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Greenhouse Production of Banana in Morocco

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Morocco, occupying a strategic bridge between Northwest Africa and Europe, has a climate similar to California and Northern Mexico. Horticulturally, Morocco is best known as a source of winter vegetables and citrus for Europe, but the development of a plastic greenhouse industry has catalyzed the export industry. Most of Morocco's tomato exports are produced in unheated plastic greenhouses. The development of bananas under plastic is a unique achievement of Moroccan horticulture.

HISTORICAL DEVELOPMENT

Bananas were introduced to Morocco in the early 1940s, but production was confined to small plantings in special microclimates along the Atlantic coast, north of Agadir, especially at Tamri. The Moroccan market was served by imports, chiefly from Equador. In 1977, banana imports (30,000 t) reached 38.6 million dirhams (DH), equal to 10 million 1977 dollars (in 1988, 1 DH = $0.125); in 1978, importation was stopped by the government in an action designed to preserve hard currency as well as to encourage expansion of the focal industry. This action increased the price of bananas almost 7 fold (from 3 to 20 DH/kg), despite low quality of the locally produced bananas. Encouraged by high prices, two local growers (L. Bocatto and H. Tayeb) planted 30 ha of banana plants from stock imported from Martinique, including three cultivars (Giant Cavendish, Dwarf Cavendish, and Poyo). The entire crop was destroyed in the first year by frost. In view of the wide use of plastic greenhouses for vegetable crops in the area, protected culture was attempted. A partnership between L. Bocatto and a plastic greenhouse supplier (J.C. Arnoux) was formed, and a large plastic greenhouse (1.25 ha × 6 m high) was specially designed and constructed to withstand high winds. The first crop was an enormous success, with yields of 40 t/ha, returning the complete investment in a single year. Buoyed by this success, the industry expanded at a rapid rate: 5 ha in 1982, 8 in 1983, 59 in 1984, 147 in 1985, 437 in 1986, 490 in 1987, and an estimated 720 in 1988. The original company has developed a turn-key operation offering both plants and structures (average price per hectare in 1988 was about 450,000 to 500,000 DH) ($56,000 to $62,000). The expansion was accelerated by government aid in the form of relaxation of custom duties and import taxes for all equipment affecting greenhouse installation, including microirrigation, and the developing of financing to cover 7% of the investment cost.

