Neth. J. Agric. Sci., 16 (1968) : 186—196

Citrus cultivation in Surinam

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Received 22 May, 1968

Summary

The subtropics have far outstripped the tropics as producers and exporters of citrus. In this article the pitfalls and possibilities of growing citrus in an equatorial country are discussed. Surinam's climate, soils and agricultural history, the founding of the citrus industry and its research problems are reviewed, followed by a glance at the economic prospects.

Introduction

Many crops have reached optimal development outside the region of their origin, for instance the African oil palm, the Brazilian rubber tree, the 'Irish' potato and Citrus. Although this genus originated in the monsoon regions of South East Asia, large scale cultivation of citrus fruits has not developed there but in the Mediterranean countries, in the southern United States and in other subtropical areas. The reason for this seemingly strange behaviour is probably an economic one: nearness of good markets. Where skilled workers were available, adaptation of the crop to soils and climate could be effected more or less easily. Furthermore, there were some advantages connected with a change of environment: serious pests and diseases were sometimes left behind, and low temperatures turned out to be required for colour formation in citrus fruits.

Thus it came about that the subtropics, despite occasional freezes and hurricanes, have far outstripped the tropics as producers and exporters of citrus. In India, Indonesia and the Philippines citrus cultivation has only local significance and is meeting grave difficulties, due mainly to virus diseases. In the West Indies some progress has been made in Jamaica, Trinidad and especially British Honduras. As an example of the pitfalls and possibilities of growing citrus in an equatorial climate, we shall now turn our attention to Surinam.

Climate and soils of Surinam

This country, formerly also known as Dutch Guyana, is situated on the north-east coast of South America, between 2° and 6° North. There are 4 seasons: a major rainy one from April to August, then a dry season lasting until November, followed by two rather uncertain (minor) seasons of two months each. According to Köppen

this can be called an Af-climate (always wet) or, in some years and along the coast Am (some dry months). Rainfall at Paramaribo averages 2200 mm a year.
The mean temperature is 27 °C, with a 2° variation between the seasons and a daily amplitude of about 10°. The lowest temperature ever recorded is 15 °C. Humidity is high, around 80 %, but there is generally some cooling wind, especially in the afternoon. Hurricanes are unknown and even strong winds are rare. Evaporation is usually between 4 and 6 mm a day, which means that short periods of water stress may be expected in the dry months. Sunshine varies between 77 % in the dry season and 44 % in the wet season, with a 58 % mean.
The agricultural area of Surinam is mainly situated in the young coastal plain which consists of heavy clay soils, intersected by sandy ridges of some 100 meters width running in east-west direction. In the clay area 'polders' have been constructed in the 18th century and plantations may still be found there. These polders are drained by gravity on the rivers, where the tides may show a 2 meter difference. Of course, this necessitates an extensive system of dams, canals and sluice gates which is rather expensive in upkeep. Therefore, in recent decades the drier sandy ridges have been favoured as planting sites. However, their extent is limited and their properties are rather uneven. Quite recently, thanks to roads leading into the interior (which could formerly only be reached by boat), large river terraces have been discovered; these are well suited for growing citrus and other tree crops, provided chemical fertilizers are used. It is therefore quite likely that these soils will become important for citrus cultivation in Surinam in the future.
But so far, citrus and most other crops are preponderantly grown on the coastal clays. They are exceedingly rich, chemically speaking. Their physical properties can be very good, especially where the soil is covered by a peat layer of moderate thickness, say about 30 cm. If this peat is burnt off or otherwise destroyed, the clay will become sticky and impermeable, too wet in the rainy season, too dry after even a short rainless period. Root growth then is limited to the upper layer, but even 30 cm, surprisingly enough, may be sufficient for good growth of citrus, cacao, coffee and such, if only excess water can be got rid of promptly and if fresh water from the swamps or rivers can be brought in during dry spells. This situation prevailed for centuries in many estates, until recently. However, there has been a succession of dry years: many places have run out of fresh water, while the river water has become quite brackish.

