Challenges Facing the Oil Palm Industry – The Plantation Perspective*

☐ Chan Kook Weng and Yusof Basiron

INTRODUCTION

The oil palm industry is noted for its ability to face challenges and overcome them. Over the past 120 years, since the introduction of the oil palm in 1871 into Malaya then (Hartley, 1988), many challenges have been overcome. The major challenges between 1905-1995 have been reviewed under three phases (Chan, 1995b).

The first phase, covered a period of 60 years from 1905 to 1965, during which the overall agronomic advancement was directed at meeting the compatibility challenge of expanding oil palm as a plantation crop in the Malaysian environment. Commercial exploitation took root with the establishment of the first plantation in 1917. By 1965, the planted area had slowly grown to 96 945 ha.

During the second phase, between 1965 to 1985, the government called upon the plantation industry to go for greater agricultural diversification by expanding the area planted with oil palm (Tun Hj. Abdul Razak, 1968). The extensive plantings made by the Federal Land Development Authority (FELDA), the Federal Land Consolidation and Rehabilitation Authority (FELCRA), the Rubber Industry Smallholder Development Authority (RISDA), state agencies such as the State Economic Development Corporations (SEDCs), and private plantation agency houses were clear responses that answered the call to meet the challenge. The low prices of rubber then prompted the government to use oil palm as a vehicle to eradicate poverty. This was done through large scale oil palm land development schemes. The private sector plantation agency houses also chipped in and included oil palm into their basket of crop mix to improve their earnings from the core business of plantations. So during the decade between 1965 to 1975, the hectareage increased substantially from 96 945 ha to 641 791 ha. The biggest increase came from extensive planting from jungle (Mansur, 1968). By 1985, the area planted with oil palm had further increased to 1 482 209 ha. The success of oil palm planting during the second phase was underpinned by the plantation industry in overcoming the expansion challenge by firstly; demonstrating that oil palm plantations are sustainable; secondly, that they contribute to the country's Gross Domestic Product (GDP); and thirdly, that crops can raise incomes of operators, particularly in rural areas, thereby fulfilling the government's objective of poverty eradication. The oil palm industry indeed had a great impact in meeting the challenge of the socio-economic development of Malaysia.

During the third phase, *i.e.* from 1985 to 1995, the industry overcame the challenge for industrialization; firstly, by looking at the expansion of consumption of both edible and non edible uses of palm oil, particularly by venturing into the development of the oleochemical industry. Secondly, by preserving the environment through sustainable use of resources. Thirdly, by operating the plantation, mill, refinery and downstream manufacturing units as an integrated process. This was due to the strong linkages between oil palm and the palm oil sectors

* Based on paper presented at 18th Palm Oil Familarization Programme, 2-11 November 1998.

through the life cycle assessment concept where palm oil production from 'cradle to grave' until its final disposal as a biodegradable waste are considered. By 1995, the area planted with oil palm rose to 2 540 087 ha.

Thus, given the strong culture of overcoming challenges, the aim of this paper is to outline the current challenges facing the industry and explore ways and means of overcoming them from the plantation perspective. The philosophy is based principally on sustaining the maximization of corporate profits as the estates are large scale operations designed to achieve such goals, and in the process, ensure constant supply of palm and palm kernel oils and their products.

THE CURRENT CHALLENGES

The current challenges, listed using the systems approach (Chan, 1998c), are shown in *Figure 1.* There are 12 challenges identified under four major elements. The purpose of systematically grouping the challenges into the four major elements is to achieve sustainable production, (Chan, 1995a, b, c; 1996). The four elements are *viz.*, increased sustainable productivity through new technologies, environmental protection of natural resources, social acceptability by stakeholders and improvements in economic sustainability.

Technological Challenges

There are three technological challenges:

• ***Narrowing yield gaps.*** Currently, Malaysia is the single largest producer of palm oil. In 1997, there were 2.82 million hectares planted. The palm oil production of 9.06 million tonnes and palm kernel oil at 1.11 million tonnes came from 2.46 million hectares of mature plantings. The national yield was 3.7 tonnes of palm oil per hectare. To date, the commercial yields show appreciable gap between potential and realized yield (*Table 1*).

The national average yield is about 1.3 t oil ha^{-1} lower than yields from good commercial fields on coastal soils at 5.0 t oil ha^{-1}. The best experimental plots are at 8.2 t oil ha^{-1} and the best progenies and the best individuals are at 10.2 and 12.2 t oil ha^{-1} respectively. Overall, the national realized average is way below the maximum theoretical of 17 t oil ha^{-1} estimated by Corley (1983). While there are indications that yields may vary with planting materials, climatic conditions, soil type and management system, there is an urgent need to narrow the yield gap. From the plantation perspective, the questions frequently asked are:

TABLE 1. OIL PALM YIELD GAP BETWEEN POTENTIAL AND REALIZED YIELDS

Yield class	Palm oil (t ha^{-1} yr^{-1})
Theoretical	17.0
Experimental palm	12.2
Best progeny	10.2
Experimental plot	8.2
Good commercial field	5.0
National average	3.7

Source: Henson (1990).

- What agronomic factors can increase production?
- What is the yield potential of a planting material at a given site, estate or agroecosystem?
- What really needs to be done to get 17 t oil ha^{-1}?

Three areas come to mind.

- Firstly, use of biotechnology and tissue culture;
- Secondly, use of the latest agronomic and management best practices to maximize exploiting the site yield potential;
- And thirdly, application of optimum fertilizer rates.

