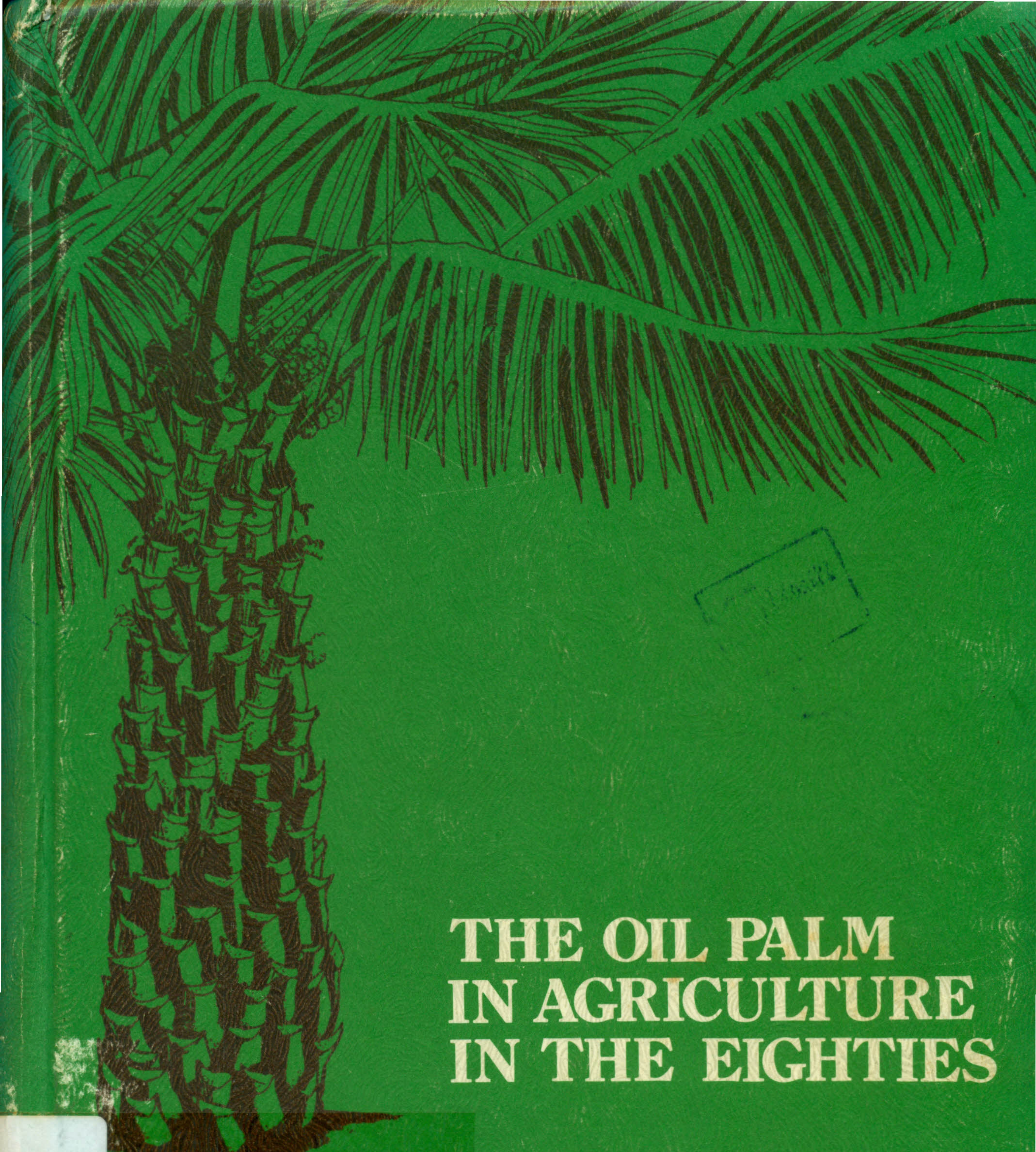

THE OIL PALM IN AGRICULTURE IN THE EIGHTIES

Volume I

The Oil Palm Industry in Brazil — Current Status and Future Potential

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The oil palm industry in Brazil, at present, is small. Annual production is estimated at 20 000 tonnes of palm oil and this is derived from both established plantations and sub-spontaneous oil palm groves. Current yield capability of the established plantations is between 16–20 tonnes of FFB per hectare per year at peak production.

There is much interest in further expanding the oil palm area motivated largely by the possibility of substituting diesel with palm oil. A national 'PRO-OLEO' policy is being formulated to provide the necessary incentives to encourage the production and use of the palm oil and other vegetable oils for the substitution of diesel.

In terms of agroclimatic and soil factors, Brazil has tremendous potential for oil palm cultivation. It is estimated that no less than 50 million hectares, mainly in the Amazonas region, would have conditions which would be considered agroclimatically ideal for oil palm cultivation. The soils in the areas concerned are largely of the 'latosol' group which, although chemically poor, possess good physical attributes which, together with proper fertiliser management, should be able to sustain yields comparable to the best oil palm areas in the world.

The oil palm industry in Brazil began during the fifties with the establishment of small extraction mills to process oil palm fruit bunches collected from naturally occurring or sub-spontaneous oil palms in the state of Bahia, Brazil. At about the same time, the first oil palm plantations were also established in the state. Since then the industry has grown but at a very slow pace. Today, there is an estimated area of only 12 000 ha of established oil palm in the country.

However, this situation is expected to change in the near future. The reason for this is the worldwide problem, namely, the petroleum crisis. Brazil has had to import to meet much of its requirements for petroleum and for 1980, the estimated cost to the country was US $11 billion and no less than 55% of Brazil's export earnings went to pay for this import (*Table 1*).

The country has achieved much success through its National Programme on Alcohol (PROALCOOL) to substitute gasoline (petrol) with locally

TABLE 1. IMPORT COST OF PETROLEUM AND TOTAL EXPORT EARNINGS IN BRAZIL

Year	Import of petroleum (U.S. $ Millions) (A)	Total export earnings (U.S. $ Millions) (B)	A/B (%)
1972	409.2	3991.2	10.25
1973	710.8	6199.2	11.47
1974	2840.1	7951.0	35.72
1975	2875.4	6669.9	33.17
1976	3612.5	10 128.3	35.67
1977	3813.9	12 120.2	31.47
1978	4196.8	12 658.9	33.14
1979	6403.7	15 244.4	42.00
1980[a]	11 000.0	20 000.0	55.00

[a]Estimated.

Source: Agro analysis 4 (7) 2.9 Julho, 1980 "Oleos combustiveis: Uma verdadeira alternativa?"

produced alcohol. Mixtures of 20% of alcohol with gasoline are now a standard practice. However, cars using 100% alcohol are already in commercial production and general usage. By 1985, it is expected that such cars will form the majority of the new cars on the road.

While a solution appears hopeful for the gasoline problem, the consumption of diesel remains a source of concern. To overcome this problem, attention is being focussed on the vegetable oils. Technically, it is possible to substitute diesel with vegetable oils and the problems of substitution are probably less than that for alcohol (Rudolph Diesel, 1911 as cited by De Souza (1980).

