

# The African Palm: A strategic resource for integrated systems of tropical production

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*[Edited version of a paper presented at a workshop: What Kind of Agricultural Science for Development will account for Biodiversity and Sustainability? Tune Landboskole, Denmark. 3-5 April 1995].*

## **The Cultivation of African Palm (*Elaeis guineensis* Jack)**

For tropical countries, the African Palm represents an interesting and important alternative for the development of integrated, sustainable production systems which exploits the comparative advantages of the tropics. The climatic characteristics of the areas where the best yields of the african palm have been observed can be summarized as follows:

- a. Rainfall equal to or higher than 2000 mm with good distribution throughout the year.
- b. Maximum average temperature of 29°C and minimum average of 22-24°C.
- c. Continual sunshine with a minimum of 5 hours/day throughout the year.
- d. Flat or gently undulating deep soils, with good permeability and free drainage.
- e. Loam or clay-loam soils.
- f. Relative humidity higher than 75%.

## **The Palm System**

This is not a single system. On the contrary, it is a system with various possibilities depending on the conditions and objectives of the producer, making it possible for the palm system to be used by

small, medium and large producers. All the alternatives discussed here have some elements that are common to all cases: biological control for integral management of pests and diseases and the use of the animal traction for the harvesting. Legume crops are grown between the rows of the crop and these are used as covering for the soil and also to fix the nitrogen in the soil.

## **Six Alternatives**

### **1. Commercial production**

Current commercial cultivation of the oil palm is where 100% of the fruit produced is taken to the extraction plant to extract the raw oil, and later subjected to some processes of refinement and industrial use. Within the system, it is possible to integrate the growing and processing of the palm fruit with animal production.

Sheep (African hairsheep) have been used, the main purpose being to control the presence of weeds in between the crop, without affecting production.

The by-products obtained from the extraction process and refining (fibrous residue, palm kernels and palm-oil sludge) can be used for feeding animals. In exchange, animal manure is produced, which could be used in two ways: the production of biogas, or directly to fertilize the crop. Biogas can be used in the factory as an energy source, and also yields an effluent which is rich in minerals and can be applied to the palms or another crop in the farming system.

The rachis and the palm kernel, residues from the extraction process, go back into the system; the first one as a source of potash, as ash or after of a process of decomposition, and the second one as hard-core for the farm roads. In some cases the palm kernels are used as fuel in the boilers. The fibrous residues are also used as fuel for the boilers, being material of good calorific value. This system has permitted the location of extraction plants in places away from electricity supplies, allowing independence of the extraction process.

It is suggested that there should be a change in the management of the effluent or muds. Currently there is a policy of recovering the maximum oil present in this by-product by means of the florentino tanks, where the oil content will not be greater than 2 or 3% at the

end of the process. For the implementation of this system it is proposed that the muds have a total content of oil near to the 8 or 10% at the end of the process. This means that the muds can be used as a source of animal feed, reducing the infrastructure needed to recover the oil after the clarification process, and instead being recovered by the animals and used for meat production.

Furthermore, in spite of recovering of the oil from the effluent, this is still the principal contaminant from the extraction plants that are emptied into the water sources, leading to pollution due to the high biochemical requirement for oxygen of these residues.

## **2. Alternative use of reject fruit**

This is basically the same as the previous alternative, except that an additional element is introduced. 20 or 30% of the harvested fruit that enters the extraction plant is rejected on quality and used instead for animal feeding. This means that only fruits with better size, ripeness and oil quality will be processed, thereby improving the efficiency of the extraction process. The fruit that is destined for animal feeding will include the unripe fruit and also the fruit that is harvested from recent plantings.

By using some of the fruit for animal feeding, it is possible to increase the number of animals in the system, thereby increasing the production of manure and reducing dependence on fertilizers.

## **3. Intercropping**

This involves the same activities as the previous alternative, but introduces a new element: the use of the inter-row area for the production of biomass for animal feeding, mainly sources of protein, which also contribute nitrogen to the soil.

The management system should involve minimum tillage to reduce labour demand and take account of the contribution of leaves, resulting from pruning, which will contribute to the crop.

Where a permanent crop is intended, the even rows may be planted, leaving the odd rows for harvesting operations.

#### **4. Palm oil for livestock feeding**

This is similar to the previous alternative but the main difference is that 20 or 30% of the crude oil is used in the animal production programme, making feasible a radical increase in the number of animals, depending on the volume of processing of the extraction plant. This represents the integration of the agriculture and livestock components, which could lead to a major improvement in the efficiency of use of the available resources. It will result in a larger production of biogas, fertilizer and animal products and reduce the dependence of the system on bought-in fertilizer. This may be further enhanced by the introduction of green manuring.

