree, Tako, Dutch Robijn, Tanganyika, Pimpernel, Kenya Baraka, Roslin Eberu, Roslin Tana, Asante, Tigoni, and Nyayo. Of these, Nyayo is noted as the most popular and widely cultivated (ibid). Most have been developed and released via local Kenya government authority, but two (Asante and Tigoni) are CIP crosses selected in Kenya. Another variety not included above, Kenya Dhamana, was distributed by CIP (personal communication, Keith Fuglie, CIP).

From 1994 to 1996, eleven potato clones with potential LB resistance (all provided by CIP) were tested across a wide range of environmental conditions, variable by altitude, rainfall, soil type, and season of cultivation. No fungicides were applied, but the range of yields (13.44 to 37.91 tons per hectare) suggests that the "recommended normal agronomic practices for potato production" were very high-input. Two clones, 381381.13 and 381381.20, exhibited mean superior performance across all environments, and as of 1996, were being multiplied for larger scale release. Two others, 387792.5 and 378699.2, appeared to be well adapted locally to some sites (Lung'Aho et. al. 1998).

The Formal Seed System

The formal system refers to seed tubers produced and distributed by state-sponsored institutions (possibly with some involvement of the private sector and/or non-government organizations). Seed from the formal sector has generally been subject to an inspection process intended to assure that the seed is of the variety claimed, with low incidence of disease or pest infestation, and otherwise viable. Such seed is often referred to as "certified seed," although the precise definition of this term is locally variable.

The Agricultural Development Corporation (ADC) was responsible for the provision of certified seed to farmers. As of 1989, ADC provided less than one percent of national demand for potato seed tubers, primarily because certified seed was too expensive for most farmers, who therefore rely on their own retained seed or other sources from the "informal" system (Gebremariam et. al. 119, p. 584). The ADC system has apparently not been functional for several years.

More recently, the Kenya Agricultural Research Institute (KARI) has taken over responsibility for the selection and multiplication of promising varieties, but with the more active involvement of farmers responsible for multiplying certified seed. The KARI Seed Potato site provides photos and brief descriptions of varieties currently being multiplied.

CONSUMPTION, STORAGE, AND MARKETING

Consumption

Since nearly all potato production is locally consumed (imports and exports are negligible), consumption can be estimated by total production. Kenya's most current (2003) production estimate of 900,000 tons, consumed by 31,540,000 people, averages out to 28.5 kg annual per capita consumption (FAOSTAT). This is high by world standards, but much less than comparable figures for some regions, such as the Andes.

Potatoes are often eaten daily, especially in producing areas, typically prepared as stews or mashed with maize and beans, or peas and other pulses to which some green vegetables might be added (KMoA 1998, p. 13). However, unlike some other regions where rural people consume far more potatoes than their urban counterparts, in Kenya potatoes are greatly in demand by urban residents, in various forms such as chips (french fries) and crisps (potato chips), and served in restaurants. White varieties such as Nyayo and Tana are generally favored for chips, though some facilities prefer red varieties since they supposedly require less oil and yield a higher volume of chips than white varieties (KMoA 1998, p. 23). Potato is considered a high quality and prestigious food, so that higher consumption rates of potatoes are associated with higher incomes. In Kenya, potato is not considered a "poor person's food" (KMoA 1998, p. 40).
Storage

Since there are usually no long intervals between harvests (typically two to three months), storage of ware potatoes (for sale or consumption) is not a universal practice in Kenya. In some areas, such as Meru District, farmers have developed their own storage structures, constructed of cemented floors, wooden walls, and corrugated iron roofs. At higher altitude locations where the climate is colder, such as the Timau Region, farmers store potatoes outside the house covered with dry grass, which can be effective for up to three months. Storage structures promoted by the National Potato Research Centre in Tigoni (possibly diffused light stores, but not specified) have not been widely adopted. Seed tubers are often stored in pits lined with dry leaves and covered with straw, where they are likely to sprout prior to being replanted (KMoA 1998, p. 12).