At current prices, 1 tonne of palm oil can buy 2 tonnes of petroleum and it would therefore seem more logical to produce and sell palm oil and purchase the petroleum. This is, of course, immediately possible but the price which is dependent on the current supply and demand situation is unlikely to remain the same, once substantial quantities are available on the market. Also, there is no basis for assuming that the rate of increase in the price of petroleum will not continue to outstrip that of palm oil. Therefore, the more important question is: At what price will it be attractive to produce palm oil and whether at this price, substitution of diesel will still be economically feasible?

There are, of course, other reasons including strategic and political considerations and the potential for considerable savings in foreign exchange which would make this substitution particularly attractive for Brazil. Some of the strategies relating to this substitution have been discussed elsewhere (Maia, Araujo, Leao & Santana, 1980; De Souza, 1980) but whatever the controversy regarding this, the government of Brazil appears firmly committed to this policy and is formulating plans for a 'PRO-OLEO' programme to provide the necessary incentives to boost the production and use of vegetable oils for this purpose.

It has been estimated (Maia *et al.*, 1980) that substitution of diesel currently consumed in the country would require the planting of 4.5–5.8 million hectares of oil palms. This is clearly beyond practical consideration in the immediate future. Also, the country has other sources of vegetable oils, the most important being soya bean, ground nuts, rapeseed, and sunflower and in the short run, substitution will be based on these oils. In the long run, greater attention will be focussed on the perennial oil crops, *e.g.*, coconut and babacu, but in particular, oil palm which has the highest oil productivity would receive greater attention.

In addition, research support which has had only little attention, presently is receiving increasingly stronger support and, the creation of the National Oil Palm Research Center shows the importance given to this product by the Brazilian Government (Nascimento, Ooi, da Silva, De Souza, Maia & Mueller, 1981).

PLANTED AREAS AND PRODUCTIVITY

Compared with the major oil palm growing countries in the world, current palm oil production in Brazil is small, estimated at 20 000 tonnes annually. The whole of this production is consumed locally by the food industries, tin plating industry and for soap manufacture. Because much of the oil is for industrial use and for local consumption, there is less concern for oil quality. Thus free fatty acid content of the oil produced can be high, between 6%–10% generally but, in some instances, higher.

Palm oil production is derived both from established plantations as well as from sub-spontaneous palms. The latter currently accounts for 50% of the total oil produced but its importance is likely to decline markedly in the near future as more of the established plantations come into production and new areas are planted.

Only some relevant features of the current status of the oil palm industry will be present here as more detailed information may be found elsewhere (Maia, 1972; Ooi, 1980).

Sub-Spontaneous Oil Palm Groves

Sub-spontaneous oil palm groves which occur naturally in Brazil along the coast from Ceara to Rio de Janeiro may be found in the largest concentration within the vicinity of Salvador and in the Valenca/Camamu area, in the State of Bahia.

That oil palms occur naturally only in this region and nowhere else in Brazil* or South America together with the fact that the early slave trade with Africa was most active here and much of the Brazilian population of African descent may also be found here leave little doubt that these oil palms have been introduced from Africa and are not indigeneous to Brazil or South America.

As mentioned earlier, the largest concentration of oil palms may be found within the South of Bahia in the vicinity of Salvador and it is only in this region that these sub-spontaneous oil palms are exploited for oil production and oil extraction mills have been established. Manual hand presses are also in use among several small farmers.

At several locations, very dense populations may be found and plant density of 100–200 palms per hectare is not uncommon. However, productivity of these groves is low. Within the region where much of the exploitation of these sub-spontaneous oil palms are taking place, it is estimated that the area involved is 20 000 ha, producing some 6000 tonnes of oil and 1500 tonnes of kernel, *i.e.*, a productivity of less than 0.3 tonnes of palm oil per hectare. Much of the palms are of the *dura* type (forming 85%–90% of the population) frequently with extremely thick shells, *i.e.*, of 'macrocarya' type (Maia, 1972). A factory in the area, with 80% of the crop that it processes being from the sub-spontaneous groves, reports an oil extraction rate of 13.5%.

Apart from thinning the stand, there appears to be little effort made to improve the productivity of the groves. Also, no cash-cropping or intercropping is carried out among the palms unlike the situation in Africa. The importance of the sub-spontaneous groves are likely to decline as other crops *e.g.*, cloves, pasture, citrus, etc. are planted in their place.

Established Plantations

Oil palm is cultivated in Brazil in the states of Bahia, Para and Amapa. The corresponding hectarage are shown in *Table 2*.

The earliest plantations in Brazil were established in the state of Bahia during the late fifties. This state, apart from the sub-spontaneous oil palms, has approximately 5300 ha of established oil palms which are extremely variable. Production of 16–18 tonnes per hectare per year has been indicated but it is likely that this production applies only to the better stands. In general, yields are considerably less. Plantation practices here are gene-

* Small sub-spontaneous groves of oil palm may also be found in Tarauaca (state of Acre), probably introduced from Bahia, but none are exploited commercially for oil.

TABLE 2. AREA PLANTED WITH OIL PALM IN BRAZIL

States	Total planted area (ha)	Mature (ha)
Amapa	700	0
Para	5100[a]	2100
Bahia	5300	2500
Total	11 100	4600

[a] Estimated.

rally not optimum. It is only recently that discriminatory fertiliser practices based on foliar nutrient levels have been initiated. Leguminous covers are generally not in use and only in some instances are proper ground management practices adopted. However, a more serious problem is that related to pest and diseases. These factors limiting productivity are discussed later.

In the state of Para, the earliest oil palm plantation was established only in 1968. The total planted area is 5100 ha of which approximately 2100 ha is in production. Field conditions are good with well established leguminous covers. Cover establishment with *Pueraria* appears to be relatively simple and 1 kg of seeds per hectare together with adequate phosphate application seems to be sufficient to obtain good ground cover with little need for subsequent inter-row weeding. Foliar analysis is used to diagnose fertiliser needs but the quantities applied are low. Peak yields of 20 tonnes of FFB per hectare per year are obtainable. Yield trends that may be expected for the different ages are shown in *Table 3.*

TABLE 3. CURRENT YIELD POTENTIAL OF OIL PALMS IN BRAZIL

Year from planting	Bunch production (tonnes/ha)
3rd	3
4th	7
5th	15
6th	18
7th	20
8th – 20th	18 – 20
20th – 25th	15 – 18
25th onwards	10 – 15

Planting of oil palms in the state of Amapa is of very recent origin and the oldest planting is less than one year old. Planted area at present is 700 ha but a much larger area is envisaged in the near future. General conditions of these plantings appear to be satisfactory but legume cover establishment is poor. The soils in the area are generally poor and have compacted surface. However, a more critical factor is that this area is within the Savannah zone and moisture deficit is well over 250 mm per year. Yields are not expected to exceed 15 tonnes of FFB per hectare per year.

Smallholders

Participation by the smallholders in oil palm cultivation in Brazil, at present, is limited. Apart from the exploitation by smallholders of the sub-spontaneous and planted oil palms in Bahia, only a small area of 2500 ha has been developed by smallholders in the state of Para. These holdings vary from 10 ha to 153 ha in size and conditions of the fields vary from satisfactory to neglected (Mueller, 1980).

