A scientific evaluation of the agricultural experiments at Frederiksgave, the Royal Danish Plantation on the Gold Coast, Ghana

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Abstract

In the 1830s agricultural experiments were carried out at the Danish state plantation Frederiksgave at the Danish Gold Coast Establishments, in order to establish an economical sustainable plantation system which could produce export crops to among others the European market. Experiments were made with coffee, tobacco, sugar cane and some other crops and spices, but they failed. Based on climatic data from Frederiksgave for the year 1835 and from nearby climatic stations in the 20th century combined with soil data from the dominant soil types analysed in 1999, the natural reasons for the lack of success are discussed.

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Keywords

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In the late eighteenth and nineteenth centuries several attempts were made by the Danes to establish plantations in the South-east of Ghana at the former Danish Gold Coast Establishments, which stretched from Osu (Danish Accra) in the West to Keta in the East. The plantations were set up in the hinterland of the Accra coast and the estuary of the Volta River. The main idea was to produce export crops to avoid the costly transportation of slaves from Africa to the West Indies, where they were used as plantation workers in the production of sugar cane, tobacco and other subtropical and tropical crops for export to Europe.

The plantations, which were established in the hinterland of the Accra coast, were located at the foot slope of the Akwapim (Akuapem) Range about 30 km north of Christiansborg Castle. One of the few exception was the first plantation which was established in 1788 by Dr. Isert at Amenapaso, a suburb of Akropong Akwapim. This plantation named Frederiksnopel existed for only a short period because Isert died shortly after the plantation had been established. Danish private merchants and civil servants who worked at Christiansborg where the Danish administration was located established several other plantations in the foothills of the Akwapim Mountains. At the end of 1820s about 5 plantations were in existence, one of these was owned by Governor Lind. In 1831 after his death, his successor Governor Hein bought the plantation on behalf of his majesty King Frederik VI and named it Frederiksgave. From that time until Denmark withdrew from the Gold Coast in 1850 by selling its properties to Great Britain, the farm was a state farm and retreat for the governor at Christiansborg. Agricultural experiments with various crops were conducted in the hope to develop a profitable plantation system, which could justify a continuous Danish activity at the Gold Coast. On April 1st 1836 the Danish Governor Mørck at Christiansborg sent a report to his Majesty in Copenhagen informing him about the results obtained since 1830 at Frederiksgave. Experiments with coffee, sugar cane, tobacco, indigo and various spices had been conducted, however, all these experiments failed. The main reason for this according to Governor Mørck was the rainfall pattern. He supported this with climatic measurement for the year 1835, but no scientific interpretations were made based on soil chemical and physical analyses or regular climatic observations.

Based on this report, a study was initiated in 1999 to look at the present day soil and climatic data so as to evaluate the agricultural experiments that were conducted.

Physical conditions

Location and topography

Frederiksgave is situated at the foot of the Akwapim Mountains towards the Accra plains near the village called Sesemi, 5°45°N, 0°15°W. Figure 1 shows the location of Frederiksgave plantation at small scales, and a topographic map of the area around Sesemi showing the extension of Frederiksgave plantation based on archival studies. It covers about 55 ha (100 tønder) of land shared between hill slope, foot slope and lowland. The highest point is about 700 meters above sea level the lowest about 300 meters above sea level. The northern part is hilly and moderately steep and is a true part of the Akwapim Mountains while the southern part is characterized by a gentle slope and is covered by talus from the mountain. The main house was a five room building with a balcony raised by Governor Hein in the beginning of the 1830s (Jeppesen 1966; Bech 1989). It was operating until the Danes left the Gold Coast in 1850, and today it is a ruin belonging to the University of Ghana.

Climate

Frederiksgave, the Danish plantation site falls within the dry equatorial climatic zone of Ghana (Dickson & Benneh 1995) characterized by two rainfall seasons. The major season is from March to June and the minor experiences its peak in October. There are two dry seasons, namely the Harmattan period from December to February with almost no rain and a minor one in July and August. In general, the total annual precipitation over the entire country is lowest along the coast of the Gulf of Guinea where Frederiksgave is located. Two reasons account for this situation, firstly the wind direction and the alignment of the coastline, and secondly the location of the Akwapim mountains. For instance from March to November, the prevailing winds blow from south west, parallel to the coast and with the presence of the Akwapim Togo ranges, Frederiksgave site turn to lie in a rain shadow.

