UNDERSTANDING THE PRODUCTION OF THE MAJOR TROPICAL/SUBTROPICAL ROOT CROPS:

CASSAVA, POTATOES, SWEET POTATOES, YAMS, AND COCOYAMS

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Volunteers in Technical Assistance (VITA)
1815 North Lynn Street, Suite 200
Arlington, Virginia 22209 USA
Telephone 703/276-1800
Cable VITAINC
Telex 440192 VITAUI

PREFACE

This paper is one of a series published by Volunteers in Technical Assistance to provide an introduction to specific state-of-the-art technologies of interest to people in developing countries. The papers are intended to be used as guidelines to help people choose technologies that are suitable to their situations. They are not intended to provide construction or implementation details. People are urged to contact VITA or a similar organization for further information and technical assistance if they find that a particular technology seems to meet their needs.

The papers in the series were written, reviewed, and illustrated almost entirely by VITA Volunteer technical experts on a purely voluntary basis. Some 500 volunteers were involved in the production of the first 100 titles issued, contributing approximately 5,000 hours of their time. VITA staff included Leslie Gottschalk and Maria Giannuzzi as editors, Julie Berman handling typesetting and layout, and Margaret Crouch as project manager.

VITA Volunteer Dr. Nail Ozerol, the author of this paper, is the director of N.H. Ozerol & Associates, a consulting firm specializing in nutrition and preventive medicine. He was formerly on the faculty of the Department of International Health, College of Medicine, Howard University, and that of the Center of Nutrition, Meharry Medical College. He has consulted on nutrition in several African countries. Dr. Herbert F. Massey, reviewer of this paper, has been a VITA Volunteer for 14 years. He is the director of International Programs for Agriculture at the College of Agriculture, University of Kentucky. He has consulted on agricultural teaching and/or research projects in several tropical countries throughout the world.

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UNDERSTANDING THE PRODUCTION OF THE MAJOR TROPICAL/SUBTROPICAL ROOT CROPS: CASSAVA, POTATOES, SWEET POTATOES, YAMS, AND COCOYAMS

By VITA Volunteer Nail H. Ozerol

I. INTRODUCTION

Root crops is a general term commonly used for a wide variety of food plants that have an underground storage organ known as a root, tuber (rhizome), corm, or bulb. Root crops are rich in starch, and low in protein and oil. They are excellent sources of calories. Some are consumed as major staples, such as cassava, potatoes, sweet potatoes, yams, and the aroids (cocoyams). Others, such as carrots, onions, garlics, parsnips, and radishes, are used as fresh vegetables.

Historically, governments and academic centers have paid relatively little attention to root crops as compared to grain crops. These crops have been regarded as inferior food, and produced and consumed only by the subsistence farmers in the developing parts of the world. In recent years, however, the tropical root crops have been "rediscovered" by the research communities and others who are concerned with the food and nutrition problems of low income people.

The tropical root crops, in general, have a great potential in meeting basic food and energy needs of the developing world, and therefore deserve to be fully explored in rural development projects and strategies. Reliable estimates suggest that annual tropical root crop production is in the range of 170 million metric tons, roughly equivalent, in calorie content, to 50 million metric tons of grain. There is now a sharp increase in scientific research and investigation in every aspect of this crop in certain well-established research centers, such as: International Institute of Tropical Agriculture (IITA), Ibaden, Nigeria; International Center for Tropical Agriculture (CIAT), Cali, Colombia; and International Potato Center (CIP), Lima, Peru. The following factors have been responsible for the growing international interest in the food potentials of these crops:

- A growing interest in and appreciation of a large group of rural poor who depend on these crops for their basic calories.

- Increased population growth, and the relative rise in the prices of fossil-based energy have contributed a great deal to interest in root crops as source of food and energy.

- World food shortages, and the ever-increasing need to explore new frontiers in order to alleviate world hunger.

ADVANTAGES AND DISADVANTAGES OF ROOT CROPS

Root crops have the following advantages:

- They are rich in starch and calories.

- They grow well in a wide range of soil types so long as there is adequate rainfall.

- They require relatively little care in terms of labor and other inputs used in their production.

- Unlike cereals, they can be stored without processing or drying in a highly humid environment.

- Relatively few serious pests and diseases plague root crops compared with those associated with cereals and legumes.

- Some root crops, such as cassava, can be left in the ground as food resources until required.

The disadvantages of root crops are as follows:

- They are low in protein and oil.

- Their awkward shapes and large size make them prone to bruising in transit and secondary infection by micro-organisms.

- They are bulky to handle in trade, marketing, and storage due to their high moisture content.

MAJOR USES OF ROOT CROPS

The following three major uses of root crops, both tropical and subtropical, are now universally recognized.

Root Crops as Food

Root crops are a major source of food and calories in many tropical countries. The Food and Agriculture Organization estimates for 1974 suggest that root crops provide 20 percent of the total caloric intake for 11 countries, and nearly 40 percent or more of all calories in Zaire, Ghana, and Togo. Again, they are basic calorie sources in Brazil and Indonesia and also provide several other nutrients.