Intercropping, particularly with papaya, black pepper, melon and other fruits is widely practised and it is apparent that these crops receive more attention than the oil palms. The better holdings report yields of 10 tonnes of FFB per hectare per year for the 1974 plantings.

Projects being Planned and Implemented

The projects in the process of implementation, *i.e.,* with plants in the nursery, is estimated at 5000 ha and these are equally divided among the Amapa Federal Territory and the states of Bahia and Para.

An additional 30 000 ha has been planned for but it is expected that not more than 50% of this area will actually be planted within the next few years. A major constraint will be the availability of planting materials.

FACTORS LIMITING PRODUCTIVITY

Productivity of oil palms in Brazil is extremely variable. Maximum yields above 20 tonnes per hectare per year have been achieved for some of the best plantings but, for the rest, much lower yields can be expected. The oil palm industry faces several problems and the more important factors limiting productivity are discussed below.

Pests and Diseases

Pests and diseases of oil palms are of serious concern in Brazil because when it occurs, it can be extremely destructive. The more important of these pests and diseases are discussed below, the order of presentation to a large extent reflect their relative importance in Brazil.

Rhyncophorus palmarum. This appears to be currently the most serious insect pest problem of oil palms in Brazil, at least in terms of the destruction it can cause to the palms. Apart from directly causing death to the palms by its activity, it is also known to be a vector for the nematode, *Rhadinaphelenchus cocophilus* (Cobb, 1922; Martyn, 1953; Hagley, 1965) the cause of red ring wilt in coconuts (Fenwick, 1969) and oil palms (de Lima, 1978).

In one plantation in Bahia, cumulative palm losses (death) over several years was 30% before the problem was brought under control. Currently, annual palm losses are estimated at three percent, a level which is still of economic importance. Control measures adopted included felling and poisoning the infested tree to kill the insects that are attracted to it.

Elsewhere in Brazil, the problem exists only at a very low level. At Para for example, the cumulative palm loss due to this pest is less than one percent in one oil palm plantation. The difference between this region and Bahia is more likely to be a reflection of the effectiveness of the pest control measures than any ecological factor.

Red ring wilt (Anel vermelho). This wilt is characterised by failure of the spears to open, yellowing and death of the old leaves and is readily identified by the presence of a distinct red ring within the dissected trunks of the infected palms. The causal agent is a nematode (*Rhadinaphelenchus cocophilus*) and although root infection appears possible (Fenwick, 1969), it is now generally accepted that the main vector is *Rhyncophorus palmarum.*

In the earlier mentioned example where a 30% palm loss was cited, there was adequate evidence to suggest that red ring was also a contributory factor but the extent is not known. In a plantation in Para, the records indicate that of the total cumulative palm loss for the 1968 planting, 50% was due to red ring.

Castnia daedalus. The insect pest concerned is an extremely large (up to 10 cm) caterpillar of the moth *Castnia daedalus*, which burrows into the bunch stalk and trunk of the palm. Where the infestation is minor and confined to bunches, crop loss is due to rot of bunches and abortion of the female inflorescences. In severe cases where the caterpillar penetrates into the trunk and the vascular tissues are damaged, reduction of leaf size, wilt and eventually death of the palms can occur.

In Brazil, this problem appears to be confined to oil palms in Para state. Estimates of crop loss before control measures were instituted was 18% (Schuiling & Van Dinther, 1980). Measures which appear to be effective in controlling pest include trapping of the adults, regular pest surveillance and institution of chemical (*e.g.*, endrin) control measures when the population build-up reaches critical levels.

The seriousness of this pest, if left unchecked, may be seen from the experiences in Peru where a crop loss due to this pest of 30%–40% was reported (Korytkowski & Ruiz, 1980).

Demotispa pr. pallida, Baly *(or Himatidium neivai,* Bond*).* Both the adult and the larvae are capable of causing damage to the palms, mainly on the fruits but at times also on the leaves (Chiacchio, 1970).

The pest is particularly widespread in Brazil, occurring in all the areas that oil palm is planted. The importance of this pest has been underestimated because the damage it causes is easily overlooked. However, in a planting in Manaus, not a single fruit was completely free from attack by this pest. No accurate estimate of crop loss has yet been made but since oil bearing tissues are directly affected, this can be very important. When young fruits are severely attacked, abortion occurs. In Colombia, crop loss due to this problem is estimated at 7%–10% (Genty, Desmier de Chennon, Moria & Korytkowski, 1978). With exception of the problem of pesticide residues, control measures with chemicals, *e.g.*, endrin and diptrex, are effective.

Ceratocystis paradoxa. This fungus which is the cause of dry basal rot in Africa (Robertson, 1962) is also a serious problem to oil palms in Brazil but at present is mainly confined to Bahia.

No reliable estimates are available on the magnitude of this problem but in one plantation it was evident that a large number of palms died due to this disease. However, the seriousness of this problem is reflected by the willingness of all oil palm plantations in Bahia to adopt the practice of applying a protective coating of fungicides and insecticide on the cut surfaces of harvested bunches and pruned leaves to protect against the disease and to exclude infestation by *Rhyncophorus.*

Inadequate Fertiliser Practices

Fertiliser practices of oil palms in Brazil are generally not optimum partly because of lack of experience with this new crop in a new environment but more so because of the lack of adequate experimental evidence to establish the benefits or otherwise of fertiliser application.

Fertilisers when they are applied are at levels between 1 kg to 3 kg per palm per year for mature palms which would be considered low by comparison to practices in Malaysia and would seem inadequate considering that these soils (latosol, sub-order) are in general chemically poor in nutrients. However, more important is the lack of the use of a proper basis for establishing the rates and composition. Another major problem is that the range of fertiliser types available, for various reasons, is limited. For example, urea is the main source of nitrogen and triple superphosphate is widely used as a source of phosphorus but actual experimental evidence to establish that these are the most economical sources of the nutrients are lacking.

Some of the experiences of one plantation where foliar nutrient levels are used to diagnose fertiliser requirements are reflected in the leaf nutrient data presented in *Table 4*. The soil concerned is a very light textured latosol and this area has extremely high rainfall, particularly in some months (exceeding 400 mm). Two features are outstanding, namely, the inherently low phosphorus level and high calcium level of the soil. The latter is likely to interfere with uptake of potassium and magnesium. The nitrogen level is moderate, while potassium and magnesium levels are high initially (presumably due to the ash from burning the forest) but decline over the years inspite of fertiliser application. However, data generally indicates an improvement in the fertiliser management practices during recent years. The recent young plantings show much better leaf nutrient levels and balance, particularly with respect to nitrogen and phosphorus and this is also reflected in the improved productivity of the younger plantings. However, there is clearly room for further improvement in the leaf nutrients with a corresponding improvement in the productivity.