CULTURE

Site selection

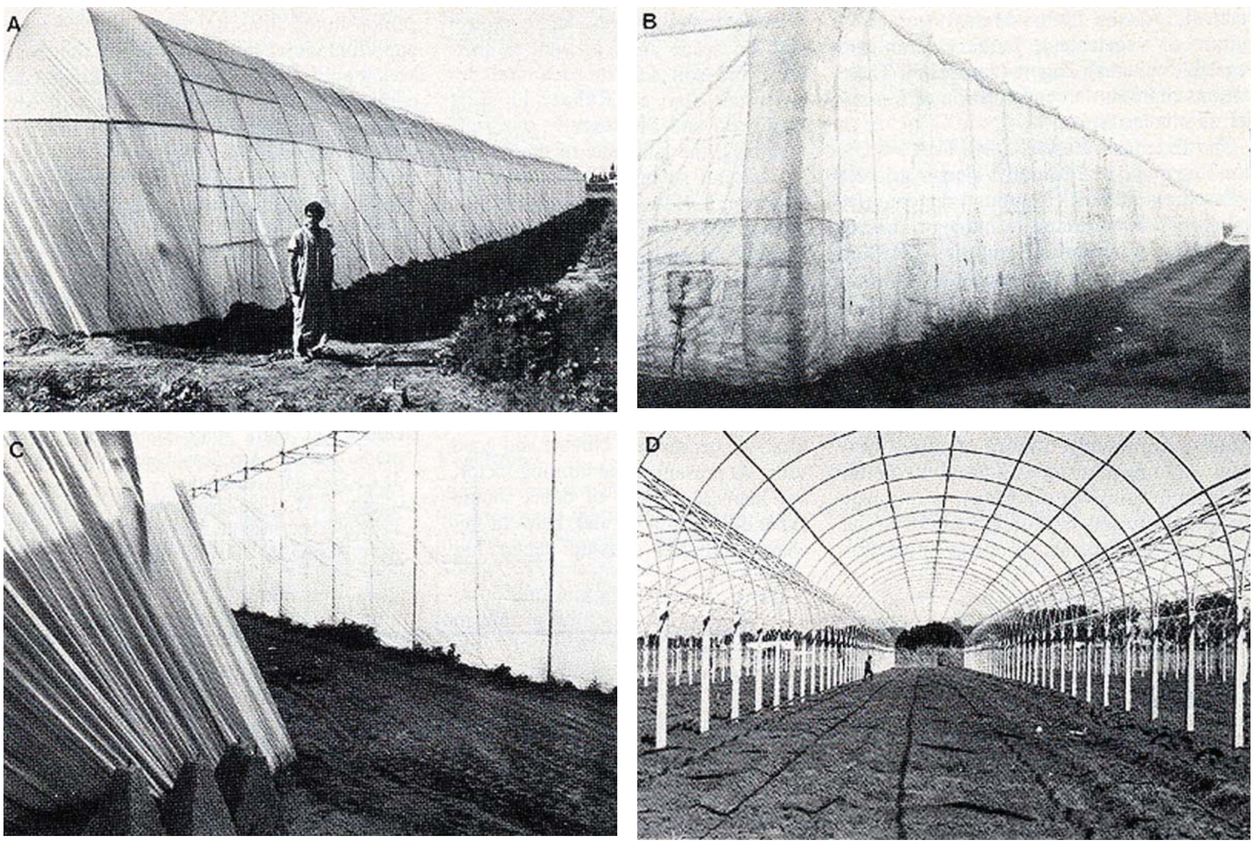
The best sites for banana greenhouses are low areas along the littoral coast that are essentially frost-free. Sites should he protected from strong winds; also, windbreaks, typically living fences of cypress or acacia, are planted around the perimeter of the greenhouse area. Bamboo fences are also used next to the structures.

Deep, well-drained soils are best, but sandy areas predominate. A good source of high-quality water, low in salt (< 1.2 g NaCl/liter) and active carbonates, is essential. Irrigation water is usually provided by wells.

The main area of production is the Souss-Massa Valley near Agadir (60% to 70% of total production). This area, which has 1470 hr of light between October and March (Sir Jacob, 1986), produces the highest quality and yields, but plantings are also increasing close to the northern coastal cities of Casablanca, Rabat, and Kenitra.

Greenhouse structures

The basic greenhouse used for banana is a structure 5 to 6 m high and covering 1.25 ha (Fig. 1A). The dimensions are dictated by the length of the plastic sheets, 3 to 6 m wide by 120 to 140 m long. Most houses are 100 m wide and 125 m long, permitting a single sheet to stretch from one end to