Frederiksgave site has neither climatic nor weather station, but two climatic stations are closely located, about 15 km away; Kotoka Airport on the Accra Plain and Aburi in the Akwapim Mountains, see Figure 1. Annual rainfall recorded on the Accra plains at Kotoka International Airport is about 750 mm and on the mountain at Aburi is about 1200 mm, Table 1 (Walker 1962; Brammer 1967; Meteorological Service Department, Ghana). Therefore at Frederiksgave the annual rainfall is estimated to be between these two values. However, its location at the foot of the mountain, and

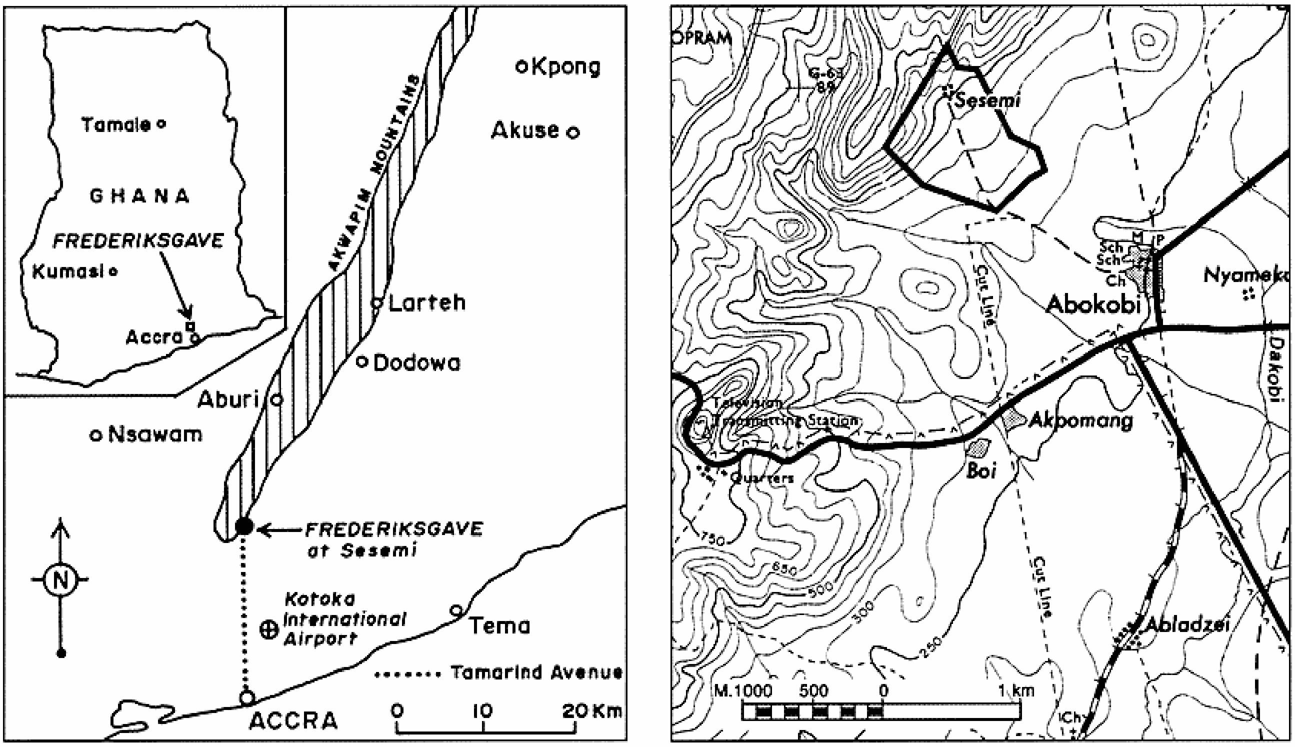

Figure 1: Small scale maps and a topographic map showing the location of the Frederiksgave plantation. The contour lines are in feet.

Table 1: Precipitation at Kotoka airport, Accra for a 90 years period 1901-1990, precipitation from Aburi for a 40 years period in the 20th century, potential evapotranspiration from Accra 1955-56 and estimated precipitation surplus at Kotoka Airport and Aburi.

Month	Precipitation (P)		Ep mm	P-Ep	
	Kotoka	Aburi	Accra	Kotoka	Aburi
January	15	27	129	-114	-102
February	32	48	140	-106	-94
March	58	114	144	-86	-30
April	85	122	135	-50	-13
May	132	165	151	-19	14
June	205	181	109	96	72
July	54	78	129	-74	-76
August	20	47	133	-113	-71
September	48	102	128	-80	-26
October	65	139	133	-68	6
November	33	122	135	-102	-13
December	21	57	136	-115	-79
Yearly	768	1202	1602	-834	-400