It also provides an alternative to the producer for the use of oil when the market is saturated and prices are low. Meat, milk, eggs and other products could be produced at a lower cost compared to production systems based on grains.

#### **5. Reduced crop density and additional crops**

This involves further diversification and alternative crops, thus reducing dependence on the oil market.

It is possible to change the density of sowing and to employ a number of other alternative crops. It is a particular condition of the area where the palm plantations are established that the micro-climate is very favorable for crop production. The system will involve 20-30% of the crop for animal feeding and additional crops which do not compete significantly with the palm.

There is no single recipe for this type of integrated system and it could involve various trees of crops for harvesting or for animal feed. Some possibilities as they relate to the Colombian Orinoquia zone include growing palms with: fruits (lemon, mandarin, orange and others), cowpea (summer and winter varieties), *Arachis pintoi*, aromatic essences, cassava, sugar cane, chili pepper, cocoa, pringamosa, nacedero (*Trichantera*), maraton (*Gliricidia*), and bananas. Generally, it is important to use crops which do not interfere with the shallow roots of the palms.

There is also the possibility of association of the palm with epiphytes, of which there is a great diversity and demand in the

national and international market. During its growth, the trunk of the palm favours the retention of water due to the position of the scales, which directly benefits the culture of epiphytes. Preferably the sowings must be done in alternate furrows, which will make the harvesting of fruits easier.

There are many alternatives that can be studied in the design of associations but it depends on the final objectives of the producer, always aiming to make more efficient use of the cultivated area.

## **6. Fully integrated system**

The crop is not intended for oil extraction, but as a strategic base for the productive system, with the fruit intended for animal feeding. The initial focus is on pigs, the species of greatest capacity to realize an efficient extraction of the oil. The fibrous residues from the pigs are offered to cattle and horses; the nuts that are not broken by the pigs are recovered and then are cracked to be offered to hens. The resultant material could be used as fuel or for roads in the plantation.

The manure produced by the animals is used for the production of biogas, as a source of organic fertilizer for the crops, or for the manufacture of compost. The cultivation of palm is associated with production of biomass, preferably energy sources, such as soybean, cowpea, pringamosa or nacedero (*Trichantera gigantea*); likewise it is associated with crops like sugar cane, cassava and aromatic plants.

Free-range hens and the sheep are used as controllers of undesirable species, and rotation is also used for this purpose..

The pigs will stay at pasture during the fattening and gestation phases; parturition and the initial phase of lactation will be under cover and with restricted pasture, until the end of the lactation phase when the average pig weight is 20 kg. During their stay at pasture, the pigs will use the newly planted areas of palm or other crops. The system may be simplified so that the pigs could be grazed under the palms trees and it will not be necessary to transport the fruit from the place where it is located. Confined systems may be employed where the area is limited.

The palm could be associated with *Trichantera gigantea*, soybean, cowpea, sugar cane, pringamosa or cassava, in order to

complete the animal diets, to increase the amount of biomass and to make the best use of soil resources. Likewise, it is possible to envisage association with cultures of bananas and epiphytes. Nevertheless, the main objective consists of crops established in association with the palm, to be used mainly for animal feeding. The density of sowing is modified depending on the design that is determined for the available area. It can involve keeping areas dedicated to the culture of palm with high densities, accompanied by areas of other complementary crops, or reduce the density to a total of 70 palms per hectare and with intercropping. The second alternative is likely to be more sustainable.

In this system the inputs are reduced to the minimum possible and it is intended to increase the products, by means of crop and animal integration. The soil management strategy involves the use of organic material by means of (worm) compost, green manure, application of biomass covering and recycling of nutrients from leaves and other residues after harvesting.

### **Other alternatives**

There is a great number of possibilities for the design of palm systems, involving the native palms of Colombia. A interesting example of this is the moriche palm, which lives with its roots under the water and produces a fruit of a high energetic value. This local resource is important to the landscape and is at risk of disappearing. It is being eliminated by the farmers in the process of pasture improvement.

### **Animal Production Aspects**

A series of consecutive trials, involving animal feeding on the oil and by-products from the extraction process, have been carried out by the author. This serves as the basis for the concept of crop-animal integration.

The animal species that is considered most appropriate for the palm system is the pig, due to its capacity for adaptation to the different components of the system and it demonstrates a high efficiency of use of the energy provided by the fatty acids of the oil

palm. Ruminants use the fibrous by-products, provide animal traction, and generally help to ensure the maximum integration of crops and animal production.

The work is described in sequence, in relation to the alternative palm systems and the different products and byproducts used for animal feeding.

### **Oil-rich fibrous by-product:**

This is the solid contents of the vibrating sieve that filters the raw oil after it has passed through the press. It is yellow, fibrous, sweet-smelling and greasy to the touch. Its composition is as follows: dry matter 95.27%, protein 5.25%, ether extract 23.06%, crude fibre 15.05% and ash 1.99%.