Outline of Surinam's agricultural history

Surinam was first colonized by the British, then became a Dutch colony in 1667 until 1954, when it achieved local autonomy within the Kingdom of the Netherlands. The first white settlers had moved away from the marshy coast, trying to grow tobacco on the sandy soils of the old coastal plain and the savannah region along the Surinam river. Owing to the wet climate all attempts at tobacco growing have failed.
On the other hand, sugar-cane was an immediate success, thanks to the know-how of Portuguese Jews who settled in Surinam after the Dutch had lost Pernambuco (Brazil) to Portugal. For several decades sugar-cane was grown on the estates around the village called 'Jew Savannah', but it was soon observed that after one or two crops yields decreased sharply, so that new land had to be taken up continually.

Meanwhile, the Dutch 'polder' system was successfully tried on the coastal clays. Here sugar-cane could be grown for as many as 15 years without interruption, after which a wet fallow of 6 years would restore the land. Sugar-cane was the most important crop, but cacao, coffee and cotton were also grown; the last named only along the coast, where the dry season is much more pronounced.
For 1785 a total of 591 estates is reported, of which 452 were producing for export, the rest grew food and firewood. The estate area was about 180,000 ha, of which probably 60,000 in crops. At that time the whole population amounted to not more than 50,000 people, mainly negro slaves.
It is a moot point what has contributed more to Surinam's economic decline in the 19th century: Napoleon's continental system, the opening of the Suez canal or the abolition of slavery (which finally took place in 1863). This decline is illustrated by the following figures:

Year	*Number of estates*	*Area in estates (in 1000 ha)*	*Area in crops*
1785	591	180	60
1853	263	172	54
1862	200	118	17
1873	131	70	10

Labour shortage had always been a feature of Surinam agriculture and it turned acute when in 1808 and again 1820 the British enacted laws against the slave trade. Yellow fever and other tropical diseases killed many; besides, slaves were treated badly as well as foolishly, so that their birth rate was lower than their death rate. The estate owners pressed the Government to import other plantation labour, first Chinese, then East-Indians and finally Javanese.
In the meantime the former slaves had frequently taken over abandoned estates and in the second half of the 19th century they enjoyed a fair degree of prosperity as cacao growers. On the remaining estates too, cacao supplanted sugar-cane as the number one crop. This period came to an end around 1895 when cacao trees were seriously affected with witch broom disease. Within a short time production of dry cocoa dropped from 1500 tons a year to next to nothing. The Government tried to remedy the situation by introducing the banana industry, but before a good start had been made the plants began to die from Panama disease. Henceforth Surinam was known as the land of unlimited impossibilities.
The next crop to come to the fore was coffee; not the Arabian kind that had been grown in the 18th century — in the year 1790 exports of this commodity had amounted to 7500 tons — but the Liberian variety which is better adapted to the Surinam climate. Liberia coffee had been the staple agricultural product of the country for twenty years when the next disaster struck: a world wide economic crisis resulting in abnormally low prices. There was a difference with former occasions, however: plantation agriculture was not any longer the virtually sole means of existence of the country. Many East-Indians and Javanese had settled as small farmers, mainly rice growers. Besides, bauxite was now getting to be an increasingly important export product.
We have now arrived at the point where citrus makes its entrance. This was to be the crop to take the place of coffee on the estates. The Surinam Coffee Board,

founded by the Government in 1936, undertook to support coffee estates on the condition of partial conversion to citrus. Small farmers too, were encouraged to grow citrus. Those that did so, soon had reasons enough to be sorry, as from 1939 to 1946 no citrus could be exported and coffee prices turned upwards sharply. One wonders if this could not have been foreseen.
We shall now conclude our historical observations in order to take a closer look at citrus and its place in Surinam agriculture.