TABLE 4. LEAF NUTRIENT LEVELS (% ON DRY MATTER)

Year of Planting	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium	
	A	B	A	B	A	B	A	B	A	B
1968	2.42	2.38	0.126	0.158	1.174	1.096	0.813	0.887	0.300	0.201
1969	2.20	2.37	0.113	0.155	1.232	1.078	0.923	0.905	0.258	0.199
1970	2.49	2.43	0.157	0.156	1.053	1.011	1.167	0.939	0.309	0.180
1972	2.35	2.69	0.147	0.153	1.010	1.007	1.040	1.034	0.300	0.210
1973	2.64	2.79	0.166	0.157	1.098	0.981	1.166	1.129	0.265	0.209
1974	2.52	2.58	0.159	0.172	0.997	0.925	1.070	1.233	0.239	0.221
1977	2.44		0.151		1.025		1.003		0.221	

A – Leaf sampled at third year from planting.

B – Latest leaf sampling (1980).

General Lack of Experience

As with any new crop in a new environment, there is a lack of accumulated experience on the appropriate agronomic practices. Also, experimental data to permit a proper decision to be made on the correct practices are lacking.

This lack of experience is reflected in one extreme case where whole fields of several hundred hectares were planted with seeds collected from an open pollinated *tenera* planting.

Other less striking examples include excessively severe pruning, unsatisfactory nursery practices with little or no seedling culling, absence of the use of leguminous covers, although *Pueraria* establishes very readily, unsatisfactory harvesting practices and poor management of pest and disease practices.

In Bahia, much of the oil palm practices have been influenced by traditions developed with exploitation of natural oil palm groves and to a large extent, practices here are less satisfactory. The situation in Para and Amapa, where modern plantation practices have been adopted, is much better.

Shortage of Planting Material

The shortage of planting material is a severe problem in Brazil and can greatly limit the expansion of an oil palm industry. Current seed production capacity in the country is adequate to plant only between 1000 and 2000 ha per year. Unless the seed supply situation is improved, no large-scale expansion of the oil palm area will be possible.

Lack of Infrastructure Support and Services

Another problem with a new industry is the lack of associated supporting industries and infrastructures. Much of what is taken for granted in Malaysia, *e.g.,* felling contractors and materials of specific use in the oil palms, namely polythene bags for nursery, harvesting chisel and knife, harvesting poles, sprinkler irrigation and leguminous seeds, are not readily available and some effort has to be made to obtain them or to search for alternatives.

POTENTIAL OIL PALM AREAS IN BRAZIL

Many factors influence this potential, not the least of which are the social and political factors and the availability of infrastructure. However, this paper is concerned only with the agroclimatic and soil aspects which may be considered as basic to determine the competitiveness of the industry.

The components of the agroclimatic and soil factors which influence the potential for oil palm cultivation are quite well-known. On examining this in relation to Brazil, it becomes quite clear that the need is not so much to demonstrate that oil palms can grow in Brazil, as there is no doubt it can, but more to identify the areas which have the greatest potential for the crop in terms of agroclimatic and soil factors.

Within Brazil, the best potential for oil palms lies within the Amazon basin and to a lesser extent (relatively) in parts of the state of Bahia *(Figure 1).*

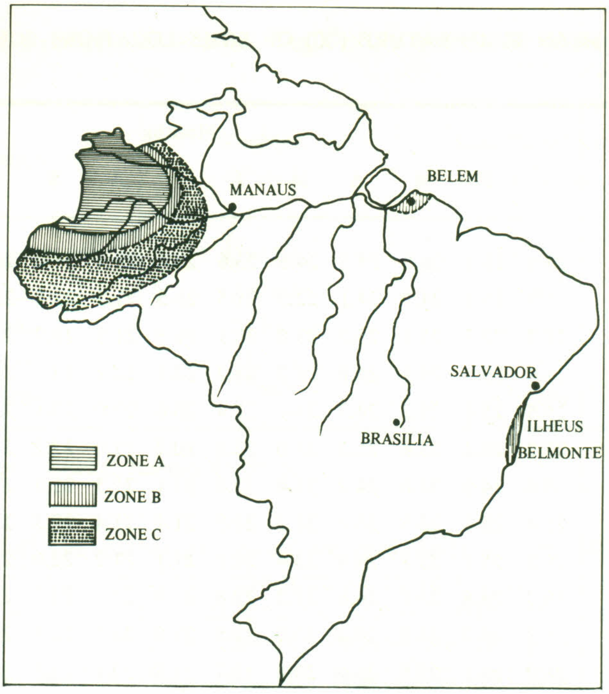

Figure 1. Zones of moisture deficit free areas for oil palms in Brazil.

South of Bahia

Considering first the state of Bahia, as has been indicated earlier, there is already a small but well developed oil palm industry in the state based on natural and established oil palms. While there is no doubt that some potential exists for oil palm in the region, the extent remains to be established. One estimate (Maia *et al.*, 1980) indicates the potential oil palm area to be well in excess of 2 million ha. This is clearly an overly optimistic estimate and the area suitable for oil palms while still substantial is probably very much less than this.

Temperature. The area concerned lies at a latitude 14° south of the equator, much further away from the equator than the major oil palm growing areas, *e.g.*, Malaysia, Indonesia, Ivory Coast and Papua New Guinea. The only comparable oil palm growing areas in this respect are Angola and Mozambique in Africa. Accordingly, mean temperatures are much lower than those areas considered to be optimum for oil palms (*Table 5*) but are at levels (between 21°C to 26°C) considered to be within tolerable limits for good oil palm growth. However, during the cold season, at some locations, night temperatures can be very low, *e.g.*, at Barrolandia – Belmonte, temperatures as low as 10°C to 12°C are experienced. The problem becomes more severe towards the south and inland. While such occasional low tem-