the direction of the prevailing winds parallel to the Akwapim mountains, no orographic rainfall is expected during the growing season. This situation therefore implies that the annual rainfall values reflect those recorded at Kotoka International Airport. Thus it must be expected that the average annual rainfall at Frederiksgave is far less than 1000 mm. The precipitation in the major rainy season (March-June) is estimated to be about 500 mm, but with large yearly variations. In some years there is almost no precipitation. The rain often falls in few heavy showers generating severe surface run off and soil erosion. In the minor rainy season (September-November), the average precipitation is estimated to be about 200 mm, while in some years it completely fails. The potential evapotranspiration is determined by Walker (1962) in Accra in the period 1955-56. The Ep is between 100 mm and 150 mm throughout the year leaving great precipitation deficits, especially at Kotoka where average precipitation surplus is only record-ed for June. This leaves agriculture highly dependent on the actual rainfall as almost no water reserve exists in the soil. The average monthly mean temperature is about 26°C, ranging between 25 and 28°C, warmest in March-April and coldest in August. Frost never occurs.

At Frederiksgave, precipitation measurements had been carried out once, by Governor Mørck from January 1835 to March 1836. Throughout the year 1835 the precipitation was recorded daily. The precipitation was captured in a gauge with an inlet area of 36 square tommer. In Table 2 the monthly rainfall in 1835 and the number of days per month where precipitation was recorded are shown. The year 1835 was rather dry with an annual rainfall value of 597 mm. The precipitation in the beginning of 1835 was lower than the average, but without agricultural significance, as it was outside the planting season which normally starts about May. May was very wet, far above average and should be able to support the germination of the plants, but the rainfall in June was critically low and might have caused severe drought problems in the end of June and especially in July and August which also had rainfall below average. The major part of the minor rainy season except for November also failed and was dry. From November 25th 1835 to March 14th 1836 no precipitation was recorded at all. Similar dry events are common at the Accra plain. In the 90 years weather record series 1901-90 at Kotoka Airport the lowest annual rainfall recorded was in 1926 with only 275 mm. Seven times the annual rainfall was below 500 mm and 21 times it was below the 595 mm recorded at Frederiksgave which is slightly below one quarter of the years.

Vegetation

The natural vegetation on the foot slope area can be classified as a coastal savanna with several types of shrubs and grassland while the upper Akwapim Mountains are covered by moist semi-deciduous forest due to heavier rainfalls. Presently most of the natural vegetation has been cleared for the cultivation of food crops like cassava and maize and some export crops like pine apple. Because of the major

Table 2: Precipitation in mm and the number of days with rain at Fredriksgave 1835.

Month	Precipitation mm	No. of days with rain
January	0	0
February	16	1
March	33	2
April	51	6
May	246	8
June	74	7
July	33	8
August	6	3
September	27	10
October	35	6
November	76	4
December	0	0
Yearly	597	55

Depth cm Soil[1]	Clay	silt	f. sand	c. sand	total	Ctotal	N total P	pH CaCl$_2$
	%							
F1 0-10	nd	nd	nd	nd	2.52	0.19		5.3
F2 10-20	nd	nd	nd	nd	0.98	0.07		4.3
S1 0-7	10.5	22.7	24.4	42.4	1.01	0.08	0.012	5.1
S2 7-23	10.8	24.8	25.5	38.9	0.70	0.06	0.010	4.5
S3 23-62	10.5	25.1	27.0	37.4	0.46	0.03	0.008	4.3
S4 62-160	9.0	24.1	26.7	40.2	0.45	0.03	0.008	4.3
S5 160+	15.0	21.3	26.9	36.8	0.39	0.03	0.008	4.5
O1 0-6	10.5	19.9	32.6	37.0	1.65	0.11	0.013	5.6
O2 6-16	10.5	17.2	30.7	41.6	0.95	0.07	0.010	5.3
O3 16-30	17.2	15.3	28.7	38.8	0.53	0.05	0.007	4.1
O4 30-75	24.6	18.4	24.0	33.0	0.28	0.03	0.010	4.1
O5 75-170	18.6	16.0	24.2	41.2	0.40	0.04	0.007	3.9

[1]F=Fete, S=Sesemi, O=Oyarifa

***Table 3:** Texture, total organic carbon, nitrogen, phosphorous and pH ($CaCl_2$).*

Depth cm Soil[1]	Ca^{2+}	Mg^{2+}	K^+	Na^+	H^+	Al^{3+}	ECEC	CEC
	cmol(+)/kg							
S1 0-7	2.97	1.25	0.20	0.06	0.00	0.06	4.54	6.52
S2 7-23	1.75	0.92	0.10	0.06	0.00	0.43	3.26	6.96
S3 23-62	1.14	0.82	0.06	0.06	0.01	1.01	3.10	5.85
S4 62-160	1.59	0.60	0.04	0.05	0.00	0.62	2.90	4.79
S5 160+	1.76	1.12	0.05	0.07	0.00	0.17	3.17	-
O1 0-6	5.11	2.21	0.43	0.06	0.00	0.08	7.89	12.93
O2 6-16	2.31	1.35	0.27	0.06	0.00	0.07	4.06	9.46
O3 16-30	1.35	0.87	0.09	0.11	0.05	1.73	4.20	6.80
O4 30-75	0.87	0.90	0.05	0.07	0.05	2.77	4.71	8.11
O5 75-170	0.59	0.47	0.08	0.06	0.06	3.18	4.44	6.70