Founding a citrus industry

It is not exactly known when citrus seeds were first taken to Surinam, but very likely it was around 1660. Many travellers have reported on the citrus fruits they enjoyed, one of them stating in 1805: 'the streets of Paramaribo are wide and regular, planted on both sides with orange trees that produce flowers and fruits twice yearly'.
Citrus fruits being subject to decay, exports to Europe could not have taken place during the reign of the sailing-vessel and even after a regular steamship service had come about, it took several years. The first oranges were shipped to Holland in 1907 and in 1908 the Agricultural Research Station (founded in 1903) made some experimental shipments. The oranges arrived in Holland with 12–23 % decay, which was considered encouraging.
So far, all plantings had been from seedlings, but in 1904 one hundred budded plants of the cultivars 'Navel', 'Sanford', 'Parson Brown', 'Lamb Summer', 'Ruby', and 'King' were imported from Trinidad. In 1906 the U.S. Department of Agriculture sent: 'Dancy', 'Oneco', 'Pineapple', 'Jaffa', 'Ruby', 'Marsh', kumquat and *Poncirus trifoliata,* while again imports were made in 1908, among others 'Triumph' grapefruit from Jamaica and 'Valencia' orange from the nursery of Reasoner Brothers in Oneco, Florida. It is practically certain that most of these plants carried viruses, although tristeza was probably not among them.
The sour orange was generally used as rootstock, although other stocks were tried too, among them 'alamoen' (a wild grapefruit), 'King', 'Surino' (a mandarin), grapefruit, lime, lemon and citron. The imported varieties were evidently not satisfactory, as in 1913 the Research Station began to look for good seedling trees on the plantations. Fruits of these were shipped to the Colonial Institute in Amsterdam for judgement. Six mother trees were chosen by the Institute and one of these, 'Kwata 202' was finally selected for further propagation.
It is always difficult to set up a new agricultural industry. In Holland importers and consumers were hardly interested in a green or at best yellow orange, the shipping company could not offer cooled or at first even ventilated holds for the three weeks' voyage and the growers had little or no confidence in the future of the industry. At heart they were still coffee growers. They had only a scant notion of the requirements of citrus cultivation, of protection against pests and diseases, of handling the crop etc. The research problems had not even been fully recognized, let alone tackled satisfactorily. Above all, capital was lacking and everything had to be operated on a shoestring. Under the circumstances it is therefore surprising that this business got started at all, be it ever so slowly.
In 1935 the area planted with citrus amounted to 200 ha only. Meanwhile a big nursery had been established at Dirkshoop, 40 kilometers west of Paramaribo. From

1936 on, this nursery delivered budded plants at a rate of 50,000 a year and in 1939 the citrus area is estimated at 950 ha, of which 700 ha on estates. Meanwhile the Coffee Board (which in reality had become a Citrus Board as well) built a packing house and a small juice plant for experiments. These installations have been of very little use, as shipments to Europe practically stopped when war broke out. After the war the area was again extended as may be seen from Table 1.

Table 1 Citrus area (ha) of Surinam

Year	*Estates*	*Farmers*	*Total*
1935	150	50	200
1940	700	250	950
1945	700	550	1250
1950	945	980	1925
1955	900	1000	1900
1960	840	800	1640
1965	1288	1292	2580

Export of citrus fruits was resumed in 1946 and amounted to about one million Surinam guilders for the next 3 years, then dropped to one half million guilders. There are 2 reasons for this decrease: devaluation of the Dutch guilder (while Surinam's guilder retained its value of US $ .55), and the incredibly bad condition in which some of the consignments arrived. Hoping to improve this, the Government bought a big modern packing house in Florida and set this up in 1950, but the expected improvement did not automatically result. This was brought about only after years of research in the causes of decay, as we shall see further on.

Six years of fluctuating, but mainly low prices followed. The domestic market could not absorb the surplus, so here too prices were low. As a result orchards were neglected severely. The situation of that period has been described by Burke (1956).