Root crops are usually prepared to be eaten in another dish, such as in various stews. The high starch content in the crops helps to thicken the liquid base, so that it adheres to the meat or vegetables in the stew.

Root Crops as Feed

The use of root crops as feedstuffs in developing countries is expanding. Recent studies in Venezuela have demonstrated that high yields of good-quality protein are obtainable from cassava leaves at reasonable cost for use in livestock feeding. Similarly, cassava leaves have been used for commercial exports as livestock feeds in Thailand. Almost all of Thailand's cassava root crop is exported as dried chips, sometimes pelleted, primarily for use as animal feed. In general, cassava products can be successfully substituted for alternative sources of feed for different species of livestock in both tropical and subtropical countries.

Root Crops as Substrate

Among the most interesting technological developments in the use of root crops are the fermentation processes for the manufacture of sugar, ethyl alcohol, and single-cell protein. Cassava, especially, among a few others, has been used extensively as a substrate (raw material) for the production of ethyl alcohol.

II. MAJOR ROOT CROPS

The five major root crops of the tropics and subtropics are cassava, potatoes, sweet potatoes, yams, and cocoyams. These and other important root crops are listed in Table 1.

Table 1. Important Root Crops

Common Name	Genus	Family
Beet	*Beta vulgaris*	Chenopodiaceae
Carrot	*Daucus carota*	Umbelliferae
Cassava	*Manihot esculenta*	Euphorbiaceae
Cocoyam, Asiatic	*Colocasia esculenta*	Araceae
Cocoyam, Tropical American	*Xanthosoma sagittifolium*	Araceae
Horseradish	*Rorippa armoracia*	Cruciferae
Jerusalem Artichoke	*Helianthus tuberosus*	Compositae
Onion	*Allium cepa*	Liliaceae
Parsnip	*Pastinaca sativa*	Umbelliferae
Potato	*Solanum tuberosum*	Solanaceae
Radish	*Raphanus sativus*	Cruciferae
Rutabaga	*Brassica napobrassica*	Cruciferae
Sweet Potato	*Ipomoea batatas*	Convolvulaceae
Yam	*Dioscorea*	Dioscoreaceae

CASSAVA

Cassava (*Manihot esculenta*, Euphorbiaceae) is a perennial shrub native to South America that is now grown throughout the tropics. Other common names for cassava are tapioca, mandioca, manioc, sagu, and yuca. Cassava was brought into cultivation by the American Indians probably 4,000 years ago, was later introduced to West Africa in the sixteenth century, and then spread to other tropical regions of the world.