On the first area, how are biotechnology and tissue culture exploited to get the maximum yield at any particular site? Despite planting the best DxP crosses, significant differences in yield performance between palms within the crosses still exist.

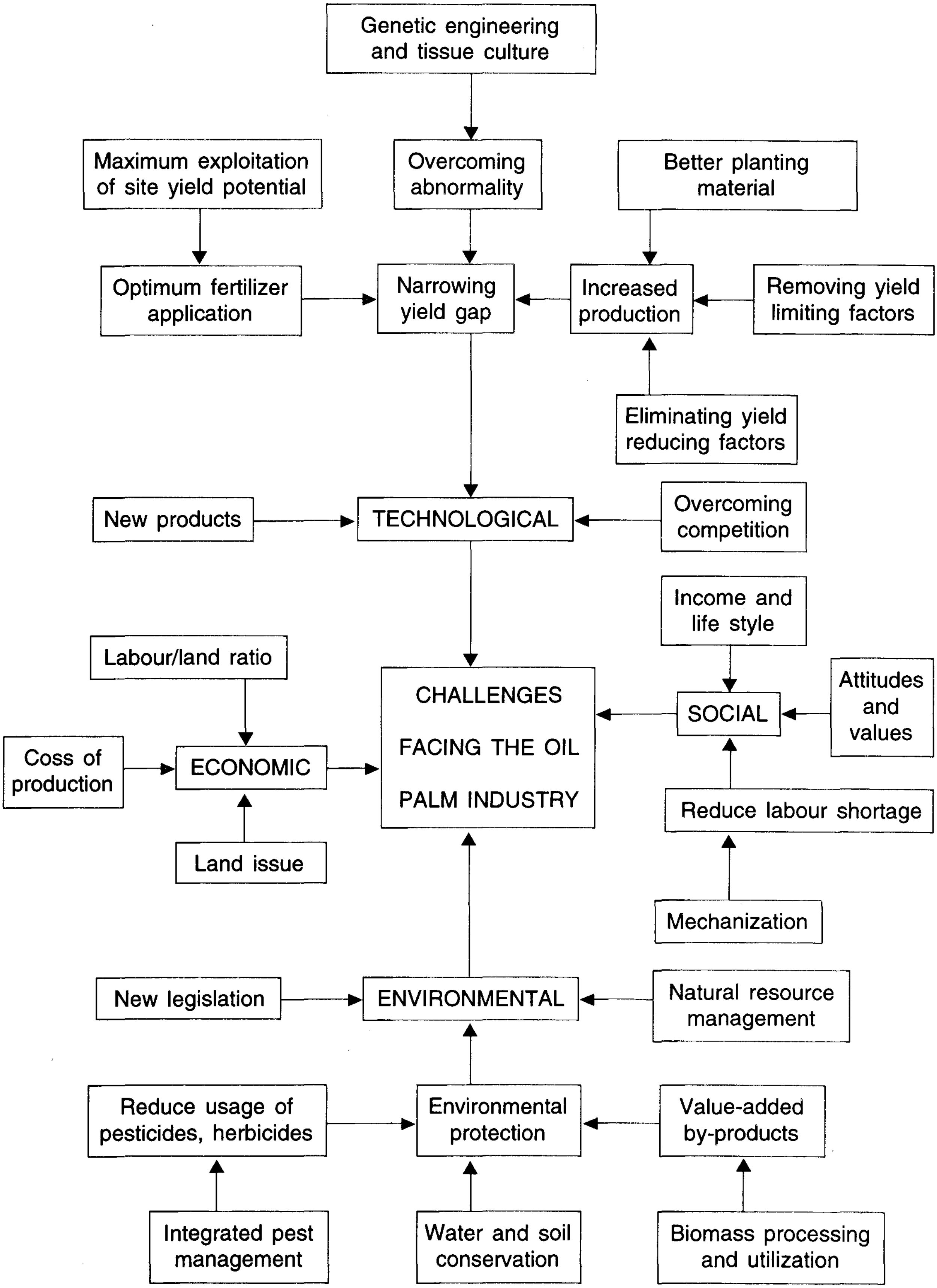

Figure 1. System approach in identifying the challenges facing the oil palm industry.

The reason for the best progenies getting high yields is that they are more uniform than even the best plantings in estates. Commercial DxP as planted, is actually a heterogenous hybrid population. To ensure maximum exploitation of the site yield potential, all palms must be uniformly high yielding. The best way to achieve this is by clonal propagation. However, the unresolved mantling problem associated with cloning oil palm remains a top research priority (Lee and Wooi, 1998).

Since the introduction of clonal palms in 1976 (Corley *et al.*, 1981), the prospect has remained pessimistic. The plantation, while awaiting the biotechnologists to attempt to understand and solve the abnormality problem (Cheah, 1998), requires the tissue culturists to increase the number of successful embryoid lines from the current 20-30 lines per clone to over 100 per clone (Tan *et al.*, 1995). This would reduce the need for extended sub-culturing of a particular clone to reproduce the same number of ramets (say 100 000 plus per clone) within reasonable time and costs. Besides overcoming the abnormality, the availability of the new tools of genetic engineering should be used to develop molecular markers for selection of desirable traits such as high oil content, better photosynthesis and efficient partitioning of assimilates to FFB yield and oil (Cheah, 1998). This type of basic research is also a priority. Thus, overcoming the abnormality problem with molecular markers becomes the first part of first challenge towards increased production.