In 1956 a guaranteed price for 5 years was decreed by the Government. Growers had to take good care of their groves and had to comply with the instructions of a Board, which consisted of representatives of the Government and the growers. This measure has been beneficial and within 2 years the situation improved very much. About 300,000 boxes of fruit were exported yearly.

In April 1962 the guaranteed price for export was discontinued, after private investors had established a concentrate juice plant and a guaranteed price for delivery to the plant had been negotiated. As this plant could easily process all citrus fruit produced in Surinam and had to be aided in making an economic start, permission to export fresh oranges was not granted for some time. Unfortunately, the plant did not stay in operation very long and in 1964 work was suspended due to technical, financial and other troubles. Although the Government bought the plant, it was not brought back in running condition. Thus, export of fresh fruit was taken up again. Like formerly, the export level has settled around 300,000 boxes a year.

Research problems

Since the establishment of the Surinam Agricultural Research Station in 1903, citrus research was carried on intermittently by several workers, among them G. Stahel.

Fig. 1 Grapefruit on coastal clay with Pueraria cover

Later on J. D. Oppenheim, J. A. Samson and D. A. Kraaijenga have devoted the greater part of their time to citrus research. A full list of publications on citrus in Surinam, mostly in Dutch, may be found in Samson (1966). We shall now take a closer look into the investigations of these workers.

Varieties and rootstocks

'Kwata 202' can be described as follows: thin skin, not completely seedless, very juicy, high sugar and low acid content, tough membranes, rather flat (D/H = 1.09), fruit ripening in 7 months, keeps well on the tree for 2 months, early to mid-season. When the 'clone' was found to be a mixture of several types, 7 mother trees out of many thousands were selected in 1958 with nearly spherical fruit (D/H = 1.01 to 1.03), having a somewhat thicker skin (5 mm), few seeds (3 or 6), softer membranes and a deeper coloured juice. The best of these was called 'Kwata'. Later on the mother trees were shown to contain several viruses, so a search for seedling trees was instituted. This did not produce a tree satisfactory in all respects, so seeds from the 7 mother trees were sown out in order to make new lines. However, it will take many years before these can be made available to the growers and in 1965 virus-free budwood of several varieties was imported from Florida.

From an experiment planted in 1928 with 'Kwata 71' (a late variety) on 11 rootstocks, it was known that sour orange was not the best stock for the sandy soils: 'King' and 'Surino' mandarin were much better, especially regarding uptake of trace elements. New stock-scion experiments were set out in 1953 on 3 soil types, with 3 stocks: sour orange, 'Rangpur' lime and 'Cleopatra' mandarin. Only on sour normal

Fig. 2 'Kwata', 2 years old, on rough lemon at Brokobaka (interior)

growth and production was achieved, on 'Rangpur' most (but not all) trees were stunted and had bark symptoms which later on were attributed to exocortis virus. Stocks have been set out in 4 localities (2 coastal, 2 interior) during 1963 and 1964; they have been or will be budded with virus-free material when this is available.

Virus diseases

Tristeza may have been imported into Surinam more than once. Every time Meyers Chinese lemon (a notorious carrier of viruses) was brought in, it died promptly after having been budded on sour stock. It is not clear whether *Toxoptera citricidus* was present at that time. Although reported in 1938 (Hille Ris Lambers, 1963), this aphid was not found again until 1954 when it appeared in massive numbers (Van Dinther, 1960). In 1963 tristeza was reported by Kraaijenga (1965), which was later confirmed by Childs (1964, 1966). Meanwhile exocortis and psorosis had also been noticed and it is to be expected that stubborn, vein enation, cachexia and other viruses will emerge as soon as efficient indexing facilities are at hand.

So far, the damage done by tristeza has been light. Scattered grapefruit trees only are affected, but this might take a severe turn suddenly. Orange trees, even when showing stem pitting symptoms, remain productive. Thus the strain seems to be a

mild one. Bové (internal report) has observed severe symptoms of stem pitting and pinholing on West Indian lime, however, indicating the presence of a severe strain.