[1]S=Sesemi, O=Oyarifa

***Table 4:** Exchangeable bases, exchangeable acidity and CEC.*

Depth cm Soil[1]	pF 1.0	pF 2.0	pF 3.0	pF 4.2	Porosity	Bulk density
	vol%					
S1 0-7	30	18	11	8	57	1.11
S2 7-23	25	18	13	11	49	1.34
S3 23-62	30	21	14	8	46	1.43
S4 62-160	35	22	14	10	46	1.43
S5 160+	34	20	13	7	46	1.44
O1 0-6	30	18	10	8	49	1.32
O2 6-16	27	19	13	7	49	1.35
O3 16-30	26	17	11	8	50	1.33
O4 30-75	28	18	10	8[2]	38	1.63
O5 75-170	24	15	7	6[2]	38	1.64

[1]S=Sesemi, O=Oyarifa [2]estimated values

***Table 5:** Soil water retention data for Sesemi and Oyarifa series. (Bulk density values in g/cm³).*

precipitation deficits (Table 1), the agricultural activities on the Accra plain are therefore depended exclusively on the major rainy season in Ghana.

Soils

The soils at Frederiksgave are developed on in situ weathering products from the rocks building up the Akwapim Mountains or on talus deposits from similar weathering products, which by soil erosion has been transported to the foot of the mountains. Geologically the Akwapim hills are a part of the Togo series, which consists of Precambrian sedimentary rocks and their metamorphosed versions like quartzite, schist, shale and phyllite. These deposits were strongly folded to form what is now called the Akwapim-Togo Ranges.

The soils at Frederiksgave plantation can be divided into three major types (Figure 2). In each of the three areas typical soil profiles have been investigated in 1999. The profiles have been described according to a system similar to FAO (1990), and samples for analyses were taken from the major soil horizons. Tables 3,4 and 5 show the results. The texture is determined by sieving and by the hydrometer method. Total carbon is determined by dry combustion, total nitrogen by Kjeldahl, and total phosphorous by ignition and extraction by 12N sulphuric acid. Exchangeable bases are determined by extraction with 1M NH_4Ac, exchangeable acidity by 1M KCl and ECEC as the sum of exchangeable bases and exchangeable acidity. CEC is determined as the sum of exchangeable bases and extractable acidity at pH8.0 by the TEA-method (Klute, 1986). Soil water retention curves and hereby plant available water is determined by the pressure plate method. In the following discussion the analytical results are classified according to Siderius (1992) as e.g. very low, low, medium, high and very high. It is believed that the chemical and physical composition of the soils are almost the same today as they were 150 years ago, because no liming or fertilizers were in use during that period.

In the hilly part of the plantation the soils are shallow and stony with outcrops of bare rocks. Today the surface mantle rarely exceeds 20 cm in depth, but before the plantation was established it might have been somewhat thicker. The soils are very vulnerable to soil erosion if the vegetation cover is removed, as it happened in the 1830's when the plantation was established. The soils belong to the Fete soil series (Brammer 1962, 1967), and it is according to WRB (ISSS/ISRIC/FAO 1998) a Leptosol. The topsoil is very dark brown (7,5YR 2/3moist) sandy loam with a low content of organic matter, less than 2%, and it is medium acid with pH about 5.3. It is very stony, about one third of the soil layer is estimated to be mainly angular quarzitic stones. The subsoil is dark brown (7.5YR 3/3moist) sandy loam with a very low content of organic matter and more than half of the horizon consists of quatzitic angular stones. It is strongly acidic with pH 4.3 and turns with depth into non weathered quarzitic rock with fractures. These fractures drain the excess of rainwater very well leaving the soil water holding capacity very low, rarely exceeding 30 mm. Similar considerations can be made about the nutrient status which is very low due to the shallow depth of the soil layers and the high proportion of stones.

At the talus slope the Sesemi series dominates (Brammer, 1967). It consists of talus accumulations derived from the mountains and hereby from the Fete soil series. The topsoil is brownish (10YR 3/3moist) but turns with depth into more reddish colours as 5YR 3/3moist and 2.5YR 3/4moist.