TABLE 5. MEAN TEMPERATURE (^{o}C) OF SOME LOCATIONS SOUTH OF BAHIA

Location	Months												
	J	F	M	A	M	J	J	A	S	O	N	D	A
Belmonte	26.2	26.2	26.3	25.5	24.5	23.6	23.6	23.4	24.0	24.8	25.1	25.6	24.9
Camaca	25.1	25.1	24.9	24.1	22.3	21.5	21.3	21.7	22.5	23.9	24.4	24.8	23.5
Camamu	25.2	25.3	25.1	25.2	23.8	23.1	21.8	21.9	22.7	23.8	24.4	24.9	23.8
Canavieiras	26.6	26.5	26.1	25.8	24.2	23.2	22.3	22.3	23.7	24.4	25.3	25.9	24.7
Caravelas	25.5	25.6	25.2	24.7	23.1	21.4	20.6	21.0	22.1	23.5	24.2	25.0	23.5
Coaraci	25.2	25.2	25.6	25.1	23.0	22.0	20.7	21.0	22.2	23.6	24.2	24.8	23.5
Kunapolis	25.0	24.9	24.8	24.2	23.4	22.4	21.1	21.3	21.7	23.2	23.6	24.4	23.3
Gandu	25.4	25.5	25.5	25.0	23.3	22.5	21.4	21.4	22.3	23.9	24.9	25.8	23.9
Guaratinga	26.0	25.7	25.3	24.8	23.4	22.1	21.1	21.2	22.0	23.2	24.2	24.7	23.6
Ibirapitanga	24.7	24.8	25.1	24.6	23.2	22.8	21.4	21.5	22.3	23.6	24.6	25.1	23.6
Ibirataia	25.3	25.2	25.3	24.8	23.4	22.5	21.3	21.5	22.8	24.2	24.8	25.4	23.9
Ilheus	26.2	26.1	25.8	25.0	23.8	22.7	21.8	22.4	22.5	24.5	25.0	25.9	24.2
Ipiau	26.0	26.0	26.0	25.7	23.7	22.8	21.7	22.0	23.2	24.8	25.3	25.8	24.4
Itabuna	25.2	25.1	25.2	25.3	23.6	22.6	21.6	21.7	22.4	23.8	24.3	24.8	23.8
Itagi	24.9	25.7	26.6	25.5	23.3	23.0	21.5	21.6	22.5	23.7	24.7	26.0	24.1
Itamaraju	26.8	26.8	26.1	25.3	24.5	23.6	22.2	22.5	23.4	24.3	24.7	25.9	24.7
Itapebi	26.8	26.8	26.8	26.1	24.5	23.3	21.9	22.3	23.4	24.8	25.6	26.3	24.9
Mucuri	25.7	25.9	26.0	25.3	23.4	22.7	21.1	21.5	22.7	24.0	24.6	26.6	24.1
Pau-Brasil	25.5	25.3	25.5	24.9	23.6	22.7	21.1	21.7	22.5	24.1	24.3	25.7	23.9
Ubaitaba	25.4	25.4	25.4	25.0	23.4	22.6	21.6	21.7	22.6	24.0	24.7	25.2	23.9
Ubata	25.9	25.6	25.0	24.7	23.0	22.6	22.4	22.6	23.8	24.6	24.6	25.0	24.1
Una	25.5	25.7	25.7	25.3	23.9	23.0	22.0	22.0	22.6	23.7	24.5	25.0	24.1
Urucuca	25.8	26.1	25.4	24.8	23.2	22.1	21.2	21.4	22.4	23.8	24.4	25.0	23.6
Vit. Da Conquista	22.5	22.6	22.4	22.3	19.9	19.2	18.6	20.0	20.7	22.4	22.3	23.1	21.4

Source: Frota, 1972.

peratures are not likely to affect general vegetative growth, it is not unlikely that inflorescence development may be adversely affected, resulting in abortion.

Solar radiation. Solar radiation based on sunshine hours and radiation measurement does not indicate that this is likely to be a limiting factor (*Table 6*).

TABLE 6. SOLAR RADIATION OF SOME LOCATIONS SOUTH OF BAHIA, BRAZIL

Location	Sunshine (h/year)	Solar Radiation ($cal/cm^2/year$)
Itabuna	2054.2	130 756
Una	2293.0	126 441
Belmonte	2126.7	132 333
Cachoeira	1991.0	134 579
Porto Segura	2020.5	139 062

Source: Informe Tecnico – CEPEC, Itabuna-Ba, Brazil.

Rainfall. Rainfall, in terms of quantity and distribution appears to be one of the factors that will limit the area suitable for oil palm cultivation in the region. It is only along the coastal regions that the rainfall may be considered to be acceptable to sustain reasonable oil palm growth and productivity. Even within this area, the rainfall is not particularly high, ranging from 1300 mm to slightly in excess of 2000 mm per year (*Table 7*). The quantity of rainfall is much lower than what would be considered optimum for oil palms but given the lower temperature, the problem of moisture stress may not be too severe. Evaporation measurements indicate fairly low values of 728.9 mm per year for Una to well above 1000 mm for Cachoeira (*Table 8*). Within the vicinity of Ilheus and perhaps also at Caravelas, no moisture stress is expected, but at Belmonte, some moisture stress will be experienced.

Proceeding inland, the rainfall pattern becomes more unfavourable. At a distance of 25 km from the coast, the total rainfall would have dropped by 25% and going inland by a further 20 km an additional drop in the rainfall of 25% would be expected and Savannah conditions would be prevalent.

Thus, in terms of rainfall, the areas that would be satisfactory for oil palms is restricted to, at the most, 20 km from the coast.

Soil Terrain. However, a further reduction in the area suitable for oil palms would arise due to the topography of the region. It is only along the coast that the land is particularly flat but these are very sandy soils and would have very little use for oil palm cultivation. South of Belmonte, slightly undulating land is available which would not present too serious a problem for oil palm cultivation. Along a narrow belt just beyond the coast, north and south of Ilheus, some possibility for oil palms exists but the terrain may present some problems particularly in relation to mechanisation. Elsewhere, the terrain would be too steep for oil palm cultivation.

TABLE 7. MEAN MONTHLY RAINFALL (MM) FOR SOME LOCATIONS SOUTH OF BAHIA

Location	Months												
	J	F	M	A	M	J	J	A	S	O	N	D	Total per year
Belmonte	69.7	92.4	89.4	176.8	144.9	143.1	155.1	111.3	104.8	110.0	114.4	75.3	1387.2
Camaca	145.0	133.8	169.8	97.7	87.1	123.0	155.5	86.5	82.2	172.6	223.1	158.7	1635.0
Camamu	159.2	185.1	226.2	219.3	172.1	159.1	169.4	137.3	102.9	123.5	185.1	114.5	1953.7
Canavieiras	91.5	96.3	141.4	142.4	105.0	162.4	187.9	103.3	78.6	205.6	154.7	96.2	1565.3
Caravelas	148.8	119.0	204.5	233.3	143.7	115.9	116.6	81.2	106.7	137.8	247.2	195.9	1850.6
Coaraci	150.0	161.7	126.3	66.6	60.7	70.9	108.5	65.5	35.6	153.5	160.8	129.9	1290.0
Kunapolis	51.8	46.9	111.6	93.3	55.3	92.4	143.2	65.6	55.0	108.1	176.5	141.7	1141.4
Gandu	94.0	171.1	155.0	127.5	104.9	161.3	171.2	84.6	49.4	121.7	165.6	101.5	1507.8
Guaratinga	84.0	91.8	123.7	49.6	52.4	72.9	57.2	37.5	41.6	138.4	244.0	142.4	1135.5
Ibirapitanga	124.1	119.0	77.6	132.6	113.8	167.9	201.7	140.0	58.8	159.8	233.0	51.8	1580.1
Ibirataia	79.0	106.4	130.8	67.9	58.4	106.7	131.7	77.5	50.4	110.6	139.6	126.3	1185.3
Ilheus	149.2	186.7	262.9	287.6	210.4	164.8	174.2	134.8	113.5	114.5	183.9	151.6	2133.9
Ipiau	82.4	133.8	128.7	65.3	64.8	101.6	109.0	51.2	41.5	128.4	152.1	135.4	1194.2
Itabuna	123.6	135.5	140.5	142.9	75.1	134.6	163.2	108.0	103.9	106.3	141.0	162.9	1537.5
Itagi	81.5	67.0	54.5	106.6	40.3	104.0	109.5	50.5	36.0	122.8	115.2	68.6	956.5
Itamaraju	99.6	139.7	131.0	98.1	91.4	105.7	162.3	120.2	62.2	180.5	228.1	181.1	1599.9
Itapebi	81.7	78.0	120.5	67.4	61.3	95.1	98.9	65.6	65.0	119.5	175.2	119.0	1147.2
Mucuri	191.6	64.9	168.1	117.2	24.4	66.0	141.0	141.1	146.4	359.4	303.4	166.0	1889.5
Pau-Brasil	124.3	80.1	122.4	58.0	84.7	128.6	143.6	86.1	37.9	104.6	208.5	104.2	1283.0
Ubaitaba	133.6	162.9	155.0	106.1	99.3	186.9	219.3	121.4	104.1	176.3	154.9	155.1	1774.9
Ubata	66.5	124.6	124.5	43.2	76.3	118.1	116.5	65.2	26.6	71.8	132.6	117.6	1083.5
Una	126.2	140.7	198.1	145.2	93.4	174.8	180.0	110.4	125.6	195.5	221.0	184.9	1895.8
Urucuca	133.8	111.4	213.2	153.3	100.9	159.2	175.2	127.9	104.4	143.0	154.3	140.3	1716.9
Vit. Da Conquista	117.9	101.3	91.0	56.3	24.9	21.1	21.8	10.6	26.8	39.9	95.7	132.1	739.4

Source: Frota, 1972.