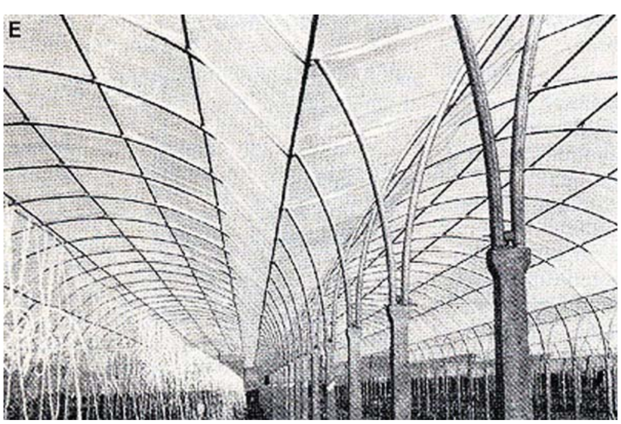
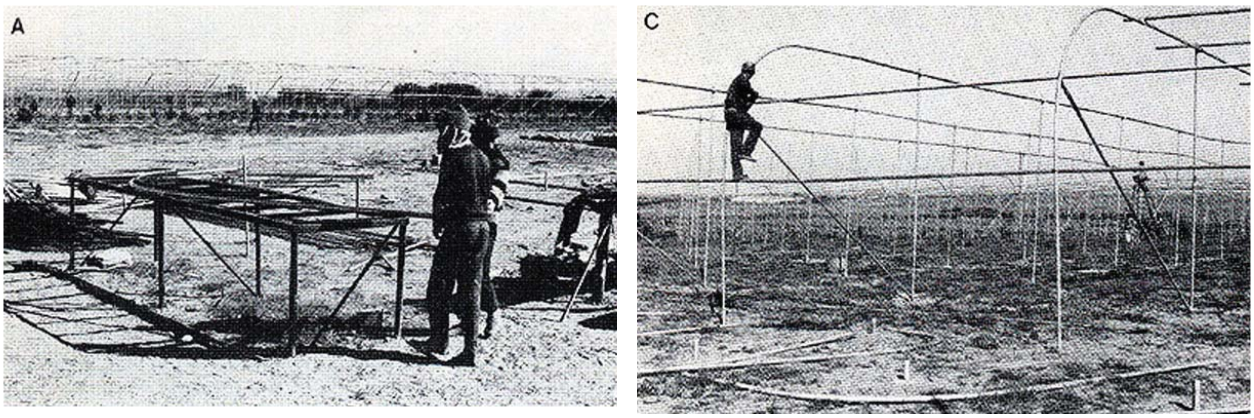


Fig. 1. Variation in banana houses. A. The most common structure covers 1.25 ha and is 5.5 to 6 m high. Constructed from galvanized steel pipe, edges are curved to reduce wind resistance. B. A block-type wood pole construction reinforced with wire mesh. C. An arcade type of structure with curtain-type walls that can be lowered by pulleys for ventilation. D. A new type of arcade using reinforced concrete poles.

the other. Thus, a 1-ha greenhouse can be covered with about 30 rolls of plastic.

There are many design variations (Fig. 1 B–D), but two basic types—a wooden pole block-type house or a galvanized steel pipe framed house (Fig. 2). The most popular present style is a flat-roofed structure with curved ends (Fig. 1A). Creative construction techniques have been developed to prevent wind damage (Fig. 3).



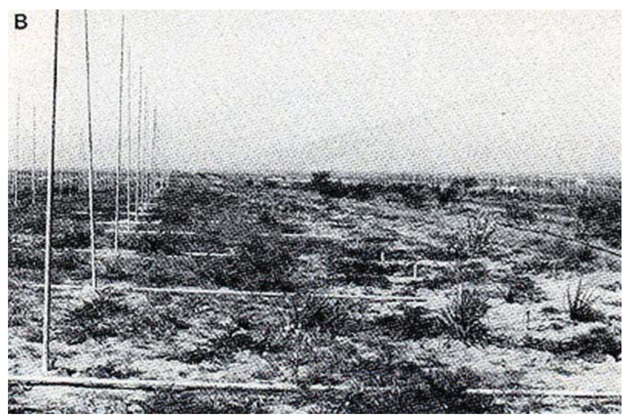


Fig. 2. Stages in on-site greenhouse construction. A. Bending aluminum pipe. B. Establishment of uprights. C. Connecting the transverse support.

