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AA RESEARCH NEWS

EDITORIAL

Precision Farming - The Way Forward

With the recent advances in precision farming technologies, a unique opportunity has been created for the Malaysian plantation sector to move boldly forward.

Will planters be able to exploit the technologies to improve production efficiency and profitability in the plantations? The answers will probably vary with the resourcefulness and the entreprenal spirit of the planters.

AAR has been preparing the ground work for site specific techniques (precision farming) since its inception. The advent of affordable GIS (Geographical Information System) and GPS (Global Positioning System) technologies for management and research purposes recently and their implementation at AAR has taken us much further towards these objectives. In fact our Tey Seng Heng created considerable interest when he presented his paper entitled **"GIS and GPS technologies for management and research in plantation crops"** at the recent International Planters Conference in Kuala Lumpur.

We have devoted this issue of AAR News to the subject on **"Prospects for precision plantation practices in oil palm"** by Chew Poh Soon. This is a shortened version of the paper presented at the PORIM Programme Advisory Committee Seminar in March 1997. We invite you to read it critically and let us have your views.

OOI, L.H.

Prospects for Precision Plantation Practices in Oil Palm

by Chew Poh Soon

Abstract

Interest in 'Precision Farming' and its related technologies is sweeping arable cropping systems in the developed countries. Limited information on use of these technologies is available for tree crops such as oil palm and their unique cropping systems currently. The talk will discuss the information and research requirements to exploit the available technologies usefully on oil palm plantations.

Plantations are based traditionally on large scale extensive agricultural practices. Now, intensification of inputs and practices to improve productivity and raise efficiency is inevitable to improve competitiveness. It is vital for the Malaysian Industry in view of the many difficulties, faced especially in management, to utilise these new technologies fully to maintain its competitive edge before other oil palm producing countries do so and to offset expected improvements in other competing crops.

The new technologies are not a 'magic bullet' to raise performances and profitabilities in the Industry. Good multi-disciplinary agronomic R&D and basic agro-management practices will be even more essential and rewarding.

Introduction

Our oil palm plantations are based traditionally on large scale extensive agricultural practices. It appears inevitable that we shall have to intensify and improve our planting practices by developing new techniques to increase ef-

Communicate with us through AAR e-mail
aarsb@po.jaring.my

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Inside

ficiency and productivity to keep ahead of our competitors and maintain our reputation as a responsible 'green' industry.

'Precision Farming' is the new term coined for farming practices which were variously described as 'prescription farming', 'site-specific' practices, 'variable-rate technology' etc. previously. Interest in precision farming is now sweeping the world, partly due to new and exciting technologies used and the new business opportunities for farm suppliers and professionals/consultants that are created as a result.

The developments in precision farming and the new technologies have been noted in the oil palm world. At least three papers applying Geographical Information Systems (GIS), Global Positioning Systems (GPS), Decision Support Systems (DSS) and site-specific management practices indicate the development areas now (Goh et al.1997, Guha and Guha 1997, and Tey and Chew 1997). Other recent publications include Sugih et al. (1995) on GIS and Lukman and Poeloengan (1996) on remote sensing.

In this talk, I shall try to examine where precision farming or in our context, 'Precision Plantation Practices' (PPP), can be implemented to advantage and how new technologies used for PPP can help us achieve our objectives in the plantations. Hopefully this will spur us to evaluate the new technologies and develop systems to use them in our unique tree cropping systems ourselves.

Precision Farming Practices

Precision farming practices prescribe application of only what are required for high productivity at various distinct points or sites in the fields. They are timely therefore to improve efficiency and productivity. Wastage and subsequent environmental problems are also avoided.

1. Technologies Required. The advent and recent affordability of several key technologies made the large scale implementation and success of precision farming possible including :-

1. Personal computers
2. New space age GPS technology employed which reads signals continuously available from 24 satellites enabling near pin-point location accuracy
3. Remote sensing where satellite or aerial images are processed and correlated with crop characteristics
4. GIS technology which manages and displays spatial data and relationships
5. Engineering systems approaches to the problems and
6. Variable rate application equipment with sensors and GPS equipment to respond to field and soil variables.

These technologies allow collection and analysis of large amounts of data, display of spatial and temporal information on any scale. Identification and information on specific locations and measurements of any features of interest within the study areas are possible with great speed and accuracy. Supplementary data and information of the areas under study and adjoining areas may also be made available. Finally, systems and machinery required to put into effect the site-specific practices for different parts of the fields have been developed for the various crops.