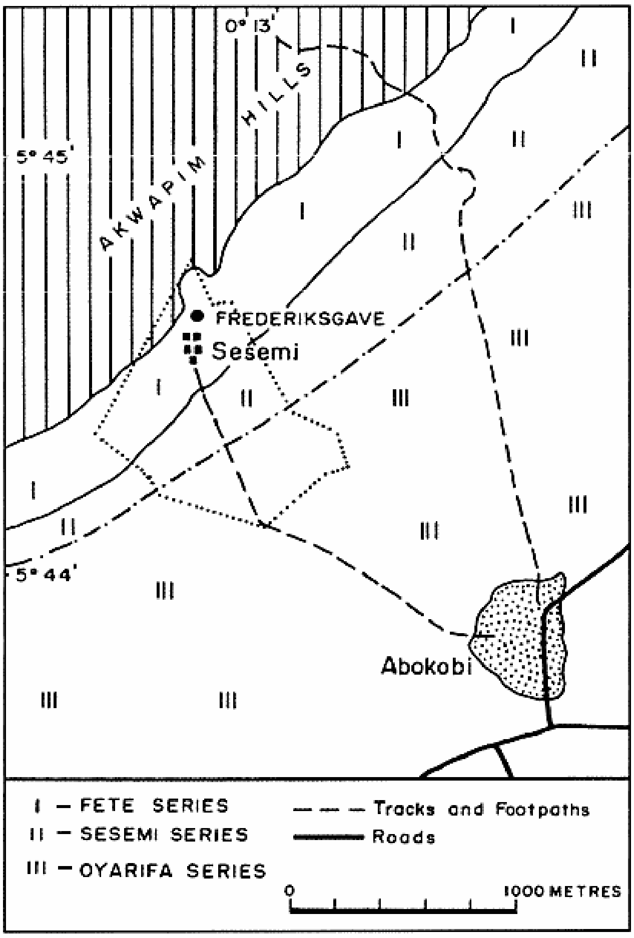

Figure 2: Soil map of the Fredriksgave Plantation and its environs. The precise extension of the plantation is shown by a dotted line.

Pedologically, according to WRB (ISSS/ISRIC/FAO 1998) it is in the transition zone between a Lixisol and an Acrisol.

The soil has a sandy loam texture. The topsoil has about 10% clay and a low organic matter content slightly below 2%. The clay content increases with depth to about 15% clay in the clay illuvial horizon. The clay is mainly kaolinitic and the soil has low to very low CEC-values. The pH of the topsoil is medium acid, but with depth it becomes strongly to very strongly acid. The content of the various exchangeable bases is low in the topsoil but turns into very low with depth. Below the topsoil at the depth of about 25 cm aluminium is present as exchangeable acidity at a toxic level for not acidic tolerant crops. The soil layers contains scattered stones and boulders of various Togo rocks. They are generally deeper than one meter overlaying moderate-weathered Togo rocks, and they are well drained although temporarily ground waters might develop through the rainy seasons due to seepage from the mountains. Under present agricultural practice the soil is rather poor for nutrient supply. It is well aerated and has a plant available water content slightly above 10% by volume which is not high. Soil erosion control would be essential if intensive cropping were to be introduced, like the use of phosphate, nitrogen and potassium fertilizers.

Below the Sesemi series on a more level ground is the Oyarifa series. These soils are reddish brown (2.5YR 3/3 moist) in the topsoil and more reddish in the subsoil (10R 4/8moist and 2.5YR 4/8moist. They are deep well-drained soils developed on slope-wash deposits. The bedrock is normally below 150 cm. At Frederiksgave the topsoil of the Oyarifa series is a sandy loam which at depths in the Bt-horizon turns into a sandy clay loam. The organic matter content is about 3% in the topsoil, well decomposed with a C/N ratio between 10 and 15. The topsoil is slightly acid, and the nutrients are concentrated in the uppermost two soil horizons although the content of exchangeable bases is only medium to low. At depth the soil becomes strongly acid with a substantial amount of exchangeable aluminium, which at a depth of about 15 cm has a toxic effect on many crops. The clay is kaolinitic with estimated clay CEC below 20 cmol(+)/kg. Pedologically the soil is classified as an Acrisol according to WRB (ISSS/ISRIC/FAO, 1998). For present agricultural practice the soil is rather poor in nutrients although it is slightly better than the Sesemi soil, but still the use of phosphate, nitrogen and potassium fertilizers is needed, if intensive cropping were to be introduced (Adu & Asiamah 1992). Crops that should be cultivated on these soils should be aluminium tolerant such as cassava. The soil is well aerated but has only about 10% by volume plant available water in the various soil horizons which is a bit lower than measured in the Sesemi series.

The agricultural experiments

The report of Governor Mørck to the Majesty dated April 1st, 1836 describes the various experiments, which were carried out at Frederiksgave. The following crops were investigated: coffee, sugar cane, tobacco, indigo, cotton and some spices. In the following comments will be given on why the coffee, sugar cane and tobacco failed.