Initially, it was evaluated as a substitute for the traditional energy sources like sorghum for pig feeding during the growing phase (20-35 kg), growing-fattening phase (35-60 kg) and fattening phase (60-90 kg). In equivalent energetic terms, levels of 25 (T0), 50 (T50), 75 (T75%) and 100% (T100) of the energy supplied by the sorghum were fed. The levels were set with reference to the standards of NRC for the nutritional requirements of the pigs. The average results for each one of the treatments during the whole trial (20 kg to 90 kg) were as follows: daily weight gains were T0 0.525 (133 days); T25 0.592 kg (119 days); T50 0.632 kg (112 days); T75 0.629 kg (112 days) and T100 0.639 kg (112 days).

The results exceeded expectations. They demonstrated that it is possible to substitute 100% of the energy provided by the cereal, with good biological and economic results in the feeding of the fattening pigs.

In addition to substituting for cereals, Preston and Sarria (1990) demonstrated that a reduction of 30 to 35% of the protein was possible in the fattening phase of pigs when it is offered as a source rich in essential amino acids (based on Speer 1990). A second trial was therefore carried out to determine the optimum level of protein to use with this energy source on diets for fattening pigs.

Different levels of restriction of the protein were applied in relation to the recommended levels by NRC (1988) as follows:

*T0 (Control)*: 256 g/day during the growing phase; 256 g/day during the growing-fattening phase; and 360 g/day during the fattening phase;

The other treatments received the same level throughout the fattening period;

*Ta* received 256 g/animal/day

*Tm* 228 g/animal/day, and

*Tb* 200 g/animal/day.

The treatment that took the least time to reach the final weight (22-90 kg) was *T0* with 121 days; followed by *Tm*, *Ta* and *Tb* with 124, 126 and 135, respectively. The highest daily weight gain was obtained by the control treatment (*T0*) with 0.558 kg, followed by *Tm*, *Ta* and *Tb* with 0.545, 0.532 and 0.505, respectively. There was no significant difference between the protein treatments. The highest consumption of byproduct was presented in *Tb* with 2.56 k/day, followed by *Ta*, *T0* and *Tm* with 2.45, 2.33 and 2.23 kg, respectively. The economic results were proportionally higher as the restriction of protein was increased, being of 11.5, 12.1, 17.3 and 17.0 USD for *T0*, *Ta*, *Tm* and *Tb*, respectively.

This trial demonstrated that it is possible to supply the fibrous byproduct with levels of protein lower than recommended.

Later, supplementation with methionine and B vitamins was evaluated, together with fibrous byproduct and restricted protein (200 g/day). The objective was to find if these supplements could improve the metabolism of the animal and consequently increase the animal response to the diet.

The treatments consisted of: *TI* without supplement; *TII* with Methionine; *TIII* with Methionine and B Complex and *TIV* with B Complex. The quantities used were based on NRC (1988). The average results in days to final weight (20 to 90 kg) were: 143 days for treatment I and 138, 133, 140 days for the treatments II, III and IV respectively; the daily weight gain was 0.48 kg, 0.50kg, and 0.466 for treatments I, II, III, and IV respectively; no significant differences were detected.

The consumption of oil-rich fibre residue for *TI* was 2.77kg, for



T-II was 2.75kg, for T-III was 2.74kg, and for T-IV-I; no significant differences were detected. Consumption progressively increased with age and animal weight. The economic analysis was positive for all treatments. There appears to be no advantage of supplementing the byproduct-protein mixture with methionine or B vitamins.

### **Raw palm oil**

The results obtained with the byproduct were mainly the result of the oil content. Raw palm oil is sometimes available in times of market surplus and when the extraction plant is in a remote place with high transport costs. In 1992, a study was conducted using raw palm oil in a pig-feeding programme. The experiment was designed to evaluate the benefits of raw palm oil as the basal diet to fattening pigs, and using *Azolla filliculoides* to replace part of the soya bean meal in the diet.

All groups received the same amount of raw palm oil, depending on whether the animals were in the growing-phase (20-60 kg) or fattening-phase (60-90 kg); the level of protein offered was 200 g/animal/day throughout. All the treatments were supplemented with 100 and 150 g/d of rice bran in the growing, (20-60 kg) and feeding-phase (60-90 kg) respectively.

The consumption of *Azolla* during the growing-phase reached 51, 34, and 26% of the quantity expected during the 10, 20, and 30% of the replacement, which meant a total protein consumption of 212, 202, 184, and 167 day/animal/day. During the fattening period, the total protein consumption was 100, 100, 97, and 69% of that initially expected for all four treatments.