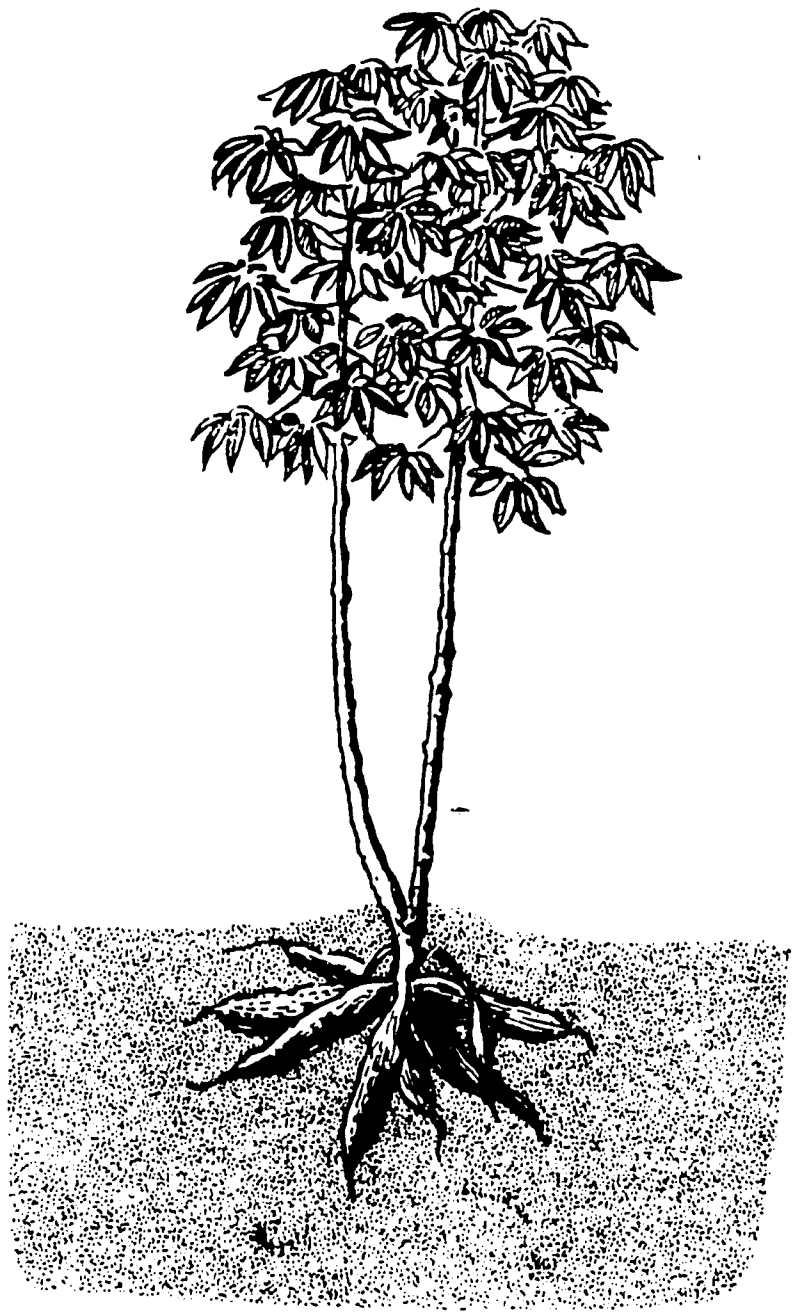

Figure 1. A Cassava Tree

Source: Bustamante, A.A, Improve Your Cassava Crop (Oklahoma City, Oklahoma: World Neighbors), p. 1.

For a variety of reasons, recent growing research interest in root crops has focused mainly on cassava. It is a major source of calories for some 300 million people in the developing countries of the world. It is one of the world's most efficient plant converters of solar energy to carbohydrates. It yields more calories of food per unit input of labor efforts than any other crop. It is relatively resistant to insects and plant diseases, and requires few inputs of a traditional production system. It is adaptable to a wide range of agro-climatic conditions, and performs surprisingly well on acidic soils of poor fertility. It can be left in the ground until it is needed.

Fresh cassava roots compare favorably with the other root crops in terms of calorie content, but rank at the bottom in terms of protein. Cassava roots are generally rich in calcium and ascorbic acid, and contain significant amounts of thiamine, riboflavin, and niacin. The cassava leaves are rich in high-quality protein, and are consumed in most of the tropical countries.

Production

Cassava is by far the most economically important of the tropical root crops, with annual production exceeding 100 metric tons grown on some 12 million hectares. It is produced in more than 80 countries, but fewer then 20 countries account for 90 percent of production.

A major factor behind the extensive production of cassava is its adaptability to a wide range of soil and moisture conditions. It can be successfully grown in areas with rainfall ranging from 500 to 5,000 millimeters. Except at planting, cassava can withstand periods of prolonged drought and is, therefore, a valuable crop in regions of low or uncertain rainfall.

Light, sandy loams of medium fertility give the best results, and the crop can be grown successfully on soils with a pH ranging from 4.5 to 9.0.* Saline and swampy soils are not suitable for cassava production.

The ideal temperature for cultivating cassava ranges from 18°C to 35°C; growth stops at 10°C. Cassava is perennial in the tropics, and annual in the temperate zone. It can be grown at altitudes up to 2,000 meters.

Cassava is grown both as a single crop, and in combination with sorghum, maize, groundnuts, cowpeas, yams, sweet potatoes, upland rice, and certain other vegetables.

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*pH indicates the acidity or alkalinity of the soil, and is based on a scale of 0 (acid) to 14 (alkaline) with the midpoint of 7 indicating a neutral soil condition.

Under the typical slash-and-burn agriculture of the tropics, cassava stem sections are hand-planted just before the rainy season. If all goes well, within as little as seven months a number of starchy roots can be harvested from each plant; however, the best yields are not obtained until about 16 months pass. If allowed to grow for too long in the soil, the roots become rather woody and less edible.

Cassava is planted on ridges and on flat ground, but ridge planting is more common. Cuttings about 20 to 30 centimeters long are inserted in the soil at a depth of about half their height, often at an angle of 30 to 40 degrees. Cuttings sprout 7-14 days after planting, and root bulking begins during the second month after planting. The crop is planted in May-June, and harvested the following September-December. Cassava has a high potassium requirement. If potassium is not present in the soil in sufficient amounts, yields are reduced, and the tubers have a low starch content and higher hydrogen cyanide (HCN) content.

Harvesting is done by hand by digging up the tubers after cutting the tops off the plants. With large-scale production, the tubers can be mechanically ploughed up, but the yields are often reduced because a higher percentage of tubers is left in the ground. Once harvested, the tubers deteriorate rapidly and begin to rot after 48 hours. Cold storage, where possible, at 0°C to 2°C and 85 to 95 percent relative humidity has been reported to extend the storage-life for periods up to 6-1/2 months.

Yields vary greatly depending on the variety of cassava, soil, climate, age at harvest, etc. The average is about nine metric tons of fresh roots per hectare. Production of cassava in 1975 exceeded 100 million metric tons (fresh roots), of which more than 40 percent was produced in Africa, about 30 percent in South America, and the remaining in Asia. Approximate estimates suggest that cassava production since the early 1960s expanded by 25 percent.

Uses

Cassava is used in a number of ways. In addition to its consumption by humans and as feedstuffs by livestock, it is now commonly used as a raw material (substrate) in the manufacture of various industrial products. Starch is the most important such product, but in Brazil the roots are used to make alcohol.