Footrot and fruit decay

In the early fifties footrot was widespread in citrus orchards, especially on clay soils. Growers wanted the soil around the stem forked regularly and thus soil particles, carrying *Phytophthora* spores were often spattered past the resistant sour orange stock onto the sweet orange scion. In those days citrus was still grown under shade, as cacao and coffee are. Thanks to the guaranteed price regulation, growers could be dissuaded from these practices: they gradually cut down their shade trees and started to grow a cover crop of *Pueraria phaseoloides* (tropical kudzu) instead. Within a short time footrot practically disappeared. However, it is bound to reappear when new rootstocks come into use. Their resistance against footrot should be one of the main considerations after resistance to viruses.

A large number of holding and shipping experiments have shown that stem-end rot, caused by *Diplodia natalensis,* is the principal cause of citrus fruit decay in Surinam. Brown rot and green mould do occur, but only as a result of bad management practices. Before these investigations had taken place, it was prescribed that fruit for export must have a button and should be 'wilted' on the estate for several days after picking; in the packing house borax was used as a disinfectant. These measures may have a beneficial effect on green and blue mould but none whatsoever on stem-end rot, on the contrary. As a result fruit seldom arrived in Europe less than 20% rotten, sometimes with 50% or more decay.

Since 1956 pulling, or rather twisting of fruit has been permitted instead of clipping and harvested fruit had to be hurried to the packing house for treatment with Dowicide A, a mixture of sodium-o-phenyl-phenate and hexamine. This caused decay to drop below 10% and after some time even to 5% or less; all this referring to a 16 days' trip in a ventilated, but not cooled room. Table 2 gives an idea of some holding experiments.

Table 2 Percentage decay of oranges after 4 weeks at room temperature (27 °C)

Experiment no.	*Treatment*			
	untreated	*debuttoned*	*borax*	*Dow. A*
1	12	2	—	0
2	39	11	43	14
3	56	—	61	30
4	29	—	—	7
5	38	—	—	3

Fertilizer experiments

Two fertilizer experiments were inaugurated in 1950. On clay soil there has been an initial response to nitrogen which soon disappeared after the whole field got covered with Pueraria. Data from Puerto Rico point to an increment of about 400 kg N per hectare per year due to this cover crop; compared to this 200 kg of ammonium sulphate (or 40 kg N per year, as administered in the experiment) is a mere trifle.

Table 3 Number of oranges per tree at Dirkshoop

Fertilizer	*Trace elements*	*1951*	*1952*	*1953*	*1954*	*1955*	*1956*	*6-year mean*	*%*
none	none	103	92	147	117	77	138	112	100
none	Zn-Cu-Mn	187	635	198	491	250	191	350	312
NKMg	Zn-Cu-Mn	190	870	340	626	493	604	520	464
NPKMg	Zn-Cu-Mn	189	770	345	742	514	470	505	451

There were indications that rock phosphate may have had some effect.
On sandy soil trees were found to be suffering from several deficiencies, especially zinc. These have to be corrected before a fertilizer experiment can very well be gotten under way. In this experiment (Samson, no year) there were 6 treatments in 3 replications of 10 orange trees per plot. Next to this experiment a field was kept without fertilizers and trace elements. Some results of the first 6 years are presented in Table 3. The treatments without K, Mg or both, produced significantly less than NKMg and NPKMg. In 1956 the experiment was continued with only these 2 treatments, now 9 times replicated, but up to 1965 no difference had become discernible. Potassium did not only influence the number of fruits, but also their size (significantly) and their decay. More work in this vein will be necessary for the soil types of the interior and standards for leaf analysis will have to be established.