Thus, taking together the climatic and terrain conditions of the region, the best prospects for oil palms lie in a narrow belt just beyond the coast. In terms of topography, the area between Belmonte and Caravelas offers the best possibilities but within the vicinity of Belmonte, some moisture stress may be expected, while towards Caravelas and to lesser extent also the Belmonte region, low temperatures may have some adverse effect on productivity. In terms of agroclimatic conditions, the area within the vicinity of Ilheus offers the best potential but terrain conditions will present problems and restrict the scope for mechanisation. Taking the area as whole, with the restrictions imposed by the factors discussed above, the potential oil palm areas are not likely to be very extensive amounting to probably between 200 000 ha and 500 000 ha. The region, however, enjoys other advantages, *e.g.*, good infrastructure, closeness to terminal market, and the availability of labour which, in the short run, will compensate for the lower productivity levels.

The soils in the areas concerned are mainly of the latosol group and the extent to which they influence productivity is considered later as they

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TABLE 8. EVAPORATION RATES FOR SOME LOCATIONS SOUTH OF BAHIA, BRAZIL

Months	Evaporation rate (mm)				
	Itabuna	Cachoeira	Porto Seguro	Belmonte	UNA
Jan.	89.9	144.5	91.1	83.0	72.2
Feb.	83.1	103.2	73.4	72.1	65.6
March	71.8	101.2	80.6	71.1	64.2
April	61.8	76.1	98.6	65.9	61.4
May	58.0	61.1	55.8	60.1	59.6
June	46.9	61.5	55.2	52.4	49.9
July	51.8	65.3	50.3	56.9	56.9
Aug.	62.3	86.6	69.0	60.6	60.8
Sep.	56.8	86.2	66.0	66.4	60.1
Oct.	62.9	103.1	63.7	70.9	55.8
Nov.	64.5	95.7	66.9	64.9	55.1
Dec.	78.8	128.4	87.7	83.5	67.3
Total	788.6	1112.9	858.3	807.8	728.9

Source: Informe Technico – CEPEC, Itabuna, Ba., Brazil (1971–1976).

are also a major soil group available for oil palm cultivation in the other areas.

The Amazonian Basin

The Amazonian Basin (*Figure 1*), or more specifically, 'Amazonia legal' as defined by the Brazilian government encompasses an area of approximately 500 million hectares and covers the states of Amazonas, Para, Acre, Matto Grosso, Maranhao, and Roraima, Amapa, Rondonia, Federal Territories.

Temperature. For much of the region, temperature is not likely to present a serious problem to oil palm cultivation. A few locations, however, *e.g.*, Tome-Acu in Para; Carolina and Imperatriz in Maranhao, and Cuiba in Matto Grosso, maximum temperature levels well in excess of 30°C are common. Since this high temperature periods also coincide with the dry season, severe temperature stress may be expected. Also parts of Matto Grosso, *e.g.*, Pres. Murtinho, may present some problems in terms of low temperature.

However, these areas need not be of much concern because, as discussed later, they will be excluded anyway because of poor availability of water.

Solar radiation. In terms of availability of sunshine, almost all the areas enjoy favourable conditions; the only exception is perhaps the area bordering Colombia where, because of the extremely high rainfall, annual sunshine hours are reduced to 1549.2. This factor together with the high rainfall (3503 mm per year) would make the area not particularly ideal for oil palms. Although oil palms have been cultivated in areas with much higher rainfall *e.g.* Cameroons in Africa, the problems of high nutrient leaching, poor pollination conditions and higher disease, the risk involved would make it not worthwhile to consider oil palms for this area, especially since more suitable areas are available.

Moisture. Within the Amazonas region, the limits to oil palm cultivation are likely to be set by the rainfall distribution in the region.

The pattern of rainfall is shown in *Table 9*. Very high rainfall is experienced along the eastern coast of Brazil, particularly at Macapa, with 3226 mm per year and to a lesser extent at Belem. Moving inland within the proximity of the Amazonas river, the quantity of rainfall gradually declines until the lowest level is experienced at Maraba in Para (1426 mm per year). In the north and south of this zone also, the rainfall level declines, particularly in the south within the state of Maranhao where some of the driest areas are found (*e.g.,* B. do Corda) with 1071 mm rainfall.

Further eastward, the rainfall level increases until Manaus and satisfactory levels of 2101 mm rainfall per year are again experienced. However, the highest levels may be found further inland towards the Colombian border (*e.g.,* Iauraete, 3503 mm and Taracua, 3654 mm).

In terms of total rainfall, therefore, only areas within the vicinity of Belem and Amapa and west of Manaus enjoy sufficient rainfall to sustain good oil palm growth. Areas close to the Colombian border however, have a slight excess rainfall than desired.

However, a further restriction on the suitability of the areas is imposed by the seasonal fluctuation in the rainfall distribution.

Estimation of moisture balance and moisture deficit requires knowledge on evapotranspiration rates of oil palms and soil water storage capacities, which unfortunately are not available with any precision for the areas concerned. Evapotranspiration rates widely adopted for oil palms elsewhere, namely 120 mm for those months with more than eleven days of measurable rainfall, and 150 mm for those months with less than ten days of rainfall (Surre, 1968) appear to be also appropriate for Brazil and will be used to evaluate the areas for their suitability for oil palm cultivation. The deficit of precipitation over evapotranspiration is shown in *Table 9*. Adjustments were then made for available soil water reserve, assuming 100 mm and 200 mm (*Table 9*).