As a foodstuff, cassava is consumed as a boiled or roasted vegetable or as paste, meal, or flour. The whole root may be boiled and has a sticky, heavy consistency, and of itself is rather tasteless. In Brazil, the roots are usually shredded, then heated and dried to make a meal known as "farinha de mandioca."

In Indonesia, the roots are sectioned, dried in the sun, and later ground into meal. In the making of tapioca, an important export from Indonesia, the peeled roots are grated, soaked with water, kneaded, strained, dried, and heated to hydrolyze the starch to sugar, and gel particles into "pearls" while being stirred on a grill. In Jamaica, the roots are ground into a mush called "bami" or formed into cakes known as "casabe." The better known preparations include "gari" and "fufu" in West Africa.

Cassava Toxicity

A major problem with the use of cassava is the toxicity from the cyanide compounds found in the fresh roots. The cyanide is concentrated in or near the skin of the root, and is freed into its active form when the skin is broken. In this manner, the cyanide compound contributes to the plant's resistance to pests. The cyanide content, however, varies from species to species, and changes under environmental conditions, such as humidity, temperature, and age of plants. However, in areas where cassava is the staple food, chronic cyanide poisoning can result if the cassava is not processed properly. Chronic cyanide poisoning is notable in some areas of Africa, particularly in Zaire. Recent studies in the Lake Kivu region of Zaire suggest that a cassava-based diet inhibits iodine uptake by the thyroid gland and may lead to goiter, birth defects, mental retardation, and other chronic disorders. Proper processing of cassava for consumption is the most effective solution to the problem of cyanide poisoning and its consequences.

Diseases and Pests

Cassava is susceptible to various pests and diseases. Leaf mosaic, a virus disease transmitted by white flies, is the most serious disease of cassava. It can be spread by infected cuttings.

Bacterial blight, a new and potentially disastrous disease, was first detected in West Africa in 1972. White thread, a root disease, has been reported to cause crop losses of 20 percent or more in Ghana. Other minor diseases are brown leaf spot, white leaf spot, and anthracnose.

The most serious insect pests are white flies, scale insects, and the variegated grasshopper. Nematodes are also very serious cassava parasites, particularly in West Africa. Various species of termites have also been known to cause damage to cassava crops, while rodents and wild animals often attack the roots.

POTATO

The common potato (*Solanum tuberosum*, Solanaceae) is a member of another large and important plant family, Solanaceae, which includes, among many others, eggplant and tomato. The genus *Solanum* includes more than 2,000 species.

The potato was first seen by Europeans in 1537 when the Spanish landed in what is now called Colombia, and was brought back to Europe by 1570. It was cultivated throughout the continent before 1600, and in Ireland by 1663. The cultivated potato is said to have been first introduced into North America in 1621.

Potatoes are the leading starchy root crop of the subtropical countries, and one of the eight leading staple food crops of the world. Annual production of potatoes is approximately twice that of all other edible root crops combined. However, because of its limited climatic adaptability, less than 10 percent of production occurs in developing countries. The International Potato Center (CIP) in Peru is developing new varieties of this nutritious root crop, which perform well under a variety of soil and climatic conditions.