On the second area of agronomic and management best practices, it must be stated that planting materials alone may not necessarily result in narrowing of the yield gap, but only provide the genetic basis for agronomic and management inputs to increase the yield (Rajanaidu, 1998). The second part of the first challenge is to project the maximum exploitation of site yield potential of an area, estate or agroecosystem by looking at two major parameters. Firstly, removing site limiting factors posed by low rainfall, poor soil type, terrain, *etc.*, and secondly, eliminating effects of yield reducing factors such as pests (Chung, 1998), diseases (Ariffin, 1998b) and control of weeds (Chee and Chung, 1998).

Once the maximum site yield potential is estimated, the optimum fertilizer rates are recommended. To meet nutrient requirements for maximum site yield potential, a site-specific approach is adopted to identify the agronomic and management factors operating in the area and formulate agronomic measures to achieve maximum profit. (Ahmad Tarmizi, 1998; Teo, 1998).

High fertilizer rates must be complemented with a balanced fertilizer programme because of the nutrient interactions that can occur on both inland (Chan *et al.*, 1991; 1992; 1993) and coastal soils (Teoh and Chew, 1980). The recommended fertilizers must be applied for maximum uptake with little run off and leaching losses by taking into account the stage of palm growth, ground cover development, extent of root development and soil and water conservation practices. Phosphate fixation losses are minimized with use of less reactive sources while volatilization losses are reduced by applying urea when moderate rains are expected (Teo *et al.*, 1998). Ground covers are controlled to reduce their nutrient requirements as they compete with palms for nutrient uptake. Thus, from above, reducing fertilizer losses and improving fertilizer efficiency will remain as the third part of the first chal-

TABLE 2. MATURE OIL PALM CULTIVATION COSTS BY PERCENTAGE

Activity	%
Manuring	65.50
Weeding (circles/path)	9.87
Weeding (lallang/selection)	7.19
Pruning	6.30
Pests and diseases	3.76
Drainage/irrigation	3.66
EFB application	2.43
Harvesting bridges	0.55
Conservation	0.30
Boundary marking	0.16
Thinning	0.05
Supplying	0.03
Total	100.00

lenge. High yields will depend on right choice fertilizers, correct frequency of application, placement and timing. All these advances are to be captured in computer based geographic information systems (GIS) together with site-specific data for maximum exploitation of sustainable high yield and profit.

Manuring as shown in *Table 2*, is the single largest cost in the mature plantation, accounting for about 65% of the total cost.

• ***New Products.*** Presently palm oil is exported to over 130 countries. As a longer term strategy, palm oil producers must diversify the uses of palm, oil and develop new products. The first part of the second challenge is for the mature Malaysian palm oil industry not to merely concentrate on marketing palm and kernel oils or their simple derivatives. This is because Indonesia and other palm oil producers are also doing just that. The Malaysian palm oil industry must be able to produce value-added downstream products such as specialty fats, develop their own brand name, move into sophisticated high value food products, food additives, cosmetics, oleochemical derivatives and also a whole multitude of oleochemical additives for industrial uses (Yusof and Lim, 1997).

PORIM has considerable local expertise in the production of cocoa butter equivalent and cocoa butter substitute and other specialty fats. Intensification in this sector will open up opportunities for stronger market penetration into the European Union, and the East European markets. Already many Malaysian plantation companies are exporting their own brands of palm-based products such as *Carotino* and *Nutrolein*. There also other specialty palm-based formulated products such as cosmetics under brand name of *Liasari*. This forms the second part of the second challenges is to have more aggressive brand name market of palm products.

Another area to work on is value-added products. Besides looking at new products, perhaps planting newer varieties of oil palms for higher yield, higher IV, higher carotene content or higher lauric content is proposed. Germplasm materials are now available for producing some of these tailored oils. With successful breakthrough in regenerating transgenic palms, the prospects for more diversed and tailored oils and fats will be possible. In future, the third part of the second challenge will be to present tailored oils for discerning customers who may want a health food with higher carotene and vitamin E content. Some current vitamin E contents in palm oil are shown in *Tables 3* and *4*.

TABLE 3. SOME CURRENT AVERAGE CAROTENOID CONTENT IN PALM OIL FRACTIONS

Palm oil fraction/product	Average (ppm)
Crude palm oil	630-670
Crude palm olein	680-760
Crude palm stearin	380-540
Residual oil from fibre	4,000-6,000
Second pressed oil	1,800-2,400

Source: Choo (1998).

TABLE 4. SOME CURRENT AVERAGE VITAMIN E CONTENT IN PALM OIL FRACTIONS

Palm oil fraction/product	Average (ppm)
Crude palm oil	843
RBD palm oil	581
Crude palm olein	998
RBD palm olein	716
Crude palm stearin	489
RBD palm stearin	365

Sources: Ariffin (1998b).
Ariffin and Mohd Haniff (1998).
Gapor *et al.* (1987).

• ***Overcoming competition.*** Among the major oils, *i.e.* soyabean, rapeseed, sunflowerseed and palm, only soyabean and palm can be said to be competitive in terms of production cost (vide *Table 5*). The oil palm is presently the highest yielding oil crop while soyabean oil cost has the soya meal price factored in (vide *Table 6*). Soyabean oil is considered more as a by-product of soya meal production and a higher price of meal will influence the cost of soyabean oil production. The overall market price of oils and fats will depend very much on the average cost of soyabean being planted and whether subsequent harvests are successful or not. For successful planting of soyabean crop, good weather and government support remain the main criteria.