Spray program
Trace elements are taken up faster if sprayed on the leaves than when applied to the soil. Particularly when the sprays contained copper, trees were found to suffer much from scales, as beneficial fungi were killed. It was also observed that populations of scales and aphids can be reduced to acceptably low levels if only ants are prevented entry into the trees; this can easily be achieved by spraying chlordane or dieldrin on the stems (*not* on the leaves) 2 or 3 times a year. Ants namely are known to move scales and aphids to uninfested parts of the tree and to chase away their predators (syrphid larvae, lady beetles and such).
Rust mite, the worst pest of citrus fruits in Surinam, is difficult to control. To do this efficiently one has to make regular counts of the number of mites. Control is specially important shortly after bloom, as spots on the young fruit will grow out to unsightly blemishes later on, and during the dry season, when they multiply explosively. On this basis the following spray program was proposed:

(1) January (or after bloom) : zinc sulphate plus zineb
(2) March or April (if necessary) : zineb
(3) June (before picking starts) : dieldrin (stem only)
(4) September (if necessary) : zinc sulphate plus sulphur
(5) November (after flush) : dieldrin on stems, if necessary lindane on flush against aphids

Sulphates of copper and manganese to be added every other year to the January spray, but never during a dry spell.
This program is not entirely satisfactory as greasy spot, caused by a fungus living in association with rust mite, is a complicating factor. This is now under investigation. Since 1954 all spraying has been done with low volume equipment.

Fig. 3 Budded plants, about 14 months after sowing, in plastic bags

Maturity

Juice content was found to be high, even in unripe 'Kwata' oranges, increasing from 48% in early June to 61% in October. During that period total soluble solids went from 8.8° to 13.9° Brix, acid content dropped from 1.5 to 0.7%, while the Brix: Acid ratio rose from 6.1 to 19.8. Prime maturity, meaning a ratio of between 10 and 16, lasted from late June to late September. 'Valencia' showed a similar pattern, but 2 to 3 months later.

This means that in 'normal' years the orange harvest can be extended from July to September. 'Marsh' grapefruit can be harvested a few weeks later than 'Kwata' orange. Of late there have been many years of low rainfall and as a result bloom and harvest periods have fluctuated wildly. This, of course, does not matter greatly if the fruit is processed, but for delivery on the fresh fruit market it may have unpleasant consequences.

Propagation

The traditional method of sowing on a seedbed, transplanting to nursery row and budding after topping has not given good results in Surinam. The seasons are too unreliable and sprinkling was not always possible, furthermore the available soil types did not favor the system and weed growth was enormous.

After many experiments a new system evolved: pregerminated seeds were sown in plastic bags put close together in 2 rows with paths in between. Budding was done in situ, at about 30 cm above the ground, with 'lopping': just above the sprouting bud, the stock was cut half through, which causes the shoot to grow straight up vigorously. Where this was possible, the traditional system was used, but with some modifications. Chemical weed control cost about 4 times as much as hand weeding.

Economic prospects

An annual export of 300,000 boxes (oranges and grapefruit) is of no importance on the world market — it is less than 1 ‰ of the total — but means a lot for Surinam. Citrus is grown on 2700 out of 43,000 hectares and contributes 1.57 million guilders on a total crop value of Sf 27 million.

Yields are not high, some 70,000 oranges or 50,000 grapefruits per hectare (200 trees) on the estates, which means between 150 and 300 boxes an acre. The small farmer gets only half of this. A considerable amount of fruit is not harvested as it cannot be sold, neither for export nor on the local market, which is glutted for the greater part of the year. It may be surmised that production could be doubled on the same area, if the export were better organized and particularly if the processing plant would start working again.

Citrus grows well on all kinds of soils, as long as they are well drained and there is plenty of room yet for expansion. It seems likely that this will take place to some extent on the river terraces of the interior. The Foundation for Experimental Farming is now engaged in setting up a 500 ha citrus farm at Baboenhol which may do for citrus what the Prins Bernhard Polder has done for rice. The Second Ten Year Plan proposes an expansion of the citrus area to 6000 ha. If this expansion is executed wisely, Surinam's citrus production might begin to count on the world market and it certainly would get to be a big factor in the economic growth of the country.

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