2. Applications in Arable Crops. As usual, the highly enterprising and competitive farming and business communities especially arable farmers, in the USA have jumped in to utilise the latest technologies for the following principal purposes:-

1. Variable seeding rates
2. Variable fertiliser applications
3. Variable tillage practices
4. Pin-point pest and weed management
5. Yield and growth logging and mapping

in individual fields where the exact predetermined rates or practices within the fields are applied at each site or point depending on the soil, terrain and microclimatic properties and expected yields. These precision farming practices are increasingly promoted and adopted for corn, wheat, rice, soyabean, cotton, sorghum, sunflower and other crops as more experience and R&D results appear to show the benefits of these practices.

Typically, the farming practices are ahead of the science but there is very active R&D now underway e.g. a list of websites on these centres in the Internet (Table 1). New ways and techniques to use these new technologies to improve farming productivity and efficiencies are still being sought and many new questions which need to be answered for the technologies to succeed are being researched.

TABLE 1. WWW PRECISION FARMING RESEARCH CENTERS

- Australian Centre for Precision Agriculture (University of Sydney)
- Bjertorp's precision farming page
- Cranfields Center for Precision Farming
- Hawkeye Community College's Precision Farming Page
- Idaho National Engineering Laboratory
- Minnesota's Center for Precision Farming
- North Carolina State's precision farming page
- Ontario's Min. of Ag's precision farming page
- Precision Agriculture Centre for Sugar Cane (USQ, Australia)
- Purdue's Electronic Precision Farming Institute
- Silsoe Research Institute
- Site-Specific Precision Farming Systems for Soybeans (Univ. of Illinois)
- Texas A & M's precision farming page
- The University of Helsinki's Gis-based adaptive cropping unit
- University of Newcastles precision farming page
- USDA-ARS RSRU's precision farming page
- Washington State's precision farming page

Source : http://nespal.cpes.peachnet.edu/pf/ipfi.stm

Prospects for PPP

Many of the concepts and ideas behind precision farming practices are not new e.g. 'site-specific' fertiliser recommendations for oil palm have been actively promoted since Ng and Selvadurai (1967) advocated the study of soils, use of soil maps for crop allocations, and various field planting practices including those for 'problem soils' in conjunction with field data and R&D results (Ng, 1983). Our large plantations have been major constraints in collecting data, planning and implementing work on detailed scale but many progressive plantations have soil maps at least to semi-detailed scale of approximately 1 examination point to 10 ha. with soils mapped at soil series and phase levels. Problem soil areas have been identified and mapped for special attention and corrections. Few however have terrain, landform, slopes and detailed drainage maps.

However, with use of the new technologies, collection of additional relevant data and information such as the above will be much easier. The principal constraints are likely to be in identification of the advantageous PPP areas for application and to develop systems to use them. The key issues involved in examining the prospects for PPP are :-

1. How accurate and precise should we be for the various agro-management practices?
2. What advantages can we expect over current practices?
3. What data and at what level of detail is required?
4. What systems, equipment and techniques are required or available for efficient implementation?

The average yields for major Malaysian Companies have remained in the 20 t FFB per ha per year range for the last 10-15 years. The inescapable conclusions are that there are severe agronomic and/or management constraints. Our plantations therefore face many challenges to improve results and remain sustainable. In our analysis of the problems, the key solutions lie in

1. Agronomic Solution Required

1. Increasing the yield productivity of the palms

2. Management Solution Required

1. Increasing the productivity of the workers
2. Introduction of 'Worker-friendly' and 'Manager-friendly' practices and technologies.

Can we introduce new precision farming technologies or PPP in our quest for solutions to these problems?

Increasing the Yield Productivity

AAR has developed a site yield potential (SYP) prediction system (Kee et al. 1994) whereby
SYP yield = f (F1, F2, F3, F4....Fi), assuming no agronomic and management constraints and F1 to Fi are factors such as planting materials, soil physical factors, climatic factors, planting systems etc. (Tinker, 1984).

Some yield prediction results are shown in Table 2 and the following may be noted :-

1. Significantly higher yields are predicted than usually realised in Malaysian plantations.
2. Yields vary from site to site
3. The factors in the yield equation are largely predetermined after planting or outside management control e.g. rain in climatic factors.

There are 2 situations involved in increasing yield productivity 1) Maximising SYP and 2) Achieving the SYP.

1. Maximising SYP.

In our prediction model, the SYP levels are more or less predetermined after planting. Very little can be done to change the variable factors such as planting density, pattern and planting materials till replanting 20+ years later.

1.1 Palm Density. The effect of density and its influence on SYP on different soils is indicated in Fig 1. PPP such as planting higher density upto 164 per ha in shallow soil areas and peat soils for higher yields especially in early years over small areas < 80 ha per block may not be worthwhile e.g. due to management constraints such as road and drain realignments required to synchronise with other adjoining areas.

