Pineapples grow in a relatively wide range of climates and soils and are raised for home consumption in many parts of Costa Rica. The plant does not tolerate freezing or long periods of drought, but it can grow well in partial shade. Fertilization increases yields but is often unnecessary in fertile volcanic soils. The plant may also be able to absorb nutrients from the rainwater that collects in the axils of the leaves and in the center of the rosette.

The major pests are nematodes, which can cause severe damage. Mealy bugs, scale insects, and mites may also reduce yields. Various fungal diseases cause rotting of the leaves, base, and fruit (Hayes 1960).

The fruit is high in water content and in sugars (8 to 15%). Maturity is indicated by the outside color. Experienced buyers can also detect watery or overripe pineapples by thumping them and listening to the sound.

Food and Agriculture Organization (FAO). 1978. *Production yearbook, 1977*. Rome: FAO.

Hayes, W. B. 1960. *Fruit growing in India*. 3d ed. Allahabad: Kitabistan.

León, J. 1968. *Fundamentos botanicos de los cultivos tropicales*. San José: Instituto Interamericano de Ciencias Agricolas de la OEA.

Padilla, V. 1973. *Bromeliads*. New York: Crown.

Potatoes (Papas)

M. T. Jackson

The potato (*Solanum tuberosum*) is a member of the family Solanaceae, as are tomato, pepper, eggplant, and tobacco. Unlike other solanaceous crops, potatoes reproduce both sexually and asexually, although at present commercial potato production is dependent upon the vegetative propagation of the crop through tubers. The life of the individual potato plant begins with the initiation of a tuber on a stolon of the mother plant. The tuber is an underground stem, much enlarged and modified as a food storage organ, with minute scalelike leaves and buds or "eyes." Stolons are underground stems that can become aerial should they reach the surface of the soil. Tubers arise as swellings between the terminal bud and the penultimate expanding internode of the stolon. Potato leaves are imparipinnately compound. The typical inflorescence is a terminal cyme, borne on a peduncle of varying length depending upon the variety.

In Costa Rica two varieties are commonly grown, atzimba and rosita, although the former represents about 85% of all potatoes produced. Atzimba has large light green leaves and is of medium height; its growth is erect. The flowers are white (fig. 6.17*a*). The tubers are oblong, with smooth white skins and a yellowish flesh; the eyes are of medium depth. The foliage of rosita is a darker green, and its growth habit is also erect. Flowers are lilac. Tubers are oblong, with smooth pink skins; the eyes are deeper than those of atzimba. Unlike many North American and European varieties, flowering is abundant in both these varieties.

In Costa Rica, as in other Central American countries, potatoes are cultivated on less than 1% of the total cropland. However, in Cartago Province, potato cultivation is one of the most important agricultural activities and provides work and income for a considerable sector of the rural population.

In 1976 it was estimated that 3,000 ha of potatoes were planted, with a total production of approximately 50,000 metric tons, of which 98% was produced in Cartago Province. Most potatoes are grown on the slopes of the Irazú volcano (fig. 6.17*b*), between 1,400 and 3,000 m, where the climate is cool and humid with only a brief (2–4 months) dry season. Other potato areas are found in Heredia Province, in Zarcero, and on the slopes of the Turrialba volcano. The concentration of potato cultivation in a relatively small area of the Central Valley is due to climatic and soil factors as well as to tradition and the proximity of markets in the metropolitan area of San José.

Growing seasons depend not only upon climate, but also upon altitude. The east-facing slopes of the Irazú volcano, around Pacayas, and the Turrialba volcano, are influenced by the Atlantic and are generally wetter. South- and west-facing slopes of the Irazú volcano (Llano Grande, Tierra Blanca, Cot, Potrero Cerrado) and other areas of the Central Valley are influenced by the Pacific climatic regime and have a dry season from January to April.