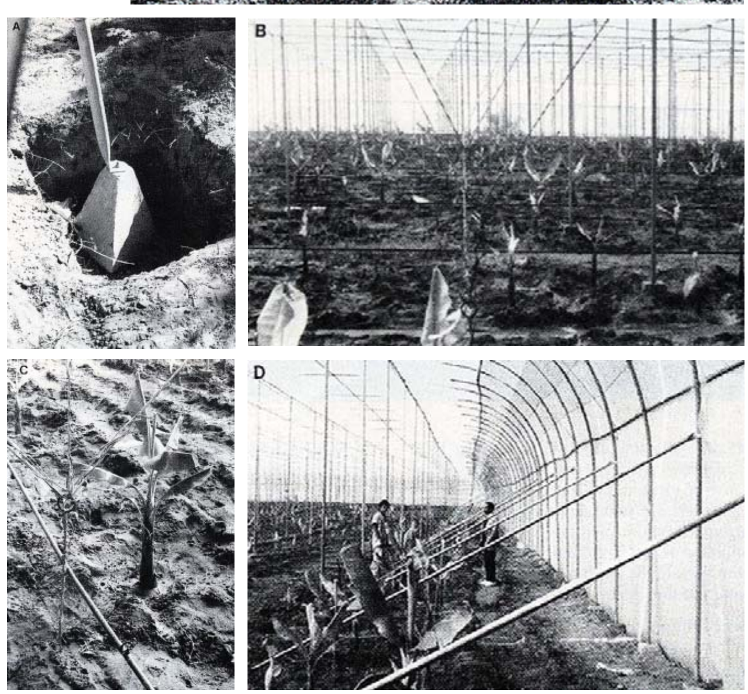


Fig. 3. A. Structural modifications are used to stabilize greenhouses against heavy winds. All vertical supports are attached to buried cement pedicels. B. In addition, guy wires affixed to the roof and the pedicels offer further support. C. In addition, guy wires affixed to the roof and the pedicels offer further support. D. The ends of the greenhouse are reinforced by diagonal rigid pipe.

The plastic covers are usually 220 µm thick (5.6 mil) and last for 3 years. The film is fabricated in Morocco from imported resin. Present costs per square meter (1988) are 4 to 5 DH ($0.050 to $0.60). The plastic covers usually are stretched over the houses in overlapping strips and are buried at the ends. In some types, the plastic is woven through the steel pipe frames (Fig. 1D), leaving a slight gap between the strips that offers ventilation but causes low temperature problems in the winter. Ventilation is achieved by separating the strips or by lifting the sides, or, in some cases, by dropping the side walls (Fig. 1C).

Crop establishment

New areas in sandy soils receive 30 to 40 t/ha of organic matter applied in trenches (Fig. 4). ‘Dwarf Cavendish’ is now the most popular cultivar, producing the most manageable plant size (3.5 to 4 m), with yields equivalent to ‘Giant Cavendish’ if density is increased. ‘Poyo’, although high-yielding, grows too high and plants often break through the plastic.

Planting Stock

Tissue-culture plants costing 25 DH ($3.12) each, from disease-free stock, produce the most uniform and early producing plants (flowering 9 to 10 months after planting) (Fig. 5). However, suckers 6 to 7 months old that produce 14 to 15 leaves are the most popular planting stock (present cost = 7 DH, $0.68) when growers expand their production or replant after house renovation. Successive crops are produced by selected followers (suckers) produced by the main plant. Rhizomes are no longer used because of the delay in production. Planting stock derived from local field-grown stock is not recommended because of virus and nematode infection.

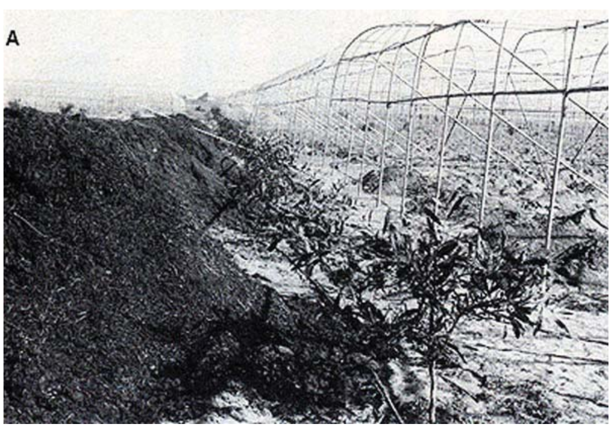


Fig. 4. A. Preplant soil preparation. A mixture of composted straw manure is used to increase organic matter in sandy soils. Note the row of acacias planted as a living wildbreak. B. Trenches being prepared. C. Trenches being filled with organic matter. These trenches will be mixed with soil and fertilizer before receiving transplants.

Suckers are soaked in fungicides and nematicides before planting (Fig. 6). Soil fumigation is not practiced. Soils are treated with nematicide when nematodes are a problem, and this treatment is becoming routine.