The first part of the third challenge is for palm oil products to keep the production cost low. This is because trade liberation in terms of GATT and its successor WTO agreements will benefit low cost producers, particularly the South-east Asian palm oil producers. Unfortunately, the continued support by governments to their oilseed farmers in various subsidies, such as guaranteed fixed prices, shipping concession, and various tariff protection have an unfair competitive advantage over the exporters of palm oil. The second part of the third challenge therefore is to show that the direct or indirect subsidies to uneconomic producers based on politics is not good in economic sense. Their governments, not wanting to have social disruptions may continue to subsidize their inefficient agriculture. Thus, the third part of the third challenge must focus on the penetration of palm oil into these inefficient oilseed producing countries, in addition to expanding the traditional markets in Asia, *e.g.* China, India and Pakistan.

ECONOMIC CHALLENGES

There are three interrelated challenges, *i.e.* land, labour/land ratio and cost of production.

• ***Land.*** The 1997 planting of 2 819 316 ha is expected to grow to a projected 3 050 000 by the year 2000. Correspondingly, the production by year 2000 is projected to be about 10 million tonnes palm oil from the 9.1 million tonnes in 1997. There were 308 mills, 44 refineries, 37 kernel crushing plants and 13 oleochemical plants operating in 1997 and it is unlikely that there will be a further increase in their numbers by year 2000. Due to limited availability of land in Peninsular Malaysia, the increase in plantation area will have to come from conversion of other crops to oil palm (for example down sizing the areas of rubber and cocoa) and opening of new land in the East Malaysian states of Sabah and Sarawak. At this present rate of planting, it is anticipated that Malaysian palm oil production at 13.6 million tonnes in year 2015 will be matched by that of Indonesia. By year 2020, Malaysian production of 14.9 million tonnes will lag behind the projected Indonesian production of 15.1 million tonnes.

The continued demand for Malaysian palm and kernel oils as a result of strong marketing effort will require expansion of new planting. As stated above, due to the limitation of land availability in Malaysia, many Malaysian companies are venturing into neighbouring countries to develop, under joint venture, new oil palm plantations. This reverse investment is necessary for the plantation companies to reduce their overall cost of production and to ensure a steady supply of palm oil for the world. Due to an abundance of labour in Indonesia for example, the cost of palm oil production in Indonesia is US$185 as compared with US$240 per tonne in Malaysia. (vide *Table 5*).

The fourth challenge to Malaysian oil palm companies in investing in lower wage neighbouring countries must be complemented with Malaysian palm oil industries climbing up the value chain while tapping into and expanding market for new products in these countries of production. Greater effort is therefore needed to keep ahead in services and downstream activities for the value-added chain of palm oil products.

• ***Labour/land ratio.*** Wages in the Malaysian oil palm industry have progressively worsened compared with other economic sectors, making it difficult to attract local labour. As a result, the plantations are forced to recruit foreign labour although such measures are at best, short term remedies. The time has come to intensify mechanization and promote new skills and technologies to transform the oil palm industry from too much reliance on unskilled foreign labour.

It is estimated that of the 1 140 000 foreign workers employed in Malaysia, about

247 000 are in the plantation sector (Arikiah, 1998). Due to a labour short fall of 12% in the required work force, the labour to land ratio for all crops is 1:7 ha and for oil palm 1:8.2 ha (Arikiah, 1998). The study done on United Planting Association of Malaysia (UPAM) estates also projected that by 2002, the labour/land ratio for oil palm will increase to 1:10.5 ha. Over the next few years greater investment in machinery through capital/labour substitution will have to be made at a rate not seen before.

Thus, the fifth challenge is to step up R&D in the use of machinery in the plantation sector, but this might present a dilemma. The plantation sector will be slow in adopting mechanization as long as foreign labour remains available. Some definite plan, with cut off point for use of foreign labour must be agreed upon. Concurrently, the rate of labour moving out of the industry must be matched by the rate of uptake of mechanization.

• ***Cost of production.*** Producers must find ways to remain competitive by keeping their cost of production low. Despite this, the plantations must give wages that are tagged to higher productivity. Together with greater supply of palm oil from reverse investment in neighbouring countries, it is indeed the sixth challenge, for the industry to maintain its cost of production. When compared with other crops, palm oil indeed has the lowest production cost (*Table 5*).

TABLE 5. COMPARATIVE COST OF PRODUCTION OF SELECTED OIL AND FATS

Country	Oil	Cost (US$ t^{-1})
Indonesia	Palm	185
Malaysia	Palm	240
USA	Soyabean	400
Canada	Rapeseed	648
EEC	Rapeseed	900

Sources: Ariffin (1998a).
Ariffin and Mohd Haniff (1998).

SOCIAL CHALLENGES

There are three social challenges, *i.e.* income and life style of workers, their attitudes and values and stepping up mechanization to reduce the labour shortage.

• ***Income and life style.*** One of the tenets of sustainability in the plantation sector is income generation and its impact on the life style of the workers. The social economic impact of the plantation industry is tremendous. In 1997, about 300 000 families were involved in smallholdings which included the independent and organized land schemes under FELDA, FELCRA, RISDA and SEDC schemes, while about another 200 000 workers were employed in private plantations. The industry also supports and benefits the rest of the work force through related activities such as contractors, suppliers, consultants, traders, fabricators, transporters, bulkers, port handlers, shippers and manufacturers. The industry contributed 8.9% of the export earnings for Malaysia in 1997 (Jalani *et al.*, 1998). The seventh challenge for the oil palm industry is to continue to attract people to work in the industry through competitive ways and other amenities.