Coffee

Coffee had already been cultivated at the Frederiksgave plantation by Governor Lind before the Danish State bought it. The coffee cultivated was raised from beans collected from the nearby Bibease plantation, which was owned by Dr. Trentepohl. Governor Mørck writes the following about the cultivation of coffee (Mørck, 1836):

'There were altogether 735 young coffee trees and 3 or 4,000 young coffee plants in beds. 2,265 of these plants were transplanted in the same year so that there were a total of 3,000 coffee trees. At the time, Governor Hein did not want a larger number transplanted because he was aware of the implications. By May 1832, 905 of the 3000 coffee trees were already dead, and were replaced with new plants. Because of the long lasting drought in July and August of the same year, more trees were severely damaged, and by June 1833, another 879 trees were dead, which were also replaced with new plants. Governor Lind further asked for 700 other coffee plants to be transplanted to the edge of a slope close to the house. In July of 1834, almost all of these 700 plants were dead. The main cause of their death was that the slope was mostly stony and gravelly, with just a thin layer of soil, which was washed away by rain, leaving the plants on the rather barren land.

In that same year, the coffee trees were counted again and out of 3,700; as many as 679 were dead. In place of the dead plants, 276 new ones were transplanted, and this number made up the remainder after transplanting that same year. By August 1835 another 702 coffee trees were dead and they could only be replaced by 40 plants, which were all that were obtained from the 6,000 to 8,000 beans which were planted in both boxes and beds. The reason for this was that because of a lack of rain, the beans could not attain the requisite maturity, and therefore lost their ability to sprout. The situation has been the same this year, such that at the moment, we have no plants to replace those that have died from August to date, numbering 125 trees in all. The Harmattan has been and continues to be uncharacteristically strong, and from 25th November to date, there has been no rain; the coffee trees, which are still alive, are in a quite pitiful state and greatly disturbed by insects and ants.'

It is not clear from the archives what type of coffee was tested. Therefore it is not possible to set up specific demands but based on our knowledge on the demands for present days coffee types, like coffee arabica and coffee canephora, the following can be stated. The suitability for a given site for good and sustainable coffee production is determined by four basic environmental variables: temperature, plant available water, light intensity and soil chemistry (Cambrony 1992; Coste 1992). The demand may differ a little for the different varieties of coffee, but the temperature should normally be between 15 and 30°C and without frost, which the area around Frederiksgave fully fulfil. Wild coffee plants are naturally woodland plants found in high forests and are therefore adapted to conditions of low light intensity. In cultivation, shading has therefore traditionally been the norm, but due to self-shading provided by overlapping foliage, shading is often not necessary. On the other hand shade trees might modify the temperature and hereby the water losses and it might reduce soil erosion. Thus even if shading might improve the coffee yields at the plantation Frederiksgave, it is not likely that the light is the reason for the failure.

The coffee plants show a great flexibility to the soil properties. They prefer to grow on acid soils like the ones we find at Frederiksgave, but the soil there is often too acid in the subsoil for especially arabica coffee and in general the amount of potassium in the soils is critically low. But the major problem for coffee growth at Frederiksgave is found in the amount of plant available water. This can be defined as the amount of water in the root zone at the beginning of the growing season plus the precipitation in the growth season minus the water loss through percolation and run off in the same period. As the percolation is less from soils with deep rooting systems compared to one with shallow rooting systems and run off is less from flat areas compared to steep ones the optimal soils with reference to water supply will be deep soils on not too steep land. Coffee might have rooting systems which goes as deep as three metres. At Frederiks - gave this is not possible in any of the soil types as the soils are shallow and the acid subsoil in itself will hinder a vigorous root development. Especially the Fete series is very shallow. The soil water retention is therefore not optimal in any of the soil types.

The variable and most critical parameter is the precipitation in the growth season. Two aspects to consider are the total monthly and annual precipitation and the precipitation distribution. This emphases the importance of the length of the dry seasons, which is the period of vegetative rest and flower induction. The dry season can be between 3 to 6 months depending on the coffee variety. Frederiksgave fulfil this by having a major dry season of about 4 months. The annual rainfall should normally be above 1200 mm, annual rainfalls below 1000 mm induce uncertainties and great risks for crop failure. At Kotoka Airport only about 15% of the annual precipitation exceeds 1000 mm. Thus, the annual rainfall at Frederiksgave must normally be somewhat below 1000 mm and crop failure must be expected in normal and in dry years. Furthermore the precipitation in the major rainy season often falls as few heavy showers with substantial run off and with only a minor part infiltrating the soil. The effective rainfall is therefore much lower than 1000 mm. It is therefore not surprising that the coffee production failed, especially on the Fete soil series where a combination of low water holding capacity and severe soil erosion killed all coffee plants within few months after planting.

