Quality R&D Practices in the Plantation Sector[+]

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INTRODUCTION

The oil palm, *Elaeis guineensis*, has come a long way from the wild groves of Africa. Outside its country of origin the plant was exploited and developed into commercial plantations. Today the oil palm has grown in prominence as a major source of oils and fats; much to the chagrin of the producers of those crops that traditionally have dominated this sector.

This journey to prominence was made possible with sound R&D backing. The discovery of the genetic factor that controls shell thickness is the cornerstone responsible for putting oil palm where it is today. This discovery marked the beginning of modern oil palm cultivation where manipulation of a single gene coupled with quality cultural practices led to an immediate yield increase of nearly 30% (Meunier, 1989). R&D in quality practices in the plantation sector had thus begun!

Today, R&D forms an integral part in the total development of oil palm. R&D activities increase in tandem with the increasing importance of oil palm as a major plantation crop. This paper discusses some of the salient features with regard to R&D emphasizing on those that affect quality in the plantation sector. Quality is defined in a much broader context to include all activities that improve the product and the environment.

R&D ACTIVITIES

One of the areas that is of prime concern to the plantation sector is the oil yield. In this respect a simple process of domestication from wild groves to plantation scale in Nigeria showed a marked increase of 789% (*Table 1*). Under the more favourable conditions in Malaysia, in terms of environment and management skill, a further increase of 85% became a reality. In fact, some areas in Malaysia command an average of 5 tonnes/ha/yr. R&D activities are continuing in order to bring the national average closer to the theoretical yield of 17 tonnes/ha/yr.

A case study of a plantation in Malaysia over a 40-year period recorded an increase in oil yield from 1.3 tonnes/ha/yr to 4.0 tonnes/ha/yr – a jump of about 208% (Davidson, 1991). This was brought about through various R&D activities including optimum fertilizers, breeding and genetics, improvement of various agronomic practices, and increased factory efficiency (*Table 2*).

Breeding and Genetics

The discovery that the *Tenera* fruits are much superior than the *Dura* and the much higher yield obtainable from this material set the breeding programme towards selection of *Dura* and *Pisifera* lines that would give high yielding *Tenera* families.

Ironically, this billion dollar industry is based on an extremely narrow genetic base from four original palms planted at Bogor Botanical Gardens in 1848. Realizing the need to broaden the genetic base of oil palm breeding a number of prospections were carried out in the centre of distribution of natural oil palm populations. Materials of *guineensis* origins were collected from Nigeria, Zaire, Cameroons, Tanzania, Madagascar and Angola. In order to broaden the genetic pool further, *oleifera* were collected from Honduras, Nicaragua, Surinam, Colombia and Peru. With exhaustive evaluation and selection some of the materials collected from Nigeria could yield up to 10-12 tonnes/ha/yr. This doubles the current yield of 5 tonnes. These palms also have the added advantage of having a height increment of only 20-25 cm/yr. This is a marked contrast to the 45-75 cm/yr in the current planting materials. This trait is useful as it can simplify the harvesting operation and prolong the replanting cycle.

R&D on quality of the planting materials also emphasizes on the fatty acid composition and the iodine values (IV). In this respect, more than 3000

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TABLE 1. REPRESENTATIVE YIELD OF OIL PALM AT DIFFERENT YIELD CLASSES
(Adapted from Henson, 1990)

Yield gap[1]	Yield class	Oil Yield (tonne/ha/yr)	% increase
e	Maximum theoretical yield	17.0	39
d	Best experimental yields		
	- Selected progenies	12.2	22
	- Best individual trees	10.0	16
	- Best plots/yr	8.6	72
c	Good commercial yields (Coastal soils, Malaysia)	5.0	35
b	Average national yields		
	- Malaysia, plantation	3.7	85
a	- Nigeria, plantation	1.6	789
	- Nigeria, wild groves	0.18	

[1] a) domestication
b) 'climatic zone' yield gap
c) agronomy/site/soil yield gap
d) genetic potential yield gap (present)
e) theoretical potential yield gap (future)

TABLE 2. INCREASE IN PALM OIL YIELD, 1951 – 1991
(Adapted from Davidson, 1991)