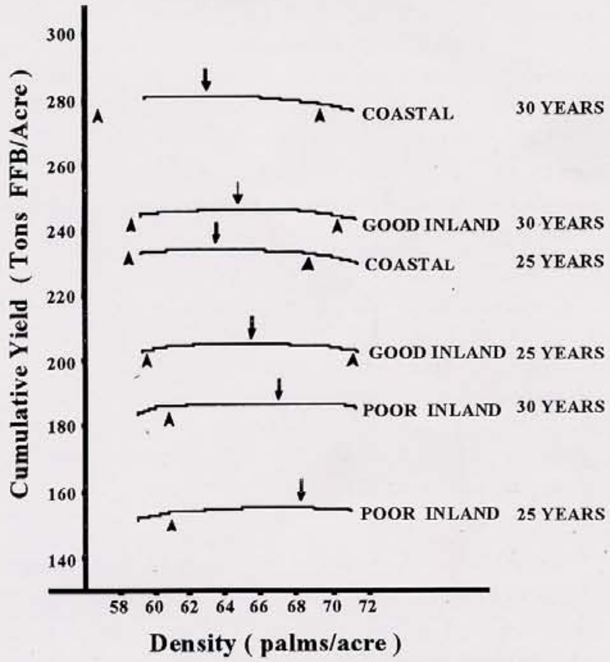


Fig.1. Cumulative yields at 25 and 30 years at different palm densities in three environments. (Corley *et al.*, 1972)

TABLE 2 . ACTUAL FFB YIELDS (t. ha^{-1} yr^{-1}) AND ASYP 1 PREDICTED SITE YIELD POTENTIAL (t. ha^{-1} yr^{-1}) FOR TRIALS AND COMMERCIAL AREAS

Trial areas						Commercial areas		
Trial no.	Actual	ASYP 1	Trial no.	Actual	ASYP 1	Block no.	Actual	ASYP 1
1	32.8	29.1	10	28.7	24.1	1	29.6	28.6
2	31.8	30.2	11	25.2	23.0	2	31.6	32.6
3	32.3	32.7	12	27.9	28.5	3	27.8	27.8
4	29.6	29.1	13	29.0	28.9	4	32.0	31.8
5	31.1	30.2	14	31.8	31.7	5	25.3	27.2
6	24.5	25.6	15	22.8	22.9	6	24.5	25.0
7	33.9	30.0	16	24.8	25.4	7	29.1	31.0
8	33.9	28.9	17	25.8	30.9	8	31.6	31.7
9	29.9	25.8				9	26.9	28.6

Source: Kee et al. 1994 Key : ASYP 1 = AAR site yield potential

The favoured form of PPP in such cases is to use different planting materials e.g. vigorous materials with high extraction rates for shallow soils or shorter materials with higher extraction rates on peats.

1.2 Planting Pattern. The more common problems are due to uneven and overcrowded spacing especially in large developments and plantings on contour terraces. Selective thinning of palms in overcrowded areas to reduce light competition will raise overall yields (Ng, 1983) although the remaining irregular canopy distribution usually results in lower SYP. This frustrating exercise is tedious in the field and it may be worthwhile to investigate the use of remote sensing images or aerial photographs with GIS to simulate the effects of thinning individual palms. The palms for thinning can then be traced by GPS. Accurate maps with supplementary information such as terrain, slopes and drainage from GIS and GPS studies could help in planning plantings e.g. spacing of terraces to minimise 'infill' terraces to achieve desired stands. The latter and other 'infills' on roadsides etc. are frequent causes for uneven spacings.

2. Achieving the SYP.

SYP yield predictions are improved with accurate spatial information of soils and terrain and a site yield analysis system for analysing yield gaps (Fig 2) in individual blocks is useful to progress towards the target yields.

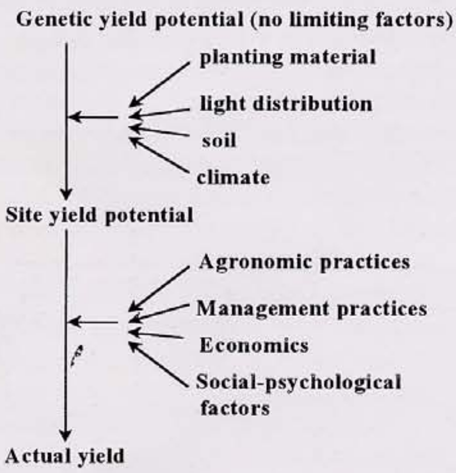


Figure 2 : Factors influencing the site yield potential and actual yield of oil palm

2.1 Monitoring Yields. Accuracy of field yield records in plantations can vary considerably. In the absence of expensive land surveys, GPS and GIS mapping provides accurate road, block, field, soil and terrain maps. Accurate hectarages of individual blocks can be determined and yields accurately computed. Table 3 indicates the ranges of accuracy seen in a random group of estates mapped by GPS recently.