Scheduling

Planting is usually from February to May or September to October, when soil temperatures exceed 10°C. Harvest can be scheduled year-round, depending on the planting date, type of planting, stock, and selection of followers, but most growers attempt to concentrate harvest in either Summer or the beginning of winter. Proper scheduling avoids flowering during the winter, when low temperatures produce weak and deformed bunches (Fig. 7). The period from flowering to harvest is usually 3 months in the summer and 6 months or more in the winter.

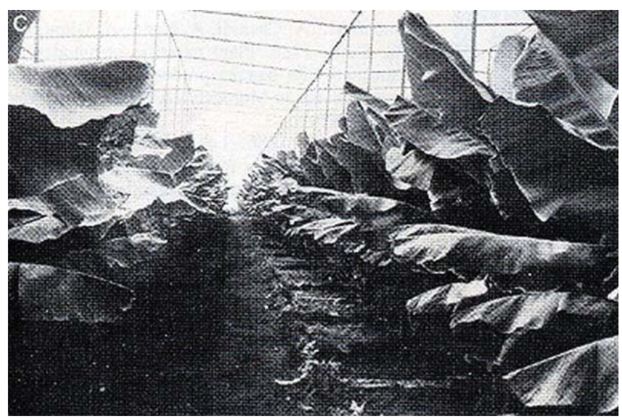


Fig. 5. Stages in crop development. A. One month after planting. B. Six months after planting. Note the extreme homogencity of tissue-cultured plants. C. Thirteen months after planting; the crop is ready for harvest.

Fig. 6. Banana suckers with roots and excess leaves removed are dipped in fungicide and nematicide solution before planting.

Irrigation

Irrigation is mostly by trickle (drip) systems (Fig. 8), with dispersion by micro-sprinklers (30 to 50 liters/ha). Irrigation is applied at 10 to 30 liters/plant per day. Houses are misted by overhead sprinklers to reduce temperatures during the summer and to warm houses in the winter (well water is usually 18°C).

Fertilization

A starting fertilizer program per plant consists of 100 g triple superphosphate, 50 g of NH_4NO_3, and 50 g of K_2SO_4. During plant

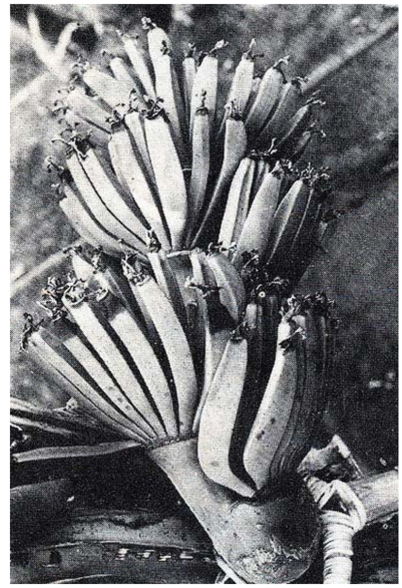


Fig. 7. A malformed bunch due to cold injury. Note the characteristic twist of the pedicel. The decaying fingers (cigar stub) is due to Verticillium.