Input	**Oil Yield (tonne/ha/yr)**	**% Increase**
Actual Yield, 1951		
(All mature, potassium only)	1.3	-
1. Fertilizer: Complete N,P,K,Mg	2.5	93
2. Breedings: Deli Dura selection, 1930-1980	3.5	40
Increase O/B from introduction of tenera	4.64	33
3. Other Agronomic Improvements:		
Improved stand-polybag nurseries	4.78	3
Drainage + water conservation	5.02	5
Introduction of *E.kamerunicus*	5.08	1.2
Loss due to poor harvesting	5.03	- 1
4. Increased factory efficiency:	5.43	8
Actual Yield 1989/90 26t/ha @ 20.5% oil	5.41	
Replanting effects :		
20% immature	4.34	- 20
15% below 15 yrs	4.04	- 7
Actual Average, 1991	4.0	

palms from the Nigerian collection were individually screened for the fatty acid composition to detect any natural variation which could be profitably exploited. Individual palms with IV exceeding 60 have also been identified (Rajanaidu, 1989). These palms are being exploited on a large scale to confirm their yield potential and superior oil quality. A special programme has been initiated since 1982 in order to make available high IV DxP seeds for commercial planting by 1995.

Agronomy and Nutrition

The most expensive management input in the production of palm oil, apart from labour, is the fertilizer. On inland soil, a typical application to mature palms averages about RM500.00/ha/yr. Considering this high input there is a need to optimize fertilizer use by an in-depth understanding of nutrient requirements for palms growing under different soil and climatic regimes. This would require inputs from a combination of field experiments, foliar diagnosis, soil analysis and soil classification (Ng, 1983).

To establish the nutritional requirements of oil palm the results of a number of fertilizer trials carried out in different sites involving coastal and inland areas of Peninsular Malaysia were analyzed (Ahmad Tarmizi *et al.*, 1986). This study made it possible to draw up more accurate fertilizer recommendations for specific soils. Production at control and optimum fertilizer rates could then be established (*Table 3*). Other than that, the method of fertilizer placement and the frequency of application have also been established in order to optimize fertilizer use (Foster and Mohd Tayeb, 1986). Besides the effect on FFB yield, information on fertilizer effect on bunch components also helps to compare optimum fertilizer rates for oil plus kernel production to that of the FFB yield.

The depletion of prime soils available for oil palm planting has left the industry with little choice but to move into less suitable land commonly termed as problem soils. This includes peat, skeletal, acid and potentially acid sulphate, tin-tailings and steepland. These soils, by nature, have their own limitations which need to be overcome for successful oil palm planting. With regard to peat, the soil is often waterlogged and subjected to constant inundation. This calls for proper drainage and flood control to make the soil suitable for oil palm cultivation. The low nutrient contents and pH need to be properly managed in order to exploit the peat soils. With proper management, FFB yield of 30 tonnes/ha/yr could be realized (Hamdan *et al.*, 1988).

R&D in agronomy and nutrition also undertake studies on underplanting as a means to shorten the non-productive period, the use of advanced planting materials, and the use of oil palm wastes such as POME and EFB as organic fertilizer and mulching materials. This approach not only provides a means of recycling nutrients but also could greatly reduce environmental contamination.

Pollinating Weevil

One of the most important events to the oil palm industry is the introduction of the pollinating weevil, *Elaeidobius kamerunicus*, in 1981. Through this introduction, the industry enjoyed millions of ringgits saving on assisted pollination. Since the introduction of the weevil, assisted pollination has completely ceased.

Besides saving on the cost of assisted pollination, the weevil was also instrumental in increasing yield. This increase was more pronounced in Sabah where the CPO production in 1982 increased by 41.7%, 20% of which was attributable to the weevil (Malek *et al.*, 1984). Together with the additional revenue from increased palm kernel production the net gain in Johore and Sabah was 173 and 1033 RM/ha/yr respectively (*Table 4*).

TABLE 3. PRODUCTION AT CONTROL AND OPTIMUM FERTILIZERS RATES

Soil Series	Fertilizer			Yield		
	AS	KCl		FFB	Mesocarp	Oil Kernel
	(kg/palm/yr)			(tonne/ha/yr)		
Rengam	0	0		21.8	5.6	1.4
Malacca	0	0		18.4	4.5	1.2
Bungor	0	0		21.4	5.5	1.5
			Mean	20.5	5.2	1.4
	Fertilizer for Optimum FFB					
Rengam	4.5	0		32.0	7.5	2.2
Malacca	5.5	6		32.5	6.5	2.4
Bungor	6.0	4		29.0	6.9	2.0
			Mean	31.2	7.0	2.1
			% increase	51.8	33.8	19.7

• *continued on page 24*

industry has come out with the right technology to exploit such a residues for beneficial results. Since the milling processes require high amounts of steam and energy, both fibres and shells prove viable as fuel in the running of the boilers. In fact as a result of such a move, palm oil mills can now boast of not only sufficient energy to satisfy their process needs, but also offer excess amounts for other ancillary purposes. On top of that, the environment is also spared from having to accommodate such materials as another pollution burden. If the energy potential of the biogas generated by the palm oil effluent digesters is added to the excess steam produced by the fibres and shells, it may not be long before such energy sources are eventually harnessed in a big way, even through the national grid.