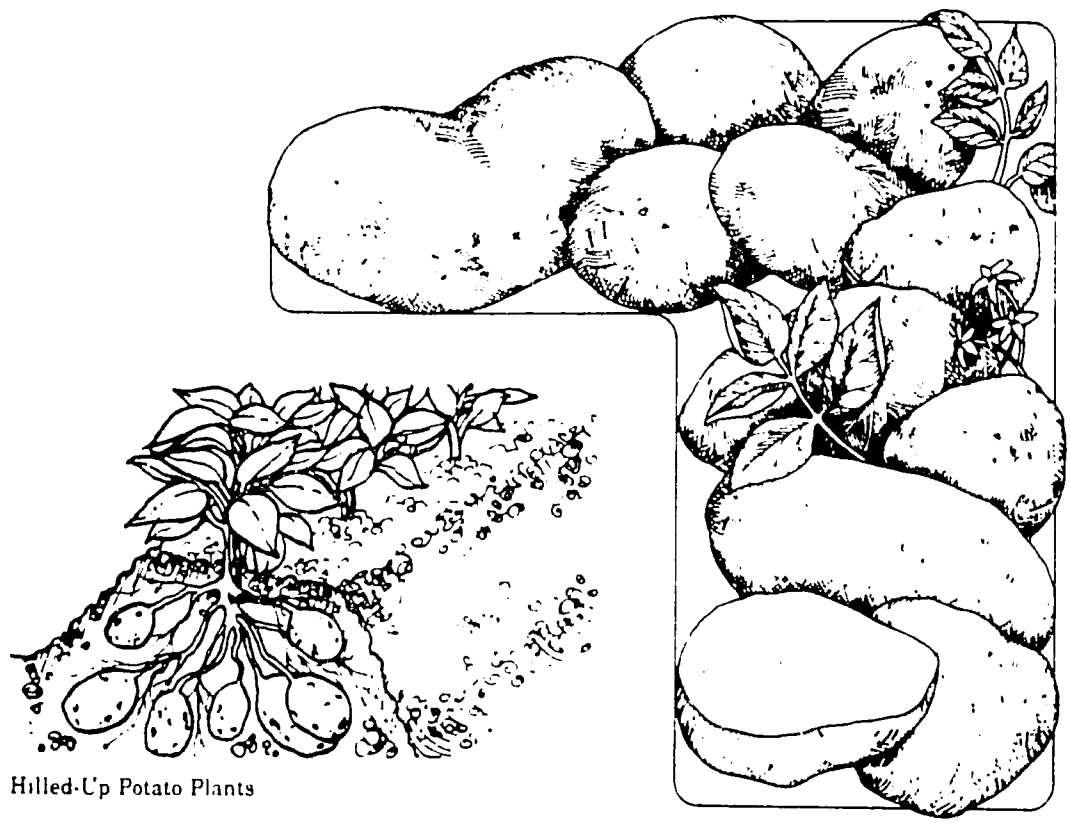

Figure 2. Potatoes

Source: Rodale Press. *The Organic Gardener's Complete Guide to Vegetables and Fruits* (Emmaus, Pennsylvania: Rodale Press) pp. 254-255.

Among the root crops, the potato is known for its high protein content. It is almost equal to rice on a dry weight basis, and with a protein quality approaching that of beef. With its high yields and short maturation periods, the potato outranks all major world food crops in protein production per unit of time. The food value of the potato varies depending on the variety, growth, environmental conditions, storage, and handling. Its composition consists of 70 to 80 percent water, 8 to 28 percent starch, and 1 to 4 percent protein. It also contains vitamins such as riboflavin, ascorbic acid, and trace elements. It is an important source of high-quality nutrients for people in the tropical highlands. The potato has been a continuous object of research and investigation all over the world, with special focus of interest in the International Potato Center (CIP) in Peru. The Center is attempting to increase the tolerance of the crop to high temperatures, and once it is accomplished, then it is likely that larger areas of West Africa will be open to cultivation.

Production

Potatoes are grown as a single crop or in combination with sorghum, millet, maize, cowpeas, groundnuts, sweet potatoes, and other vegetables. Propagation is done by tuber, either whole or cut. Whole tubers are less liable to rot in the soil. Planting material should be free from diseases, pests, and damage. Certified potato "seeds," free from virus, should be used when possible. Potatoes may be planted by hand or mechanically, and the crop is usually planted on ridges at a depth of 5 to 15 centimeters.

Most potato varieties have very specific temperature requirements, thereby limiting the adaptability of this crop in tropical regions. Tuber formation is retarded when the soil temperature rises above 20°C; above 29°C, little if any, tuberization takes place. Although young potato plants are very susceptible to hard frosts, most varieties will tolerate light frosts.

Potatoes require a continuous supply of moisture. Evenly distributed rainfall is considered essential, and drought, even for short periods, can have serious effects on yields and quality of the crops. Well-drained peat soils are particularly suited; however, potatoes could grow on most soils if drainage is adequate. A deep, well-drained loam, or sandy loam, with a pH of 5 to 5.6 is considered to be the best. Potatoes respond well to manures and chemical fertilizers, and good yields can be obtained only with adequate fertility. Fertilizer requirements vary greatly depending on the variety and growing conditions.

Potatoes do not compete well with weeds, and timely, efficient weeding, by pulling or tillage, is essential. In temperate zones, the crop is often repeatedly hoed, up to five times during

the growing season. Normally, the crop is ready for harvest in three to four months. Harvesting should be done on a dry day, when the tubers are mature. The crop can be harvested by hand or mechanically. If it is harvested mechanically, a wide range of equipment can be used, including diggers, spinners, and ploughs. Harvested tubers should be stored temporarily in a shaded, dry, and well-ventilated place for 7 to 10 days to allow the skins to harden before the potatoes are prepared for market or storage. Potato yields vary with variety, length of growing season, climate, and the type of soil. With efficient farming methods in temperate climates, yields well in excess of 25 metric tons per hectare are quite common. Yields are lower in the tropics, averaging about 14 to 15 metric tons per hectare.

Uses

Potatoes can be eaten boiled, roasted, baked, fried, or mashed. They can be made into fried chips or crisps, dehydrated and flaked, or made into flour.

Potatoes can be pulped and fermented to produce alcohol. Potato tubers make an excellent livestock feed and can be fed fresh or dried and used in the form of a meal.

Diseases and Pests

Potato crops are subject to a number of diseases, some of which are of great economic importance in both developed and developing countries. Brown rot, or bacterial wilt, is the most serious potato disease in West Africa. The disease is carried by seed tubers. Other bacterial diseases include soft rot, ring rot, and late blight. Several other diseases are also of considerable importance. Among these are virus diseases that can cause crop losses. Virus-free planting stock is essential since there are no effective treatments for these diseases. Finally, a number of pests, particulary aphids and nematodes, have been found to cause economic losses. These pests not only harm the crop, but also spread virus diseases such as leaf roll and mosaic.