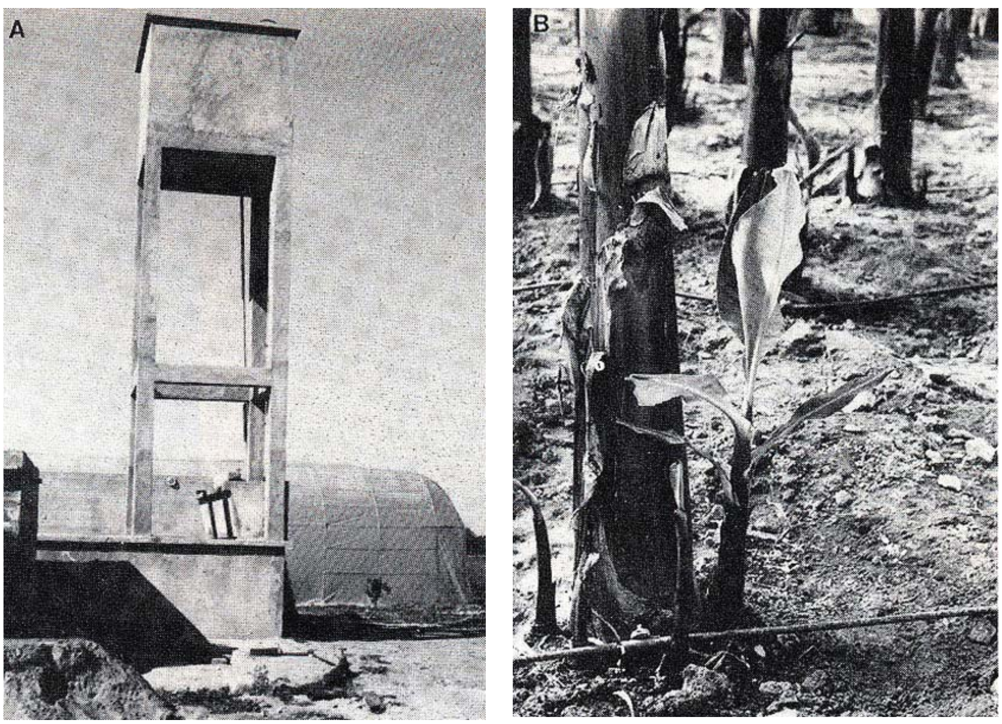


Fig. 8. A. An abundant supply of high-quality water is essential for greenhouse bananas. Water is provided from wells and pumped to an elevated storage reservoir. Drip irrigation and mist systems operate from gravity flow or by special pumping systems. B. Banana with followers showing surface drip system. C. Elevated (50 cm) microjet sprinklers are increasingly used for better distribution of water.

growth, fertilizers are applied monthly to reach a yearly total per plant of 300–200 g N, 250–300 g P, and 500–700 g K. Fertilizer is usually hand-spread as granules in a ring around the pseudostem or followers, 15 cm from the plant (Fig. 9).

Disease Control

Nematodes have been the main pest problem in Morocco. The major pathogenic species are *Meloidogyne javanica*, *Helicotylenchus multicenctus*, and *Radopholus similis* (Ammati et al., 1988). Control is best-achieved with prevention, using nematode-free stock from tissue-cultured plants. Planting stock should be treated with nematicide and, when infestations are severe, soil-applied nematicides [organophosphates such as Nemacur (Bayer) and Mocap (BASF) or carbamates (Furadan)] are recommended at intervals of 1 to 3 months to reduce population levels. The use of soil-applied nematicide is now routine. The use of Temik is under trial. Solarization before planting greatly decreases soil infestation. Soil fumigation with methyl bromide for new plantings is under consideration.

The major fungus disease is cigar stub (Fig. 7), caused by *Verticillium theobromae*, and is controlled by fungicides. Sigatoka is not a problem at present. Virus diseases, including bunchy top, banana strip virus, and cucumber mosaic virus, have been a problem when local field-grown stock have been planted.

Harvest

Bunches are harvested when the most mature hands are well-filled with rounded corners on the in-