Admittedly the palm oil industry does generate a lot of residual materials. However, through the ingenuity of the industry, all such potentially polluting residues are put to beneficial uses. In the plantation, for example, the harvesting and pruning activities generate large amounts of fronds, while at replanting time, oil palm trunks are available in considerable quantities. These can be classified as residues which require appropriate disposal if the well being of the environment is to be safeguarded. Fortunately, a number of R&D initiatives prove successful in generating the technologies to harness the fronds and trunks in the manufacture of commercially viable furniture. Studies confirm that commercialization of the fronds will generate another additional source of income for oil palm growers.

Mankind is justifiably concerned about the fate of the environment. Evidence abound demonstrating the concern of the Malaysian palm oil industry on the environment. Trade has been used increasingly by environmentalists to highlight their concern. In the oils and fats trade, palm oil, because of its attractive techno-economic features, is the major oil traded accounting for about 33% of the international trade. However, judging by the high degree of commitment of the industry, as shown by the many environment-friendly technologies used, the production of palm oil should have no problem exhibiting a high environmental score. This, coupled with the fact that palm based products often demonstrate acceptable biodegradability, would no doubt augur well for the international environmental image of palm oil.

- *from page 21 : Quality R&D Practices in the Plantation Sector*

Plant Protection

In the plant protection discipline, R&D is geared towards the Integrated Pest Management (IPM) concept which seeks to harmonize the chemical and biological controls of pests and diseases of the oil palm. Chemicals will be used to the minimum in order to ensure a quality environment. Techniques of chemical treatment, such as trunk injection for the control of insect pests and pressurized trunk injection for the control of *Ganoderma*, are being thoroughly investigated aimed at reducing the amount of chemicals used and the hazards to non-target organisms.

Approach to the biological control of bagworm, the common insect pest of oil palm, concentrates on screening for viruses, bacteria, and fungi pathogenic to the pest. The work at PORIM has established a number of viruses and fungal isolates that show potential as possible agents for control.

The breakthrough in *Ganoderma* research with respect to successful artificial inoculation, opens up new spectra of research activities. Greater understanding of the development of this disease could be studied and screening for oil palm progenies tolerant to this disease is now possible. The mechanisms involved in host-parasite interaction leading to resistance or susceptible reaction could then be investigated at the molecular level. With a fuller understanding, breeding for resistance to *Ganoderma* could provide a long term solution to control this disease.

In the control of rats, a major vertebrate pest of oil palm, the use of the barn owl seems to provide sound biological and economic grounds (*Table 5*). By providing suitable nest boxes in the

TABLE 4. REVENUE CHANGES AFTER WEEVIL INTRODUCTION, 1982 – 86 MEAN.
(After Donough and Law, 1987)

	Johore	Sabah
	(RM/ha/yr)	
Revenue from additional CPO	39	809
Revenue from additional PK	134	185
Total additional revenue	173	994
Plus pollination savings	23	202
Total gain	196	1196
Less additional cost	23	163
Net gain	173	1033

plantation, substantial savings on the cost of rat baiting could be realized. What is even more important is the protection of environment against judicious use of rodenticides.

Farm Mechanization

In view of the labour shortage and the increasing cost of production, mechanization must play a more active role. This is in order to produce palm oil at a competitive price in the world market. While reducing the cost of production, mechanization is also a means to increase productivity and hence the earnings of the plantation workers. Various advances, such as the aluminium harvesting poles, infield transportation and mechanical fertilizer application have been made. Mechanical in-field transportation (*Table 6*) has been shown to increase output at a minimal labour requirement. The use of the grabber for collecting FFB would further improve the efficiency of this farm operation.

By-Product Utilization

Further improvement to the quality of the environment is manifested in the work towards converting oil palm wastes into value added products. This is especially critical since the amount of waste in the form of oil palm trunks and fronds are estimated at 2.5 million tonnes and 1 million tonnes/year respectively (Mohamad *et al.*, 1986). Ongoing studies reveal the potential of converting oil palm trunks into block board and furniture. Oil palm wastes, such as the mesocarp fibres, trunk and fronds are also good sources for particle board and plastic filler. Research is now concentrated at producing quality products from these wastes.