• ***Attitude and values.*** Working in plantations currently seems to be a stigma for local workers. This appears to be an attitude problem as values have changed. However, some companies are making moves to attract workers back to the rural setting. Perks include free housing, land, subsidized water and power and other sports facilities and medical amenities. Already, a higher take home pay is being advocated. There is a definite move to transform plantation life into one that compares well with urban factories. A relatively clear work environment and definite working hours unlike shift work in factories, may attract workers back to the plantations. This, together with mechanization to ease work load and bigger take home pay associated with higher productivity plus quality living with green surroundings must be sustained in the effort to overcome the present stigma of plantation work.

A key element in successfully coping with changes surrounding the plantation industry is effective human resource management (Chan and Yee, 1994). Quality people are harder to come by and even harder to attract and retain in the current Malaysian economy. More important is the training of new employees and retraining of existing ones. To this end, PORIM with its expertise in all spheres of the oil palm and palm oil industries should lead the industry in its training programmes. The eighth challenge to the industry is to go strongly into formalized training, which is best done through the setting up of training institutes. This entails the human resource 'inventory' to be critically assessed. After training, a compensation package to attract and retain those who can perform in the estate environment should be worked out. All these have to be backed by an annual open objective performance evaluation. The success of such a training scheme will be a challenge that will eventually tackle the long term labour problems at different levels.

• ***Mechanization to overcome labour shortage.*** Mechanization to improve labour: land ratio has been gradual. In plantation, the priority in mechanization has being directed at harvesting and pruning. These two crucial interrelated operations require greater effort. PORIM is currently developing a prototype machine that can propel itself up the palm trunk to carry out the function of pruning and cutting down ripe bunches.

Under the present labour situation in Malaysia, it is increasingly difficult to ensure that all loose fruits, which contain more oil are collected. The shortage of labour may have contributed to the decline in OER because not all loose fruits are collected and companies are adopting the one loose fruit per bunch ripeness standard to avoid picking up of excessive loose fruits.

As for in-field FFB collection and its subsequent evacuation to palm oil mills, there are another two interrelated operations that have received a lot of focus. The most popularly adopted FFB evacuation systems are the mini tractor trailer - grabber cum division of labour system and the mechanical buffalo cum *gotong royong* system (Teo, 1998). There are payment schemes for recovery of the cost of machines to be considered in these two schemes together with loose fruit collection and in on line transport of FFB to the mill.

Besides harvesting, mechanization of fertilizer application with tractor mounted spreaders, turbo spin or Emdek turbo spins have reduced the cost of mechanical spreading of fertilizers. In future, aerial application with fixed wing air craft may be reconsidered if the industry is faced with a very acute labour shortage.

Another area to look at is mechanization of replanting which requires a tracked-excavator fixed with chipping bucket to shred oil palm trunks, plough, construct roads and drains and also construct the planting and conservation drains. If dense logged-over forests are cleared, there may be a need to burn due to the large volume of biomass and zero burning of these dense logged-over forest will pose as the first part of the ninth challenge to the plantation industry.

Two other areas that have been mechanized are distribution of the bulky POME and compaction of the camber roads on peat soils. As there is a strong negative correlation between availability of foreign labour and the adoption rate of mechanization, the second part of the ninth challenge is to step up mechanization by developing more suitable and efficient machinery rather than adopting those from elsewhere.

ENVIRONMENTAL CHALLENGES

There are another three challenges. They are meeting new legislations, natural resource management and environmental protection. In the quest for export-based manufacturing and services in palm-based products, Malaysian oil palm and palm oil industries must position themselves from other palm oil growers by having innovations towards environmentally acceptable products. There is a need to provide new knowledge for the existing people and to train a new generation of skilled workers attuned to the new environmental requirements for sustainable industrialization.

• ***New legislations.*** To improve the quality assurance for palm oil, it is best that quality assurance in the palm oil industry be certified to ISO 9000 series standards. Likewise, to improve the environment performance of the industry, certification to ISO 14000 series standards is necessary (Chan, 1998b). For this to be realized, the four distinct operations of plantations, milling and processing, refining and manufacturing, and export must be integrated into a single process with each having its own distinct systems boundaries. The areas under each operational influence are to be used for certification to ISO standards. To date, for example, three palm oil companies have been certified to ISO 14001 environment management system standard. Further, the government, through amendments made to the Environmental Quality Act (1997), has prohibited the burning of biomass in oil palm replants. Thus, the tenth challenge is to ensure zero burn in all replants in the future to meet all legislations, including overseas market demand for environmental protection.

• ***Natural resource management.*** In the globalization of Malaysian palm oil trade (Chan, 1998a), certification to ISO14001 on environmental management system (EMS) standards is one of the best assurance to overcome disputes by competitors on how our natural resource management is carried out. Through ISO14001 implementation (Chan, 1997), the plantation will be able to spearhead its activities towards sustainable development. The end result in obtaining the ISO14001 EMS certificate will show competitors that there is no depletion of natural resources; attempts are made to utilize all wastes and that there is no heavy metal contamination from using palm oil mill effluent. Thus, the ISO14001 EMS certificate will allow the entire product development to conform to international standards of environmental labelling, environmental performance evaluation and life cycle assessment of the palm oil product from 'cradle to grave'. There are continuous six-monthly independent audit to review the performance of the activities in the overall operation. Hence, as we advance into the new millennium, the environmental issues will be more complex and would require greater inputs from R&D. This eleventh challenge is for the plantation industry to meet the international quality and environmental requirements for our palm oil to facilitate its trade.