SWEET POTATO

Sweet potatoes (Ipomoea batatas, Convolvulaceae) are widely grown in tropical, subtropical, and warm temperate areas of the world. They originated in tropical America and likely spread to the Pacific before the time of European exploration. Japan is probably the leading sweet potato producer; it is a national staple and largely consumed there. In many other parts of the world, sweet potato is utilized as feedstuff for livestock.

Figure 3. Sweet Potatoes

Figure 4. The Underground Portion of Sweet Potatoes

Source: Mike Kane, "The Surprising Sweet Potato," Organic Gardening and Farming, Vol. 25, No. 5, May 1978, p. 61.

The sweet potato, although a perennial, is normally cultivated as an annual crop. The crop under normal circumstances is harvested from three to eight months after planting, depending upon the variety and environmental conditions. Sweet potato varieties vary considerably in their adaptability to soil and other conditions. They require at least 500 millimeters of rain during the growing season. For good yields, an annual rainfall of 750 to 1,250 millimeters is necessary, with drier weather as the crop reaches maturity. The sweet potato can tolerate lengthy dry periods once roots are established. However, yields are greatly reduced if soil moisture is inadequate during the period when root storage begins. The sweet potato is easily adapted to a considerable range of soils, but is sensitive to alkaline or saline conditions. It does not tolerate waterlogging. Warm days and nights are essential, and a mean temperature above 24°C is required for optimum crop growth. At least 25 millimeters of moisture per week for four to five months is essential. Increased altitude appears to result in increased protein content of the roots. Sandy-loam soil, with a pH range from 4.5 to 7.5, appears to be ideal for satisfactory growth. Tubers reach their ideal conditions at four to seven days of short-term storage with 85 to 90 percent humidity. After harvest, the tubers should be stored at 12 to 16°C with 85 to 90 percent humidity, or where warm.

Tubers are rich in carbohydrates, vitamin A, and vitamin C, and also contain significant amounts of calcium and iron. Studies and reports of the International Institute of Tropical Agriculture indicate that the yield of sweet potatoes under favorable conditions is between 20 and 30 metric tons per hectare, and experimental yields greater than 40 tons/hectare have been obtained.

Production

In most parts of the world, the sweet potato generally is a home garden crop that never goes to market. It is mainly grown in combination with other crops such as sorghum, millet, maize, rice, cowpeas, groundnuts, yams, cassava, potatoes, and tobacco. It may be propagated by tubers, slips, or vine cuttings. Cuttings are the most commonly used planting material. In slip propagation, tubers are planted in a nursery bed. The new plants, which sprout from the various buds of the tubers, are known as slips. They are separated and planted and are relatively free from soil-borne diseases, and the tubers produced are of a more uniform shape and size. Vine cuttings 20 to 45 millimeters long with seven or more nodes are planted one-half to two-thirds of their length in the soil.

Roots sprout from the subterranean nodes within 5 to 15 days depending on the quality of the planting material and the environmental conditions. Once the crop is established, it requires minor weeding if the land has been properly prepared, and is not

over-infested with weeds. The growing period generally varies from four to six months depending upon the variety. At maturity, the stems turn from green to brown.

Harvesting usually takes place during the dry season in November and December. Mechanical harvesting of the crop is possible but losses can be considerable. Sweet potato tubers are very perishable, and the methods used to harvest the crop could have a very significant effect upon the market quality and storage life of tubers.

Uses

Sweet potatoes are harvested primarily for human consumption. In the tropics, the major proportion of the crop is eaten straight from the ground as a vegetable, after boiling, baking, or frying. In Malawi, they are sometimes boiled or roasted and pounded with groundnuts to produce "futali." In some areas, notably India and parts of East Africa, the peeled tubers are sometimes sliced and dried in the sun to produce chips, which are often ground into flour. Sweet potatoes are also a source of starch and are used as livestock feed.

Diseases and Pests

Diseases that attack the sweet potato tubers during storage are more serious than those affecting the crop during cultivation. Black rot, for example, can be serious especially when the tubers are damaged during harvesting. The sweet potato weevil is the major insect pest. Its larvae feed on the roots and tubers. Proper crop rotation helps in its control. Chemical control also appears to be promising. Recently, several weevil-resistant varieties have been isolated.

YAMS

The true yam (*Dioscorea*) is not to be confused with the sweet potato, which is sometimes incorrectly termed a "yam." The genus *Dioscorea* includes several hundred species, but only a few are of importance as food crops. Of these, the Asiatic species *Dioscorea alata* (commonly called the greater yam), and two closely related Western African species, *Dioscorea cayanensis*, (yellow yam) and *Dioscorea rodundata* (white yam), are the most common and economically important.