These activities will not only provide value to the wastes but more importantly they ensure quality of the environment.

Physiology

Processes controlling development contribute to ways of increasing yield and/or quality of harvested product while at the same time reducing the production cost. For example, simulation models by Van Kraalingen *et al.*, (1989) showed that any increase in crop photosynthesis, due to improvement of husbandry or genotype, will result in a proportional increase in bunch yield without much influence on vegetative growth. Multi-disciplinary or integrated approach to simulation models of oil

TABLE 5. COMPARISON OF COST BETWEEN BAITING AND BIOLOGICAL CONTROL OF RATS

Nest	RM 150.0/box
Life of box	8 yr
Density of box	1/10 ha
Cost of Biological control	RM 2.0/ha/yr
Baiting cost	RM 20.0/ha/yr
Savings	RM 18.0/ha/yr

TABLE 6. COMPARISON BETWEEN MANUAL AND MECHANICAL IN-FIELD TRANSPORTATION

Types of Transporter	Output tonnes/day	Operating Costs (RM/ha)	Labour required
Manual Loading (Mini-tractor)	18 – 28	2.00 – 3.00	3
Mechanical Loading	24 – 30	2.50 – 3.00	1

palm development and yield, involving fields such as agronomy, breeding and genetics, physiology and plant protection, would contribute a significant step towards increasing the quality of palm oil.

Vegetative Propagation

The oil palm clonal abnormality problem, first highlighted in 1985 is undermining the confidence to clone palms in large numbers. It also questions the feasibility of commercial tissue culture laboratories. There are at least two hypotheses on casual mechanism to this problem: epigenetic and genetic. In epigenetic hypothesis, there is no genetic change (no mutation) but the expressions of the genes have been altered. Currently this hypothesis is more appealing (Paranjothy, *et al.*, 1989). Cytokinins habituation, cytokinins affect sex-expression and apparent reversion of abnormal ramets to normality suggest an epigenetic change.

On the other hand, tissue culture (particularly those involving callus phase as with oil palm) has been known to give rise to genetic variants (mutants). In fact, some researchers regard tissue culture as a mutagenic technique for generating genetic variability. Data of offsprings from open-pollinated seeds of mantled palms seem to suggest that the syndrome to be transmissible (Rao and Donough, 1990). The presence of an extra RFLP band in the ramets of two clones as compared to their respective ortets seems to suggest a genetic change. However, the extra band was present in both normal and abnormal ramets, and this particular change is not likely to be linked to abnormality problem.

Studies on genetic segregation (on the expression of abnormality) in the sexual offsprings from open-pollinated seeds of mantled palms, selfings and crosses among mantled palms and crosses of mantled with normal palms are in progress.

Biotechnology

A Task Force was set up by PORIM in 1985 to study various aspects of oil composition in oil palm. It recommended that an oil with IV of more than 72, palmitic acid content less than 25% and oleic of more than 60% should be developed. This will ensure that palm oil could break into the liquid oil market, especially in temperate regions.

There are three approaches to reach the above objective. Contents of palm oil could be altered by chemical (including enzymes) process during milling and/or refining. The second approach would be by the conventional breeding and selection within *E. guineensis* as well as interspecific hybrid with *E. oleifera.* The third alternative is to use genetic engineering to produce novel palms. PORIM carries out the latter two approaches concurrently.

One of the objectives of genetically engineered oil palm would be for the production of high oleic acid oil with IV of more than 72, 8%-13% palmitic and 70%-80% oleic acids. Such an oil could be diversified into the liquid oil market, promoted as a nutritionally desirable oil, and served as a source of oleic acid for the oleochemical industry. Another objective is for the production of high stearic acid oil with triglycerides rich in the symmetrical disaturated glycerides of the POST - and STOST - type. This is for use as cocoa butter equivalent (CBE) fats. The price differential between palm oil and CBE should justify this objective.

CONCLUSION

It is clear that R&D plays a very significant role in quality practices in the plantation sector. Right from the moment a seed is chosen for planting, through the process of field management, and finally getting the product R&D has a hand to ensure quality. Although significant contributions have been provided by R&D in the plantation sector, it cannot be denied that more needs to be done to improve every aspect of the operation.

The improvement to quality through R&D is a never ending process; it will evolve with time.

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