• ***Environmental protection.*** Oil palm has the highest yield when compared with various major oil crops (*Table 6*). Due to higher yield and energy efficiency (*Table 7*)

TABLE 6. AVERAGE PRODUCTIVITY OF VARIOUS MAJOR OIL CROPS

Crop	Oil ha^{-1} yr^{-1} (kg)
Oil palm	3 200*
Rapeseed	556
Sunflowerseed	504
Groundnut	384
Copra	356
Soyabean	357
Cottonseed	188
Sesameseed	178

Sources: Ariffin (1998a).
Ariffin and Mohd Haniff (1998).

* Note: refers to palm oil. Another 454 tonnes of palm kernel oil ha^{-1} yr^{-1} are also obtained.

TABLE 7. PALM OIL ENERGY EFFICIENCY AS COMPARED WITH OTHER CROPS

Cropping system	Annual energy value ($GJ\ ha^{-1}$)		
	Input	Output	Ratio
Oil palm (Malaysia)	19.2	182.1	9.5
Maize (USA)	30.0	84.5	2.8
(Mexico)	1.0	29.4	30.0
Rice (USA)	65.5	84.1	1.3
(Philippines)	1.0	24.4	4.4
Wheat (India)	6.6	11.2	1.7
Rapeseed (UK)	23.0	70.0	3.0
Soyabean (USA)	20.0	50.0	2.5

Sources: Ariffin (1998a).
Ariffin and Haniff (1998).

of the oil palm, palm oil will play a greater role in the world fats and oils market. To strengthen its position, palm oil has to demonstrate its environmentally friendly practices.

This is demonstrated by the three strategies in the 12th challenge.

• Firstly, develop new techniques to reduce crop loss by another, say, 30% by controlling weeds, vertebrate pests and a host of disease organisms. Through integrated pest management, there are ways to reduce use of pesticides. For example, the use of barn owls to control rats will reduce the use of rodenticides. The use of biological control comes with the construction of barn owl boxes with a density of 1/10 ha and, with the life span of each barn owl box being eight years, this will amount to RM 2 ha^{-1} yr^{-1}. Against this is the rat baiting cost of RM 20 $ha^{-1}yr^{-1}$, thus realizing a saving of RM18 ha^{-1} yr^{-1} with natural biological control. The first part of the 12th challenge is to ensure that on one hand, agronomy and management advances use more biological predation to control pests, weeds and diseases, thereby reducing the use of pesticides, herbicides and fungicides. On the other hand, where pesticides are to be used, they must be increasingly target-specific, biodegradable and less accumulative as residues in the food chain throughout the environment.

• Secondly, reduce water pollution by sediment from agricultural operations. The use of legume cover planting, soil and water conservation measures like terracing and silt pits, and water control like irrigation and drainage are some standard practices that have been applied to reduce losses of sediments and nutrients. In addition, use of oil palm residues such as pruned fronds, chipped trunks, POME and empty bunch mulching are to conserve water and recycle nutrients. The second part of the 12th challenge is to continue to improve the use of these by-products efficiently in the field to conserve organic matter.

• Thirdly, value-added products from by-products. As a guide, the oil palm produces about 55 t ha^{-1} yr^{-1} dry matter but the main products, palm and palm kernel oils constitute only about 5.5 t ha^{-1} yr^{-1} (Ariffin and Mohd Haniff, 1998). Thus, as a rule of thumb, only 10% are currently utilized and the scope to improve percentage utilization is high. Already R&D on the various uses of oil palm fibres from empty fruit bunches (EFB), trunk and petioles have been explored for potential production of a number of commercial products. They are pulp and paper, particle boards, medium density fibre boards (MDF) and chemical products like xylose and xylitol (Mohamed *et al.*, 1998). Thus, the third part of the 12th challenge is to adopt a new management system whereby the selective removal of certain biomass from the field will not affect the organic matter recycled from such biomass residue needed for conservation of soil, water and nutrients.

CONCLUSIONS

The oil palm industry is well placed to overcome the 12 challenges it is facing as it moves into the new millennium. The strategies developed have taken into consideration the full web of interdependence of these challenges from the point of a sustainable development approach. The strategies mapped out for the four major areas are – continuing to achieve higher yield through new technological breakthroughs, have good economic returns, be socially acceptable and have high regards for the environmental and ecological principles.

The multifactorial systems approach will boost yield through new technologies, yet ensure that natural resources used in the production are protected, be they air, water, soil, palm, its biomass or the operators. All these factors are constantly reviewed together with the various agronomic best practices for their soundness in terms of sustainability and environmental friendliness. This includes using principles of life cycle assessments to ensure that value-added products are produced with good conservation of soil, water and air. Use of fertilizers and pesticides should be at optimum levels so that such value-added products, being environmentally acceptable, will generate higher incomes for the operators.

Finally, all these strategies and the enthusiasm generated from strong scientific R&D rigour must be passed on to the younger executives through training so that these sustainable practices will continue to generate more environmental friendly palm and kernel oil products well into the next millennium.