Tobacco

Tobacco was introduced at Frederiksgave in April 1835. Governor Mørck describes the experiments with tobacco in his report to the Majesty in Denmark in the following way:

'On April 15th 1836, tobacco seeds were planted in 8 cartons. From 11th to 16th July, 4,000 tobacco plants were planted on a piece of land measuring about a half tønde (1 tønde = 0.55 ha). During both the planting and growing stages, the greatest care was taken of the plants and when there was a lack of rain, as far as the situation permitted the tobacco plants as well as all the other plants were watered. In August, of these 4,000 plants, about 500 had obtained a height of 2-3 feet, with leaves 12 to 16 inches long. 700 were between 1 and 2 feet, with leaves 8 to 12 inches long. There were 100, which were 6 to 12 inches long, with leaves 4 to 8 inches long. The rest of the plants were only 4 to 6 inches high, with leaves 2 to 3 inches long, and had already reached maturity. Of the above mentioned 4,000 plants, nearly the same number have been transplanted to replace those which have died as a result of lack of rain, excessive sunlight or attacks of insect. In October and November of the following year, 500 new plants were planted on another piece of land. Because of lack of rain, these new plants had to be watered twice a day. In the end of November, the source of water for this purpose ran out, and there was scarcely enough water for the negroes own use. The watering was therefore stopped, and most of the plants therefore died. In all these attempts, a total of 100 lbs of tobacco has been harvested, which is only 1/15th of what could have been harvested. It is intended that these 100 lbs of tobacco should be made into cigars, and since some of these cigars have already been made, I have the liberty of sending the High Colleguim a sample.'

Two experiment series were made, one in the major rainy season and one in the minor rainy season extending into the major dry season. In the first series the tobacco was irrigated when necessary. In normal years this should not be necessary as a precipitation of above 400 mm during the growth cycle should be enough to secure a production (Sys et al., 1993), but in June 1835 the precipitation was very low. Although adequate water was provided during the experiment, the yields were very poor. This was due to very unfavourable soil condition for tobacco growth. It is not clear on what soil type the experiments were conducted, but the Fete soil series can be excluded as being too shallow. The Sesemi and Oyarifa soil series are both too acid for tobacco growth as tobacco soils should have pH-values of more than at least 5.0 but ideally above 5.5. The subsoils in both soil series have pH-value below 5.0 even if it was measured in water, and the high aluminium content is toxic for the tobacco. Furthermore tobacco demands a high input of potassium, and a substantial input of potassium fertilizer up to more than 130 kg/ha/growth cycle is needed on potassium poor soils. Both Sesemi and Oyarifa soil series are characterised by low to very low contents of potassium.

The second experimental series did not succeed because the planting was done too late in the minor rainy season, so the vegetative phase was extended into the major dry season and not followed up by irrigation. Even so the production would probably have failed due to the unfavourable soil conditions. It must be concluded from the experiment and the present day investigation at Frederiksgave that the tobacco growth failed mainly due to unfavourable soil condition.

Sugar cane

In May 1835, 200 sugar canes were planted. Although all precautions were taken, after one month they were almost all eaten up by ants or were wilting due to various diseases. This was probably due to many soil and climatic factors. First, the climate is too dry for sugar cane production; the average annual precipitation should be higher than 1300 mm (Sys et al. 1993) which is not the case. At Kotoka Airport only in 2 out of 90 years the annual precipitation exceeded 1300 mm. In regions with marginal rainfall for sugar cane production good responses on irrigation are normally observed (Williams & Joseph, 1970). Thus irrigation is needed for a successful cultivation at Frederiksgave, but in dry years the only spring in the vicinity dries out and there will therefore be no water for irrigation. Furthermore the soil is not suitable for sugar cane production, the shallow soil material and the acid subsoil does not favour a deep and vigorous root development which is needed in dry climates. In addition, the texture is rather coarse for sugar cane production, because in coarse textured soils nematode populations are easily built up (Sys et al., 1993). Infestations may be aggravated because sugar cane is a perennial crop. Finally it is a question whether the soils can support the plants with essential nutrients like phosphorous and potassium. Thus it must be concluded that sugar cane production is not possible at Frederiksgave due to unfavourable climate and soil conditions.