Yams originated in the Far East, spread westward, and have since evolved independently in the Eastern and Western Hemispheres. Yams are now widely grown throughout the tropics, under both rain forest and savanna conditions, where there is a combination of adequate moisture and good drainage. Yams require adequate

Figure 5. Typical Yam of the Select Variety "Florido"

Source: United States Department of Agriculture, Tropical Yams and Their Potential: Part 3, Dioscorea alata, Agricultural Handbook No. 495. Washington, D.C.: USDA, 1976, p. 14.

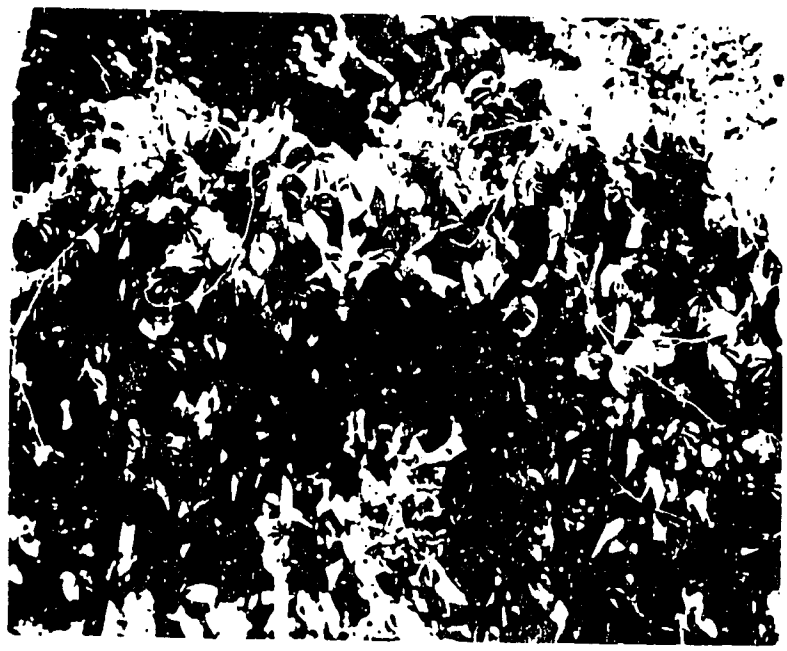

Figure 6. Typical Yam Vines Growing on Bamboo Poles for Support

Source: United States Department of Agriculture, Tropical Yams and Their Potential: Part 2, Dioscorea bulbifera, Agricultural Handbook No. 466. Washington, D.C.: USDA, 1974, p. 3.

moisture throughout the growing period. In several countries of West Africa--the major production zone, with 66 percent of the world's crop--yams are becoming increasingly expensive because of their high labor requirements and low yield. As a result, yams are being partially replaced by cassava, rice, and wheat, despite the fact that they are richer in protein than cassava.

Production

The average growth period is 8 to 11 months. Yields range from 5 to 15 metric tons per hectare. Only a very small portion of yams enters the international market; the bulk of the yams are marketed as fresh produce or eaten upon harvesting. Optimum temperature requirement appears to be around 25 to 30°C. Growth slows down below 20°C, while temperatures over 30°C have an adverse effect, especially if accompanied by dry conditions. Yams require adequate moisture throughout the growing period, and there is a positive correlation between moisture supply, vine growth, and tuber formation.

In West Africa, yams reach their highest productivity in areas where there is a dry season of two to four months and a rainfall of 1,200 millimeters or more during the growing season. Good drainage is essential for high yields and quality. Yams perform best in well-drained sandy-loam soils. In heavy soils, they are susceptible to rot, while in very sandy soils favorable moisture conditions are difficult to maintain. Yams are influenced by photoperiodicity--that is, their growth is affected by the relative amount of light they get in a day. However, the effects of day length on the vines and tuber production have not been completely investigated.

Yams are propagated either by seed yams or sets. Most yams produce one or two tubers larger than the rest, and these are the ones suitable for use as food. They are cut off near the top, leaving the crown with the green stem attached. This is replanted, and gradually grows again, producing two or more small seed tubers.

The production of seed yams usually is not sufficient. Thus, large yams are cut into pieces known as "sets," which are then used for plantings. On average, seed yams and sets weigh between 170 and 400 grams. Spacing plays an important role in the growth of tubers: generally, the closer the spacing, the higher the yield. Little or no chemical fertilizer is used on yams, though yams respond well to phosphate and potassium fertilizers if they are applied correctly.

Both seed yams and sets are planted in the middle of hills in holes 15 centimeters deep. Shallow planting may dry out the sets before sprouting. After planting, the hills are capped with a

layer of dry grasses or weeds about 30 centimeters in diameter on the top of the hill, and kept in position by a thin layer of soil. In general, protected yams sprout more quickly than unprotected yams as they do not dry out. When young shoots appear, long [illegible]m poles from hardwood trees are installed to support the vines and promote healthy tuber growth.

During the growing season, cultivation includes weeding, hilling, and setting the poles. While chemical fertilizers are not commonly used on yams, organic manure is. Most edible yams normally reach maturity 8 to 11 months after planting. Harvesting is done by hand.