REFERENCES

ABDUL RAZAK HUSSEIN, TUN HJ (1968). Opening Address. In Turner, P D (ed). *Oil Palm Developments in Malaysia,* The Incorporated Society of Planters, Kuala Lumpur, p. 177.

AHMAD TARMIZI, M (1998). Nutritional requirements and efficiency of fertilizer use in Malaysian oil palm plantations. *Advances in Oil Palm Research.* Palm Oil Research Institute of Malaysia, Bangi. In press. 61 pp.

ARIFFIN, D (1998a). Major diseases of oil palm and their control. Paper presented at Mosta Symposium 5. Recent Advances in the Oil Palm Sector held between 15-17 October 1998, Orient Star Resort, Lumut, Perak, Malaysia. 14 pp.

ARIFFIN, D (1998b). Oil palm industry in Malaysia – an overview. Paper presented at the Oil Palm Management Course conducted by PORIM from 5-17 October 1998, Kuala Lumpur. 20 pp.

ARIFFIN, D and MOHD HANIF, H (1998). Potential and constraints of oil palm production in Malaysia. Paper presented at the National Food Production and Security Conference on Issues, Strategies and Role of Plant Biologists held from 1-2 September 1998 at UKM, Bangi. 4pp.

ARIKIAH, A (1998). Labour situation. Paper presented at the Mosta Symposium 5. Recent Advances in Oil Palm Sector held between 15-17 October 1998 at Lumut, Perak, Malaysia, 12 pp.

CHAN, K W (1995a). Malaysian aquatic environment – the plantation industry experience. Plenary paper at the Seminar of Malaysian Aquatic Environment held on 17 April 1995 in conjunction of the International Workshop on Aquatic Toxicology. UPM Serdang, Selangor. 23 pp.

CHAN, K W (1995b). Advances in agronomy and management practices and their effects on the competitions advantage and sustainable development challenges on the oil palm industry. Keynote address No. 2. In Jalani, S; Ariffin, D; Rajanaidu, N; Mohd Tayeb, D and Mohd Basri, W (eds.). *Proc. of 1995 PORIM Nat. D.P. Conf. - Tech in Plant.* Palm Oil Research Institute of Malaysia, Kuala Lumpur. p. 51-74.

CHAN, K W (1995c). Sustainable agriculture: the case of the Malaysian plantation industry. Keynote paper delivered at the 1995 International Conference on Soil Resources and Sustainable Agriculture held from 12 to 15 September 1995. Malaysian Soil Science Sociely, Kuala Lumpur, 19 pp.

CHAN, K W (1996). The economics of environmental protection and sustainable crop management practices in the oil palm industry. Plenary lecture III. In Ariffin, D; Mohd Basri, W; Rajanaidu, N; Mohd Tayeb, D; Paranjothy, K; Cheah, S C; Chang, K C and Ravigadevi, S (eds.) *1996 PORIM Int. P.O.Cong. Competitiveness for the 21st Century.* Palm Oil Research Institute of Malaysia, Bangi. p. 181-203.

CHAN, K W (1997). Environmental management system – a competitive factor for plantation in the 21st century. In Pushparajah, E (ed.). *Plantation Management in the 21st century, (Vol. 1).* Incorporated Society of Planters, Kuala Lumpur. p. 105-124.

CHAN, K W (1998a). The mechanism for implementation of ISO 14000 series environmental management standards and trade implications with reference to palm oil. Panel paper delivered at the National

Seminar on the Development, Application and Implication of the ISO 14000 Series of Environmental Management Standards on Palm Oil and Related Industries, 4 August 1998, PORIM Conference Hall, Palm Oil Research Institute of Malaysia, Bangi. 8pp.

CHAN, K W (1998b). Recent developments in quality and environmental standards. Paper presented at Mosta Symposium 5. Recent Advances in the Oil Palm Sector held between 15-17 October 1998, Orient Star Resort, Lumut, Perak, Malaysia. 22 pp.

CHAN, K W (1998c). Systems approach: a tool for modernising management of technologies. Paper presented at the 1998 International Oil Palm Conference Commodity of the Past, Today and the Future, Bali, Indonesia. Indonesian Oil palm Research Institute (IOPRI). 19 pp.

CHAN, K W and YEE, C B (1994). Some structural changes and strategies for the plantation industry in the 90s. In Chee, K H (ed.). Management for Enhanced Profitability in the Plantations. *Proc. of the 1994 International Planters' Conference.* Incorporated Society of Planters, Kuala Lumpur.

CHAN, K W; LIM, K C and AHMAD, A (1991). Fertilizer efficiency studies in oil palm. In Yusof, B; Jalani, B S; Chang, K C; Cheah, S C; Henson, I E; Norman, K; Paranjothy, K; Rajanaidu, N; Mohd Tayeb, D and Ariffin, D (eds.). *1991 PORIM International Palm Oil Conference - Agriculture (Module I). Progress; Prospects and Challenges towards the 21st century.* Palm Oil Research Institute of Malaysia, Bangi. p. 302-311.

CHAN, K W; LIM, K C and AHMAD, A (1992). Fertilizer efficiency studies with interaction in oil palm. In Aziz, B (ed.) *Proc. of International Conference on Fertilizer Usage in Tropics* (FERTROP) Malaysian Society of Soil Science, Kuala Lumpur, p. 65-80.