Between 1,400 m and 2,000 m (Cartago to Potrero Cerrado), planting is done in May and the crop matures in approximately 3.5 months. From Potrero Cerrado to San Juan de Chicuá (2,000 m to 2,800 m) the main season is from April to October, with the crop harvested after 4 months. Above 2,800 m, the duration of the growing cycle is approximately 5 to 6 months, owing to lower temperatures and lower light intensity caused by almost continuous cloud cover. However, the presence of clouds, and consequently humidity, allows the crop to be planted here as early as February or March.

Much of potato cultivation is on steep slopes, and consequently mechanization is used only for land preparation before planting where this is possible. Oxen are commonly utilized for planting, as well as hand labor. Distances between rows are generally 70–80 cm, but distances between plants vary depending upon whether the crop is for seed production or ware production (i.e., for consumption). A distance of 30 cm is generally used to produce ware potatoes. Approximately 2 metric tons of seed potatoes (size 40–60 g) are needed to plant one

FIGURE 6.17. *Solanum tuberosum*. *a*, Flowers and leaves. *b*, Field in full flower. Above Cartago, Costa Rica (photos, D. H. Janzen).

hectare. Seed potatoes are produced at the highest elevations on the Irazú volcano because insect vectors of virus diseases, as well as wilt-causing bacteria, are less prevalent there.

Potatoes are grown on ridges to give sufficient room for the new tubers and to leave a layer of soil above them. Such a layer helps to prevent green tubers and infection by various pathogens. Planting depths vary according to area, variety, and growing season. Fertilizers and soil insecticides and fungicides are applied in the bottom of the furrow at planting. Tubers are then placed in the furrow and covered with soil to form a small ridge. A layer of loose soil is added to the ridge when plants are 20–40 cm high. Weed growth is also controlled by ridging, carried out by hand or with a ridging implement pulled by oxen.

The potato is subject to many diseases and pests in Costa Rica, and without the efficient use of fungicides and insecticides it is impossible to cultivate potatoes successfully. The major fungal disease, late blight, is caused by *Phytophthora infestans* (Mont.) De Bary. Atzimba was originally bred in Mexico for resistance to late blight. In Costa Rica two factors—the widespread cultivation of this one variety and local climatic conditions—have contributed to the selection of physiological races of the pathogen that overcome the genetic resistance of the variety. Conditions on many parts of the Irazú volcano are ideal for sporulation of the fungus, and weekly fungicide spraying is necessary. Early blight, caused by *Alternaria solani* (Ell. and G. Martin) Sor., is of less importance and is controlled by the same fungicides as late blight. Stem canker, caused by *Rhizoctonia solani* Kühn, is present in many soils because it is easily disseminated on tubers. It causes considerable damage to emerging sprouts when the soil is cold and wet.

Two important bacterial diseases of potato—bacterial wilt, caused by *Pseudomonas solanacearum* E. F. Smith, and blackleg, caused by *Erwinia carotovora* var. *atroseptica* (Van Hall) Dye—are found in Costa Rica. The former is found below 2,220 m and can persist in the soil for many years. Only rotations, including pasture grasses, and the use of healthy seed reduce the severity of attack. Blackleg is a serious problem at altitudes over 2,500 m. It is carried on the surface of the seed tuber and

causes a general yellowing and wilting of the plant through a rotting of the stems, which eventually may pass to the tubers.

There are many virus diseases of the potato, of which PLRV (potato leafroll virus), PVX, PVY, and PVS are the most important. Viruses are especially important in seed production, since they cause a degeneration of potato varieties—that is, a reduction in vigor, cropping capacity, and disease resistance over a period of time if tubers from a diseased crop are used as seed for the next. PLRV is prevalent in Costa Rica, and it is estimated that 95% of all potatoes are infected with the virus. It is transmitted by aphids, principally the green peach aphid, *Myzus persicae* Sulzer, and consequently seed tubers are produced in isolated areas, generally at the highest altitudes, where insect vectors are uncommon. PLRV can cause yield reductions of up to 90%. In combination, PVY and PVX can also cause severe yield reductions.