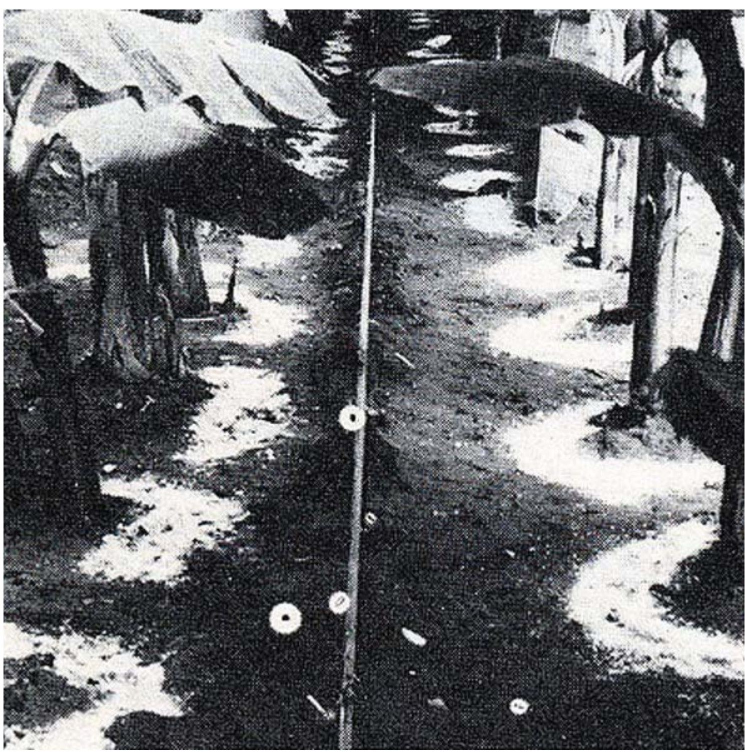


Fig. 9. Fertilizer is applied in a semi-circle around base of plants facing wetted area.

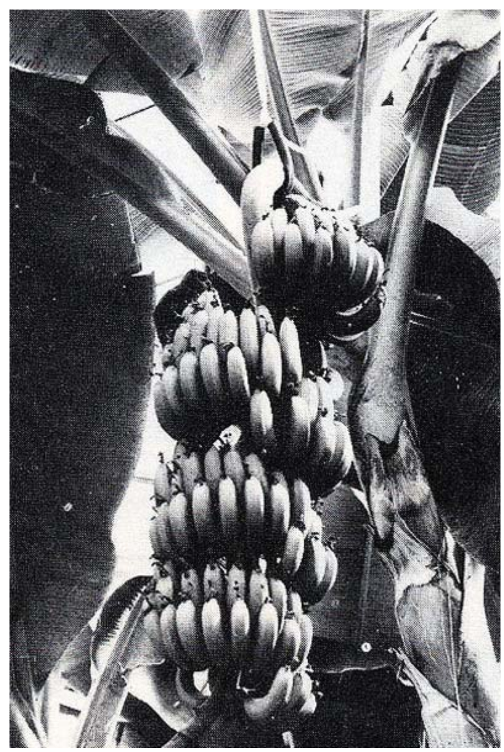


Fig. 10. A well-developed (about 35 kg) stalk of 'Giant Cavandish' fruit supported with a sling attached to the traverse supports.

dividual fingers. Bunches at harvest (Fig. 10) weigh between 20 and 60 kg, depending on cultivar, time, season of harvest, and general cultural practices. Fruit are sold to wholesalers, who store and ripen it before distribution. Casablanca is the major market. Yields average 45 t/ha, but 90 t/ha have been achieved.

Interplanting

The edges of houses with curved sides are often used for production of short-cycle crops, particularly spring melons. This area is also used as a nursery to produce banana planting stock.

Renovation

Most systems operate with five harvests (6 years), with houses re-covered once. After the fifth harvest, all plant material is removed, soils are treated with nematicide, and are usually solarized over the summer. Solarization does not eliminate nematodes, but seems to increase yields. There is little information on yields of replants.

THE FUTURE

Annual demand for banana in Morocco has been estimated as 100,000 t/year, about 4 kg per capita. The demand is elastic and should increase with decreasing prices. At the present time, there are close to 1000 ha of producing bananas, which supply 30,000 to 40,000 t. Thus, it is reasonable to assume the area will double in a few years, as long as imports are restricted.

Present costs and returns to bring a hectare of bananas into production are shown in Table 1. Payback of capital may be achieved in 3 years at 40 t/ha yield (Table 1).

In the early 1980s, when prices were 12 DH/kg, growers repaid capital costs in a single year. At present prices (8 DH/kg), capital investments are returned in 2 to 3 years.

Capable growers will find bananas a profitable crop at returns as low as 5 to 6 DH/kg. Thus, the future of banana culture is still bright in Morocco and the possibility for export of surplus is a distinct possibility. Because of the success of bananas, many growers are experimenting with new crops for large greenhouses, including kiwifruit, tobacco, table grapes, and pineapple.

The success of greenhouse bananas in Morocco is an example of grower ingenuity and entrepreneurial skills that have exploited high-technology agriculture. It demonstrates the agricultural potential possible with a vigorous agricultural service industry, the availability of government credit, and the assistance of education, extension, and research organizations.

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