CHAN, K W; LIM, K C and AHMAD, A (1993). Intersification of oil palm cropping through interactions between inorganic and organic fertilizers. In Jalani, B S; Ariffin, D; Rajanaidu, N; Mohd Tayeb, D; Paranjothy, K; Mohd Basri, W; Henson, I E and Chang, K C (eds.). *1993 PORIM Int. P.O. Cong. Update and Vision (Agric).* Palm Oil Research Institute of Malaysia, Bangi. p. 329-342.

CHEAH, S C (1998). Oil palm technology. Paper presented at Mosta Symposium 5. Recent Advances in the Oil Palm Sector, held between 15-17 October 1998, Orient Star Resort, Lumut, Perak, Malaysia, 30 pp.

CHEE, Y K and CHUNG, G F (1998). Integrated weed management in oil palm. Paper presented at Mosta Symposium 5. Recent Advances in the Oil Palm Sector held between 15-17 October, 1998, Orient Star Resort, Lumut, Perak, Malaysia. 15 pp.

CHOO, Y M (1998). Specialty products: Carotenoids. Chapter submitted for *Advances in Oil Palm Research.* Palm Oil Research Institute of Malaysia, Bangi, 31 pp.

CHUNG, G F (1998). Oil palm pest control. Paper presented at Mosta Symposium 5. Recent Advances in the Oil Palm Sector held between 15-17 October 1998 Orient Star Resort, Lumut, Perak, Malaysia. 34 pp.

CORLEY, R H V (1983). Potential productivity of tropical perennial crop. *Expl. Agric., 19:* 217-237.

CORLEY, R H V; WONG, C Y; WOOI, K C and JONES, K H (1981). Early results from the first oil palm clone trials. In Pushparajah, E and Chew, P S (eds.). *The Oil Palm in Agriculture in the Eighties (Vol. I).* Incorporated Society of Planters, Kuala Lumpur p. 173-196.

GAPOR, A M T; KATO, A and ONG, A S H (1987). Studies on vitamin E and their useful components in PFAD and oil palm leaflets. In Ma, A N; Maycock, J H; Sieh, L M C and Augustin, M A (eds.). *International Oil Palm / Palm Oil Conference.* Technical Papers, Palm Oil Research Institute of Malaysia, Bangi. p. 124-128.

HARTLEY, C W S (1988). *The Oil Palm (Elaeis guineensis* Jacq.) 3rd ed. Tropical Agricultural Series, Longman, UK, 778 pp.

HENSON, I E (1990). Estimating potential productivity of oil palm. In *Proc. of the 1990 ISOPB International Workshop on Yield Potential in the Oil Palm.* Thailand, p. 98-108.

JALANI, B S and CHAN, K W (1998). Sustainable agriculture in Malaysia. The case of the oil palm industry. Keynote address presented at the Fifth Symposium of Applied Biology, organized by the Malaysian Society of Applied Biology, 5-6 May 1998. UPM, Serdang, Malaysia. 24 pp.

LEE, C H and WOOI, K C (1998). Current status and strategies of the oil palm tissue culture. Paper presented at Mosta Symposium 5, Recent Advances in the Oil Palm Sector held between 15-17 October 1998, Orient Star Resort, Lumut, Perak, Malaysia. 14 pp.

MANSUR, Y (1968). Jungle clearing for oil palm. In Turner, P D (ed). *Oil Palm Development in Malaysia.* Incorporated Society of Planters, Kuala Lumpur, p. 18-25.

MOHAMAD HUSSIN; RIDZUAN RAMLI and ASTIMAR A AZIZ (1998). Commercial products from oil palm biomass. Paper parented at the Mosta Symposium 5. Recent Advances in the Oil Palm Sector. Orient Star Resort, Lumut, Perak, Malaysia. 26 pp.

RAJANAIDU, N (1998). Oil palm breeding. Paper presented at Mosta Symposium 5. Recent Advances in the Oil Palm Sector held between 15-17 October 1998, Orient Star Resort, Lumut, Perak Malaysia, 21 pp.

TAN, Y P; MUKESH, S and HO, Y W (1995). Oil palm planting material – prospects. In Jalani, B S; Ariffin, D; Rajanaidu, N; Mohd Tayeb, D and Mohd Basri, W (eds.). *Proc. of 1995 PORIM Nat. O P Conf. – Tech in Plant.* p. 30-37.

TEO, L (1998). Mechanization in oil palm plantation. Paper presented at Mosta Symposium 5. Recent Advances in the Oil Palm Sector held between 15-17 October 1998, Orient Star Resort, Lumut, Perak, Malaysia. 34 pp.

TEO, L B; CHEN, P S; GOH, K J and KEE, K K (1998). Optimizing return from fertilizers for oil palm: an integrated agronomic approach. Paper presented at Mosta Symposium 5. Recent Advance in the Oil Palm Sector held between 15-17 October 1998 at Orient Star Resort, Lumut, Perak, Malaysia. 23 pp.

TEOH, K C and CHEW, P S (1985). Investigation on areas and frequency of fertilizer aplication in mature oil palms. In Bachik, A T and Pushparajah, E (eds.). *Proc. Int. Conf. on Soils and Nutrition of Perennial Crops.* Malaysian Society of Soil Science Kuala Lumpur, p. 375-387.

YUSOF, B and LIM, W S (1997). New technologies needed for the oil palm industry in the 21st century. In Pushparajah, E (ed.). *Plantation Management for the 21st century (Vol. 1).* The Incorporated Society of Planters, Kuala Lumpur, p. 37-45.