A number of insect pests are common in all potato-producing areas. The most important are the two species of tuber moth, *Phthorimaea operulella* Zeller and *Scrobibalpopsis solanivora* Povolni. These insects attack both the foliage and the developing tubers. *Phthorimaea* larvae often burrow through the stems to the tubers, but it is more common for the female to lay her eggs on exposed tubers, as with *Scrobibalpopsis*. The damage done by both moths is considerable, rendering tubers unmarketable.

Rice and beans are the staple foods in Costa Rica, and consequently potato is utilized as a vegetable. Because of high production costs, it remains expensive and is not a regular food in the diet of the rural poor, despite its high nutritive value. Most potatoes are sold fresh at harvest, as there are no ware potato storage facilities in the country. Only a small portion of the crop is processed, mainly to produce potato chips and frozen french fries.

Current research in Costa Rica is concerned with developing late blight- and virus-resistant varieties, producing healthy seed potatoes, and adapting potatoes to hot, humid conditions. With the development of adapted varieties with genetic resistance to various pests and diseases, the potato has the potential to become a more important component in the diet of a larger proportion of the Costa Rican population.

Rice (Arroz)

J. Stout

Rice (fig. 6.18), the second most important crop grown in Costa Rica in terms of area planted, is a member of the family Gramineae. At germination a seminal root forms, after which secondary root development occurs at stem nodes. These tillers begin forming after the plant has developed four or five leaves. The number of tillers increases as leaves develop on the main stem; the maximum number produced coincides with plant anthesis. Tillers become independent from the parent stem once they develop three leaves and four or five roots of their own. With sufficient sun and water and proper temperature, the capacity to tiller depends on nitrogen and phosphorus concentrations in the soil. Active tillering, important to crop yields, requires more than 3.5% nitrogen and more than 0.25% phosphorus in the soil.

At anthesis one flower is borne on each spikelet, developing laterally from the main panicle. An optimum temperature for pollination and fertilization is 31–32° C. Fertilization success is high if there is sufficient moisture; if a drought or low temperatures occur during this time, crop yields can be severely reduced.

The rice grain is rather invariant in size, unlike grains of wheat and barley, in that the inner and outer glumes containing the developing grain do not expand beyond the size of glume, which assumes maximum size approximately five days before anthesis. Thus rice yields are much more closely related to numbers of tillers, panicles, and spikelets than to individual grain size.

Details on the origin of rice, the basic food plant of Southeast Asia, remain more obscure than for other grain crops in spite of its agricultural importance. It definitely existed as early as 5000 or 3500 B.C. in Thailand, but its origins could date back much farther. From China, rice was introduced to Japan and to Europe during the second century B.C. Rice was brought to the New World soon after the Spanish Conquest.

Oryza sativa, the primary species used in world rice production, is grown principally in the provinces of Guanacaste and Puntarenas on the Pacific side of Costa Rica. In the 1950s Guanacaste Province produced more than 50% of the country's rice. However, there were often severe drought years in that province. During those times, imports of rice were necessary, causing price increases. In the 1960s rice production extended southward along the Pacific Coast at sites where conditions allowed the production of dry rice. (Only about 10% of rice produced in Costa Rica comes from paddy or wetland methods of production). By 1968 Puntarenas Province, south of Guanacaste Province, produced 50% of Costa Rica's rice. Although in Costa Rica rice is second only to coffee production in terms of area under cultivation (63,000 ha versus 82,000 ha), rice is produced for domestic use rather than being an export crop. In fact, rice is often imported to Costa Rica to supplement domestic production.

Most Costa Ricans use rice and beans, either separately or combined in a dish called *gallo pinto,* at every meal. Breakfast usually is gallo pinto; lunch and supper consist of beans and rice served separately, along with fried plantains and possibly a piece of meat or a vegeta-