Marketing

Farmers in Kenya generally sell an average of 25 to 45 percent of their total crop. The percentage of retail prices received by marketing factors (transportation, commissions, market fees, etc.) can vary from 15 to 60 percent (Lutaladio et. al., 1995, p. 555).

The most commonly accepted unit of marketing potatoes is the sisal bag, of roughly 100 kgs. Some local governments, such as the Meru District Agricultural Committee, have attempted to enforce the use of the uniform "flat bag" as a means to protect farmers from exploitation by traders. However, since the Nairobi market requires an "extended bag," the "flat bags" are off-loaded so that a sisal net extension can be woven onto each bag, increasing weight to about 130 kgs. From 100 "flat bags," traders sell approximately 72 "extended bags" (KMoA 1998, p. 15).

The system, if not entirely efficient, is well organized and provides a major source of employment. Rural brokers are directed by traders, who often own the lorries which transport potatoes, to assemble crops at an agreed price several days prior to a trip. Brokers in rural areas contact farmers and often leave bags, and sometimes a deposit, toward a promised quantity of potatoes to be delivered. Brokers are responsible to traders for maintaining quality standards and correct quantities, i.e. checking that bags are properly filled.

At central markets, such as in Nairobi, market brokers usually approach lorry operators and offer to sell potatoes at negotiated prices and commissions. The wholesale market in Nairobi consists of two structures built in the 1960s when Nairobi was a much smaller city. Since the facilities are now much too small, trading often takes place in the surrounding streets. Lorries arrive late at night and hand over their freight to brokers, who prepare sales for the opening of the market at 4:00 am.

Smaller-scale agents distribute smaller quantities down the line of the marketing system, which must continue providing services such as repackaging and hauling, ultimately on the backs of porters. The overall system seems fairly consistent throughout the year; traders have reported that transportation hire rates do not widely vary (KMoA, 1998, pp. 15-18).

The farmgate price of potatoes is likely to be less than half the ultimate retail price, but many factors can affect prices at all stages, including not only the relative supply and demand of potatoes, but also the availability of maize (often a factor of the rains), and the effective distance from a rural site to wholesale and retail markets. For the survey carried out by the German GTZ, a 100 kg bag of potatoes sold in Kenya Shillings (KSh) for:

- 900 at the farm gate in Meru District;
- 1,300 at the Meru wholesale market;
- 1,385 Nairobi wholesale;
- 2,500 Nairobi retail.

Note: The exchange rate of the Kenya Shilling was not provided, but as of December 2004 was quoted at approximately 81/ US$1 (Greenwich Mean Time).

RESEARCH FACILITIES AND CONTACTS

The home page of the Kenya Agricultural Research Institute (KARI) http://www.kari.org/ provides information on a wide variety of crops and issues.

The Regional Potato and Sweetpotato Improvement Network in Eastern and Central Africa (PRAPACE) http://www.asareca.org/prapace/ developed out of PRAPAC, a network established in 1982 by the national research institutions of Burundi, Rwanda and the Democratic Republic of Congo to coordinate their potato programs. PRAPACE currently collaborates with potato and sweetpotato programs of ten countries (Burundi, Democratic Republic of Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda), all members of the Association for
Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). The International Potato Center (CIP) provides support in the forms of improved germplasm, scientific information, training, and administrative assistance. The United States Agency for International Development (USAID) funds the network.

The Famine Early Warning System (FEWS), also supported by USAID, sponsors FEWSNET, which publishes reports of climate and food security status by region of several countries of Africa, including Kenya (in English).

CONTRIBUTORS

Kelly Theisen is the principal contributor to the revised (2005) text of the Kenya potato chapter, some sections based on the previous edition by R.E. Rhoades, R.J. Hijmans, and L. Huaccho.

Keith Fuglie, who provided information via personal communication, is the leader of CIP's Impact Enhancement Division and former CIP Regional Representative to East and Southeast Asia and the Pacific.

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