TABLE 9. RAINFALL AND MOISTURE DEFICIT

Location	Annual rainfall (mm)	Prep-et_p (mm)	Adjusted (A) (mm)	Adjusted (B) (mm)
A. Tapajos – Para	2696	–375	–275	–175
Altamira – Para	1680	–661	–561	–461
Arumanduba – Para	1951	–427	–327	–227
Belem – Para	2761	– 49	+	+
Cachimbo – Para	2141	–530	–430	–330
C. do Araguaian – Para	1653	–633	–533	–433
Igarape-Acu – Para	2442	–436	–336	–236
Itaituba – Para	1754	–463	–363	–263
Jacareacanga – Para	2087	–627	–527	–427
Maraba – Para	1426	–789	–689	–589
Obidos – Para	1863	–559	–459	–359
Porto de Moz – Para	2300	–364	–264	–164
Salinopolis – Para	2770	–632	–532	–432
Santarem – Para	2096	–418	–318	–218
Soure – Para	2943	–421	–321	–221
Tome-Acu – Para	2591	–490	–390	–290
Tracuatena – Para	2629	–492	–392	–292
Barcelos – Para	1999	–28	+	+
Benjamin Constant – Para	2902	+	+	+
Carauari – Amazonas	2623	–149	– 49	+
Coari – Amazonas	2348	–178	– 78	+
Eirunepe – Amazonas	2474	–215	–115	–15
Fonte Boa – Amazonas	2802	–	–	–
Humaita – Amazonas	2316	–363	–263	–163
Itacoatiara – Amazonas	2166	–352	–252	–152
Iauraete – Amazonas	3503	+	+	+
Manaus – Amazonas	2101	–356	–256	–156
Manicore – Amazonas	2541	–262	–162	–62
Maues – Amazonas	2696	–311	–211	–111
Parintins – Amazonas	2327	–285	–185	–85
S.P. de Olivenca – Amazonas	2710	– 11	+	+
S.C. da Cachoeira – Amazonas	2914	+	+	+
Taracua – Amazonas	3654	+	+	+
Tapuruquara – Amazonas	2690	+	+	+
C. do Sul – Acre	2229	–193	–93	+
S. Madueira – Acre	2097	–316	–216	–116
Amapa – Amapa	3226	–464	–364	–264
Macapa – Amapa	2314	–444	–344	–244
P. Santana – Amapa	2442	–337	–237	–137
P. Planton – Amapa	2138	–296	–196	–96
S. do Navio – Amapa	2319	–232	–132	–32
Clevenlaudia – Amapa	3570	–291	–191	–91
P. Velho – Rondonia	2252	–403	–303	–203
B. Vista – Roraima	1759	–717	–617	–517
B. do Corda – Maranhao	1071	–853	–753	–653
Carolina – Maranhao	1565	–641	–541	–441
Grajau – Maranhao	1318	–698	–598	–498
Imperatriz – Maranhao	1631	–644	–544	–444
S. Bento – Maranhao	1773	–669	–569	–469
S. Luis – Maranhao	1954	–646	–546	–446
Turiacu – Maranhao	2177	–575	–575	–475
P. Nacional – Goias	1661	–673	–673	–473
Parana – Goias	1337	–777	–677	–577
Taguatinga – Goias	1770	–703	–603	–503
Caceres – Matto Grosso	1240	–756	–656	–556
Cuiaba – Matto Grosso	1375	–630	–530	–430
Pres. Murtinho – Matto Grosso	1776	–630	–530	–430

(A) Adjustment assuming available soil water reserve is 100 mm.
(B) Adjustment assuming available soil water reserve is 200 mm.

An approximation was used to take into account soil water reserve, namely by directly adding 100 mm and 200 mm respectively, to the annual deficit of precipitation over evapotranspiration. For the present purpose, this approximation is considered adequate.

On the basis of the moisture deficit data, various zones have been drawn up (*Figure 1*). Zone A represents the areas where precipitation alone would be adequate to meet evapotranspiration needs, *i.e.*, soil water reserves are unimportant. Zone B represents the areas without moisture deficit, assuming the available soil water reserve to be 100 mm. This level of moisture reserve can clearly be met by most soils, the exception being very shallow soils (less than 50 cm), very light textured (more than 90% sand) and rocky or on very steep slopes. This may be considered as the minimum area that would be ideal for oil palms in terms of absence of moisture deficit, and the estimated area (Zone A and Zone B) is between 25 and 30 million hectares. Zone C represents the areas without moisture deficit assuming a soil moisture reserve of 200 mm. This level of moisture reserve can be met only by very deep soils with high clay content and flat land. Within this zone, choice of site is critical if moisture deficit situations are to be avoided.

Outside these zones, oil palm may be expected to suffer varying degrees of moisture stress irrespective of soil conditions.

Taking the area as a whole, it is estimated that there would be well in excess of 50 million hectares of land which could be considered as ideal for oil palms, in terms of the absence of moisture stress.

Soil. The oil palm is tolerant of a wide range of soil conditions but different soils have different economic implications because of the variable productivity and level of inputs in terms of fertilisers.

Some of the best soils in the region belong to the type referred to as 'Terra Roxa'. Chemically these are fertile soils with C.E.C. of between 2.17 to 39.8 me/100 g, exchangeable potassium of between 0.10 to 1.7 me/100 g. and phosphorus (P_2O_5, Troug) of between 0.5 to 2.3 me/100 g. Within the Amazon region, there is an estimated one million hectares with such soils, mainly in the region south of Para, other parts of Para, *e.g.* Altamira, Alenquer and Almeirin, and other states, *e.g.*, Rondonia and Roraima. However, much of these areas lie within rainfall belts which are considered definitely unsuitable for oil palms. Furthermore, the suitability of these soils for oil palms remains to be established as the high exchangeable calcium levels 1.5–28.8 me/100 g may lead to difficulties in uptake of potassium and magnesium. It is not expected that these soils offer much potential for oil palms.

Of the other soils available within the Amazon basin, the riverine alluvial soils (varzea) offer the best prospects in terms of natural fertility. These soils have physical and chemical characteristics similar to those of marine and riverine alluvial soils of Malaysia which are some of the most productive oil palm soils. An estimated area of 15% of the Amazon basin is with such soils of which 8% are considered to be of high fertility (Cochrane & Sanchez, 1980). Of these, between 50% and 60% lie within climatic belts suitable for oil palm cultivation. However, these soils lie along the margin of the Amazon river and its tributaries and the extent of the area available for oil palms would depend on whether they are subjected to flooding.

Within the Amazon basin, the most suitable soil types belong to the group referred to as latosols. These soils cover approximately 70% of the Amazonas region and parts of the south of Bahia, much of which lie within areas considered to be agroclimatically suitable for oil palms. Therefore, the potential of oil palms in Brazil is related to the suitability of these soils for oil palm cultivation.

These soils are mainly oxisols and further classification had been made based on colour and texture. This classification is clearly too broad to provide accurate assessment of the soil capabilities of the region. Also, the Amazon basin, because of its size and limited accessibility, has not been adequately surveyed.

In the present discussions, therefore, consideration is given only on a very generalised basis, as precise evaluation of the capability of the soil in a region will require detailed survey. The group as a whole is soils which are characterised by the presence of high concentrations of iron and aluminium sesquioxides which are responsible for the high phosphate 'fixing' properties. These soils are fairly acidic and generally very low in their inherent fertility (*Table 10*). The main clay mineral is kaolinite which is well known for it's low activity. However, these soils have good physical properties, being of good depth and good soil structure. In some instances, clay contents are perhaps too high but they do not appear to interfere seriously with oil palm growth. This is important because, in terms of fertility, the heavy textured soils appear to be more favourable. In many ways, these soils appear to be similar to much of the inland soils of Malaysia where, given adequate fertiliser management, good oil palm growth and yields can be attained.