Uses

Yams are a starchy staple crop, normally eaten as a vegetable, either boiled, baked, or fried. In West Africa, the major proportion of the yam crop is eaten as "fufu," a stiff dough. Yams are sometimes dried and made into flour. In villages, peelings and waste from the yams are often used for feeding poultry or livestock.

Diseases and Pests

Among the various diseases affecting yams, shoe string and die back are of major importance. Varieties resistant to these diseases are now being developed. Witches broom has been known to cause damage to yam crops in West Africa, and a virus disease of the mosaic type has been reported. Storage losses from various fungal rot diseases are generally severe, especially when the tubers are damaged.

Among the insects, yam tuber beetles are by far the most serious pests in West Africa.

COCOYAMS

The cocoyam, commonly called taro or dasheen, is an important staple in Southeast Asia and Polynesia. It has many varieties. Colocasia esculenta (Araceae family) is of Asian origin, but has been grown in West Africa for centuries. It is known as the "old cocoyam," distinguishing it from Xanthosoma sagittifolium, the "new cocoyam" of tropical America, which was introduced to West Africa during the nineteenth century.

Like many plants of the Araceae family, called aroids, the cocoyam grows from a fleshy corm (tuber) that can be boiled, baked, or mashed into a meal. The well-known "poi" of Hawaii is a product of taro which has been crushed and fermented. Cocoyams are rich in carbohydrates and very low in protein.

Figure 7. Cocoyams

Source: Michael Lambert, ed., Taro Cultivation in the South Pacific. Handbook No. 22. Noumea, New Caledonia: South Pacific Commission, 1982, p. 30.

Figure 8. Cocoyam Plants

Source: Michael Lambert, ed., Taro Cultivation in the South Pacific. Handbook No. 22. Noumea, New Caledonia: South Pacific Commission, 1982, p. 74.

The aroids are the least significant of all tropical/subtropical tuber crops in terms of production. However, they perform well under hot, humid conditions, and show best results on deep loam soils with a high water table. The maturation period, which varies according to the variety, ranges from 6 to 18 months. Yields vary from 10 to 30 metric tons per hectare. Although accurate figures are not available, the cocoyam is a major root crop in the forest region of West Africa, accounting for up to 75 to 80 percent of the total world output.

Production

The cocoyam is grown as a rainfed crop. Small corms or pieces of corms, or the tip of the main root stock with part of the original corm attached are used for propagation. Spacing varies widely. The cocoyam is grown as a single crop, or in combination with maize, rice, and vegetables. Planting is usually done during the rainy season. The cocoyam can be grown on a wide variety of soils, but deep, well-drained loams with a pH of 5.5 to 6.6 are considered to be the best. Yields are very low in sandy or hard clay soil. The more fertile the soil, the higher will be the yield. Cocoyams are very sensitive to waterlogging and saline conditions. For maximum growth, a mean temperature of 20 to 30°C is a must.

Sprouting usually takes place one to two weeks after planting. The crop is harvested when the leaves turn yellow. Mechanized, commercial production of aroids under irrigation and rainfed conditions is possible in the tropics.

The cocoyam's potential as a calorie source and its adaptability to unfavorable growing conditions make it a valuable crop for many rural development programs. Cocoyams are now included in many agricultural projects, and their cultivation is readily progressing in most developing countries because of their resistance to fungal infection, and tolerance of drought.

Uses

The corms (the underground part of the cocoyam) and the cormels (lateral tubers) are rich in starch. Like potatoes, they can be eaten after being boiled, baked, roasted, or fried in oil. The young leaves of some cocoyam species are boiled and eaten as a green vegetable. The peeled tubers, after pre-cooking and drying, can be used to produce a flour.

Diseases and Pests

Several diseases, viral and fungal in nature, have been known to attack the aroid varieties. Root-knot nematodes can also cause damage if the soil is heavily infested.

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SOURCES OF INFORMATION

Asian Vegetable Research and Development Center
P.O. Box 42
Shanhua, Tainan, Taiwan

Cameroon National Root Crops Research Institute
Institute of Agricultural Research
B.P. 13
Nyombe, Cameroon

Centro Internacional de Agriculture Tropical (CIAT), or
International Center for Tropical Agriculture
Apartado Aeroe 67-13
Cali, Colombia

Food Technology Development Center
Pertanian Bogor
P.O. Box 61
Bogor, Indonesia

International Development Research Centre
Box 8500
Ottawa, Canada K1G 3H9

International Institute of Tropical Agriculture (IITA)
P.M.B. 5320
Ibaden, Nigeria

International Potato Center (CIP)
P.O. Box 5969
Lima, Peru

Mayaguez Institute of Tropical Agriculture
P.O. Box 70
Mayaguez, Puerto Rico

National Root Crops Research Institute
P.M.B. 1006
Umudike, Umuahia
Nigeria

Philippine Root Crop Research & Training Center
Visayas State College of Agriculture
Baybay, Leyte 7127, Philippines

Root and Tuber Crops
Central Research Institute for Agriculture
Jl. Merdeka 99
Bogor, Indonesia

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