The daily weight gain was 0.450, 0.482, 0.457, and 0.407 kg/day. (SE 0.13, P=0.80) for the growing phase; and 0.654, 0.692, 0.666 and 0.528 kg/day (SE 0.18; P=0.12) during the fattening phase. The average for all the fattening period was 0.526, 0.561, 0.535, and 0.452 kg/day for the 0, 10, 20, and 30% *Azolla* replacement levels. The dry matter feed conversion is clear evidence of the quality and potential benefits of this diet. For each level of substitution, from low to high, FCR was 2.1, 1.98, 2.0 and 2.2 respectively during the whole the period. These results are above the recommended ideal standards

for the NRC (1988), and well above to the results obtained with commercial foodstuffs, or those obtained by growers using cereals.

A commercial demonstration (Penuela L and Ocampo A 1993; unpublished data) using 169 pigs, took place in San Nicolas swine farm located in the Department of Meta, Colombia. The animals were random-distributed in four groups using a daily ration per animal of 500 g of raw palmoil, 500 g of soya bean cake and 500 g of rice bran. The daily gain was 0.722, 0.628, 0.524, and 0.464 kg per day for each of the groups, and the dry matter conversion was 1.8, 2.0, 2.4, and 2.8 respectively. In economic terms, all groups showed an advantage, and the feed costs represented 46% for all production costs.

### **Whole palm fruit**

The use of whole palm fruit was evaluated as an alternative energy source for fattening pigs, being intended as an alternative use for the crop and a further integration of crop and animal production.

This work was designed to evaluate the substitution in isocaloric terms of sorghum for 25, 50, 75, and 100% of whole African oil-palm fruit during the fattening phase. The animals received restricted protein level based on 200g soya bean cake, supplemented with vitamins and minerals. The daily weight gains for all the fattening phases were 0.625, 0.598, and 0.466 kg/day respectively. The feed conversion based on dry matter was 3.2, 3.2, 3.3, and 3.4.

The pigs demonstrated excellent ability to use the whole fruit, by eating all the way into the internal hard nut and it demonstrated the capacity to extract nutrients in a foodstuff without industrial processing. The utilization of whole fruits will allow the feeding system to be used by small, medium, and large farmers.

Based on previous experience, where strategic supplements of carbohydrates in oil-palm diets have favoured the animal response, an experiment was designed to determine the optimal level of rice bran in fattening diets based on whole fruits of African oil palm, and restricted protein 200 g/day (using soya bean cake fortified with vitamins and minerals). The treatments were 100, 200, 300, and 400 g. daily of rice bran during the growing phases, and 150, 250, 350

and 450 grams during the fattening phase; the fruit was given *ad libitum*. The daily weight gains, for all phases (growing and fattening), were 0.485, 0.515, 0.492, and 0.497 kg/day with feed conversion of dry matter of 3.2, 3.2, 3.3, and 3.3. The consumption of whole-fruits was 1.1, 1.1, 1.0, and 0.9 respectively. No significant differences were detected in any of the variables. The best economic response was found at 200 g of rice bran during the growing phase and 250 g during the fattening phase.

There appear to be excellent prospects for using oil-palm fruit and byproducts in pig nutrition. As an alternative to the industrial extraction process, intergrated production systems can offer a successful and sustainable alternative.

### **Indicators of Sustainability**

Sustainability involves an equilibrium between production systems and the natural ecosystem. Production systems must take account of the natural ecology and biodiversity of the region. This is particularly important in the more fragile geomorphological zones.

We must also be concerned with the level of energy dependency, type of energy and quantity required for production. This implies the quantification of energy invested to obtain the final product, and an analysis of energy flow through the production processes. This is likely to be improved by integration of agricultural and animal systems.

The potential to utilize the byproducts and the multi-purpose capacity of the species utilized are important. Recycling and exchange of nutrients are key elements to enable the system to function with a minimum inputs and the maximum outputs. The conservation, use and management of water resources are also essential to avoid the acceleration of the general ecosystem degradation. The elimination or diminution of contamination during production processes is an important indicator. Reducing the emission of carbon dioxide, methane gas, the release of chloro-fluorocarbon products, sulphur dioxide, and nitrate oxides are a priority for all.

In overall terms, sustainability may be measured as the ability to retain carbon over time. It is determined by the amount of biomass production and accumulation of organic matter through the use of multi-purpose crops with a high nutrient return. In turn, this depends on photosynthetic capacity and, in these terms, the perennial species has a predominant role in providing continuous biomass production.

In addition, the social function of production systems is to provide employment at a regional level.

### **Conclusions**

The African oil-palm is a strategic resource for the development of integrated production systems in the tropics. It satisfies the principles of sustainability and has a high potential for small, medium and large farmers.