However, within Brazil, the capacity of these soils to support oil palm growth and productivity may be inferred from the performance of the existing plantings which are located on such soils. In Bahia, for example, productivity of 16–18 tonnes of FFB per hectare per year has been reported. Taking into account the pest and disease problems, the indifferent fertiliser and other cultural practices, these are fairly good yields. At Para, where a plantation has been located on the soil type 'Latosol ameralo textura media' (medium textured yellow latosols) but with chemical properties more similar to that for 'textura pesada' (heavy textured) as

TABLE 10. CHEMICAL PROPERTIES OF SOME LATOSOLS OF BRAZIL

Property		Latosol amarelo (Amazon region)[a]			Latosol (Bahia region)[b]
		Media (medium textured)	Pesada (clay)	Muito pesada (very clayey)	
Clay	A hor.	6–9	40–54	43–78	20 – 60
Content (%)	B hor.	14–26	58–65	60–86	
Carbon (%)	A hor.	0.53–0.95	0.67–2.42	2.42–4.68	1 – 3
	B hor.	0.13–0.14	0.27–0.57	0.28–0.72	
Nitrogen (%)	A hor.	0.03–0.07	0.07–0.16	0.6 – 0.95	–
	B hor.	0.01–0.03	0.03–0.07	0.2 – 0.7	
C/N	A hor.	13–18	12	10	–
	B hor.	11–25	11	7–15	
C.E.C.	A hor.	4.65–7.04	4.61–10.52	5.3 –18.51	1.0 – 14.0
(m.eq./100g)	B hor.	2.04–5.41	2.53–3.55	3.19–5.19	2.0 – 8.0
Total bases	A hor.	0.47–0.92	1	0.46–0.95	–
(m.eq./100g)	B hor.	0.38–0.92		0.28–0.79	
Base sat.	A hor.	0.10–0.15	low	4–14	
(m.eq./100g)	B hor.	0.14–0.31		8–20	
pH (Water)	A hor.	4.1 –4.7	Approx. 4	3.9 –4.9	4.3 – 5.3
	B hor.	4.1 –4.8		4.3 –5.9	
Calcium	A hor.	very low	0.10–0.35	0.10–0.40	0.3 – 3.3
(m.eq./100g)	B hor.	very low		0.10	0.2 – 1.0
Magnesium	A hor.	very low	0.01–0.23	0.01–0.25	0.4 – 2.9
(m.eq./100g)	B hor.	very low		low	0.2 – 1.0
Potassium	A hor.	very low	0.05–0.28	low	0.04 – 0.30
(m.eq./100g)	B hor.	very low			0.01 – 0.10

[a] Source: L.A.S. Melo, L.B. Teixeiro & E. de Moraes 1979
Latosol amarelo = yellow latosols.

[b] Source: Maia *et al.*, 1980.

shown in *Table 10*, yields of 18–20 tonnes of FFB per hectare per year have been attained under conditions of fairly good management but with perhaps slightly lower fertiliser rates than optimum. Data on leaf nutrient levels for these plantings are presented in *Table 4*.

The low inherent natural fertility of these soils and the need for proper fertiliser management practices is reflected in the data from experiments on similar soils where no fertiliser has been applied (*Table 11*). Leaf nutrient levels in the early years would suggest a fairly good availability of nitrogen, not unexpectedly as this is the first planting from jungle and because of the leguminous cover and a fairly good supply of potassium and magnesium, largely from the ashes of the burnt jungle. The extremely low phosphorus level is particularly noteworthy. However, even in respect of the other nutrients, in the absence of any supplementary fertiliser application, they are rapidly depleted such that by the time the palms come into peak productivity, the leaf nutrient levels have declined to very low levels indeed, thus confirming the inherently low natural fertility of these soils. The level of productivity is shown in *Table 11.* Comparing with the expected productivity levels under current management practices (*Table 3*), it is apparent that dependence on the natural fertility of the soil alone would be only capable of giving production levels of less than 50% of that from existing practices.

It may thus be concluded that these soils are capable of sustaining good oil palm yields only with adequate fertiliser management practices. Considering the similarities of these soils with those in Malaysia and given the experience in fertiliser management practices there, it is not unexpected that much of these soils, given optimum fertiliser practices, will be capable of giving yields of between 25 and 30 tonnes of FFB per hectare per year during peak yields.

TABLE 11. LEAF NUTRIENT CONTENT AND YIELD OF OIL PALMS[a] ON LATOSOLS WITHOUT FERTILISER

Year	Nutrient content (% on dry matter)				Yield (FFB)	
	N	P	K	Mg	kg/palm	tonne/ha[b]
1971	2.62–2.67	0.134–0.137	1.547–1.380	0.211–0.246	–	–
1972	2.54–2.61	0.149–0.153	1.303–1.435	0.244–0.386	24.45	3.50
1973	2.66–2.68	0.138–0.151	0.826–1.06	0.240–0.292	83.51	11.94
1974	2.55–2.63	0.144–0.149	1.06 –1.20	0.260–0.300	71.24	10.19
1975	2.23–2.60	0.124–0.141	0.952–1.018	0.218–0.268	65.33	9.34
1976	2.26–2.58	0.119–0.149	0.926–1.010	0.226–0.277	59.81	8.55
1977	2.39–2.53	0.117–0.123	1.029–1.192	0.207–0.254	53.07	7.59
1978	2.35–2.47	0.125–0.128	1.080–1.188	0.201–0.217	67.46	9.65
1979	2.05–2.25	0.109–0.113	1.147–1.217	0.281–0.247	49.34	7.06
1980	–	–	–	–	42.87	6.13

[a]1968 planting.

[b]Based on 143 palms/ha.

CONCLUSIONS

Considering all the factors, it is evident that Brazil possesses tremendous potential for oil palm cultivation. Extensive areas, in excess of 50 million hectares, are available for oil palm cultivation where moisture stress, a critical problem for oil palm productivity, is practically absent. There are of course other areas with marginal problems of moisture stress which would still allow fairly good oil palms to be grown. Soils remain the main constraint to high productivity in these areas because of their low natural fertility and high phosphate 'fixing' properties. However, these soils have good physical characteristics and drawing from the experiences in Malaysia, it is clear that with optimum fertiliser management practices, yields of between 25 and 30 tonnes of FFB per ha per year should be easily obtainable from much of the areas concerned.

From experiences of oil palms in Colombia and Peru, disease risk, *e.g., Machitez,* and pests *e.g., Castnia daedulus,* can be of serious concern and need to be given special attention particularly in the upper Amazonas regions with the higher rainfall distribution and a large natural occurrence of *E. oleifera.*

Within Brazil, the best potential for oil palms lies within the regions west of Coari in the state of Amazonas (between the latitudes 1°N to 5°S), within the vicinity of Belem in Para and within the vicinity of Ilheus and Belmonte in the south of Bahia. The latter two locations offer the best immediate potential, being better developed in terms of infrastructure, availability of labour and close to the terminal markets. Topography may present a problem for some areas in Bahia and restrict the scope for mechanisation. However, in the long term, it is the Amazonas state that can offer the best potential for oil palm cultivation as very large areas are available with nearly perfect climatic conditions, level land and satisfactory soil conditions.

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