Final remarks

The investigation shows that the climate and soil conditions at the foot of the Akwapim Mountains are so poor that location of plantations in that region is risky, because plant growth often fails. The climate is too dry for coffee and sugar cane production, but could support tobacco growth without irrigation in normal or wet years according to precipitation in the growing period. On the other hand the soil is too shallow and too acid in the subsoil to support tobacco and sugar cane production. Furthermore the overall nutrient status of the soils is so low that it hardly can support most crops. The results of the experiments carried out at Frederiksgave in the 1830's support this strongly, and it is one of the major reasons why the Danes gave up occupying that part of the Gold Coast and sold it for 10,000 pounds Sterling to the British in 1850. One major question arises: was the location of the plantation at the foot of the Akwapim mountains a reasonable choice or should they have been located at another place? The climatic measurements from the 20th century shows clearly that the plantation was located wrongly at the place along the Guinea Gulf coast with lowest precipitation. On the other hand the plantations could probably have survived in the mountains around Aburi or Akropong where Isert established Frederiksnopel. Here the annual precipitation is about 1200 mm, enough for supporting e.g. coffee growth.

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bacco has been harvested, which is only 1/15th of what could have been harvested. It is intended that these 100 lbs of tobacco should be made into cigars, and since some of these cigars have already been made, I have the liberty of sending the High Colleguim a sample.'

Two experiment series were made, one in the major rainy season and one in the minor rainy season extending into the major dry season. In the first series the tobacco was irrigated when necessary. In normal years this should not be necessary as a precipitation of above 400 mm during the growth cycle should be enough to secure a production (Sys et al., 1993), but in June 1835 the precipitation was very low. Although adequate water was provided during the experiment, the yields were very poor. This was due to very unfavourable soil condition for tobacco growth. It is not clear on what soil type the experiments were conducted, but the Fete soil series can be excluded as being too shallow. The Sesemi and Oyarifa soil series are both too acid for tobacco growth as tobacco soils should have pH-values of more than at least 5.0 but ideally above 5.5. The subsoils in both soil series have pH-value below 5.0 even if it was measured in water, and the high aluminium content is toxic for the tobacco. Furthermore tobacco demands a high input of potassium, and a substantial input of potassium fertilizer up to more than 130 kg/ha/growth cycle is needed on potassium poor soils. Both Sesemi and Oyarifa soil series are characterised by low to very low contents of potassium.

The second experimental series did not succeed because the planting was done too late in the minor rainy season, so the vegetative phase was extended into the major dry season and not followed up by irrigation. Even so the production would probably have failed due to the unfavourable soil conditions. It must be concluded from the experiment and the present day investigation at Frederiksgave that the tobacco growth failed mainly due to unfavourable soil condition.

Sugar cane

In May 1835, 200 sugar canes were planted. Although all precautions were taken, after one month they were almost all eaten up by ants or were wilting due to various diseases. This was probably due to many soil and climatic factors. First, the climate is too dry for sugar cane production; the average annual precipitation should be higher than 1300 mm (Sys et al. 1993) which is not the case. At Kotoka Airport only in 2 out of 90 years the annual precipitation exceeded 1300 mm. In regions with marginal rainfall for sugar cane production good responses on irrigation are normally observed (Williams & Joseph, 1970). Thus irrigation is needed for a successful cultivation at Frederiksgave, but in dry years the only spring in the vicinity dries out and there will therefore be no water for irrigation. Furthermore the soil is not suitable for sugar cane production, the shallow soil material and the acid subsoil does not favour a deep and vigorous root development which is needed in dry climates. In addition, the texture is rather coarse for sugar cane production, because in coarse textured soils nematode populations are easily built up (Sys et al., 1993). Infestations may be aggravated because sugar cane is a perennial crop. Finally it is a question whether the soils can support the plants with essential nutrients like phosphorous and potassium. Thus it must be concluded that sugar cane production is not possible at Frederiksgave due to unfavourable climate and soil conditions.

Final remarks

The investigation shows that the climate and soil conditions at the foot of the Akwapim Mountains are so poor that location of plantations in that region is risky, because plant growth often fails. The climate is too dry for coffee and sugar cane production, but could support tobacco growth without irrigation in normal or wet years according to precipitation in the growing period. On the other hand the soil is too shallow and too acid in the subsoil to support tobacco and sugar cane production. Furthermore the overall nutrient status of the soils is so low that it hardly can support most crops. The results of the experiments carried out at Frederiksgave in the 1830's support this strongly, and it is one of the major reasons why the Danes gave up occupying that part of the Gold Coast and sold it for 10,000 pounds Sterling to the British in 1850. One major question arises: was the location of the plantation at the foot of the Akwapim mountains a reasonable choice or should they have been located at another place? The climatic measurements from the 20th century shows clearly that the plantation was located wrongly at the place along the Guinea Gulf coast with lowest precipitation. On the other hand the plantations could probably have survived in the mountains around Aburi or Akropong where Isert established Frederiksnopel. Here the annual precipitation is about 1200 mm, enough for supporting e.g. coffee growth.

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