TABLE 3. DIFFERENCES IN DECLARED HECTARAGES IN INDIVIDUAL BLOCKS IN OIL PALM PLANTATIONS AFTER GPS MAPPING

	Ha	Total Blocks	Ha Difference (%)				
			<2%	2-5%	6-9%	10-14%	>15%
Estate 1	639	7	1	-	-	5	1
Estate 2	864	38	1	2	6	5	24
Estate 3	974	16	3	7	3	2	1
Estate 4	811	27	3	3	4	9	8

Yields are estimated from bunch count numbers and estimated bunch weights now. With infield mechanisation and collection, prospects for development of infield weighing and electronic data transfers directly to computers to compute harvester and field productivity quickly each day are good. This will reduce supervisory problems besides eliminating bunch counters and tedious office work. This also raises the prospects of recording relatively small blocks of palms e.g. task sizes of 3 ha each accurately and easily all over the estate in future, if good uses can be made of the yield maps.

2.2 Yield Improvement. Poor yielding blocks can be examined to determine the causes e.g. using GIS with databases of field agronomic and management information and the technique of site yield analysis (Fig. 2) to partition possible contributions from agronomic and management constraints (Fig 3)

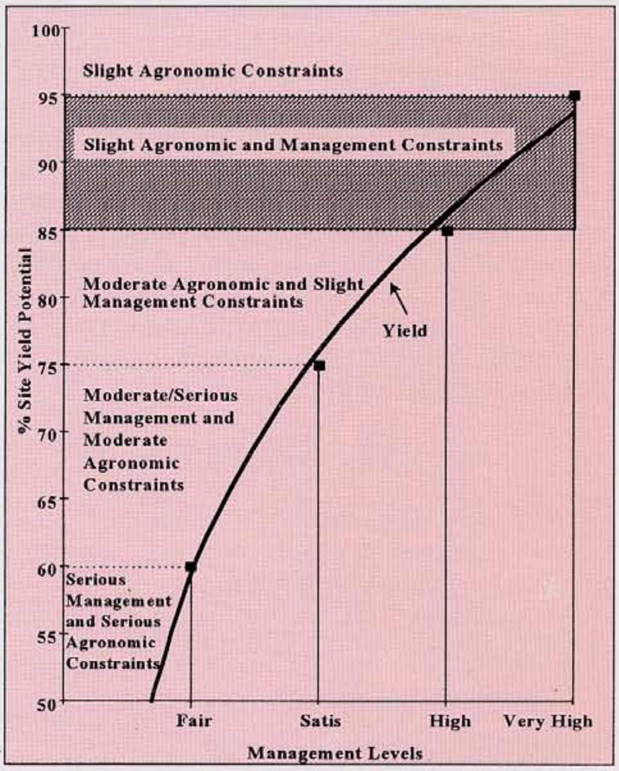


Figure 3 : Expected Oil Palm Yield Levels and Management Quality

At yields <60% SYP, basic management and agronomic practices e.g. crop recovery and fertilisation need to be checked. Between 60-70% SYP, management practices and agronomic constraints are probably still limiting while above 70% SYP, improved agronomic inputs including PPP may be required for raised yields. Improved quality of agronomic inputs is probably needed as yield levels are pushed beyond 85% SYP especially PPP.

2.2.1 Agro-management Practices. The main practices to improve yields can be grouped into 3 areas, in usual order of importance

1. Fertilisation
2. Agronomic practices such as planting density, ground covers, pruning and drainage
3. Pest and disease management including weeds

1. Fertilisation. The principal agronomic constraint to high productivity is usually inadequate soil nutrient supply. Fertilisation may cost between RM400 - 600 per ha per year, accounting for 60% of the annual operating budget. Wrong fertilisation techniques may result in high financial losses through loss of crop or excessive fertilisation and risks of high nutrient losses in run-off, leaching and other nutrient loss mechanisms.

Considerable R&D efforts on correct fertiliser usage showed different yield responses on different soil series and also within the same soil series e.g. Table 4.

Foster and Tarmizi (1988) analysed 5 trials with different yield responses on Rengam series and concluded that variations in yields in plots without fertiliser applications were due to palm age, annual rainfall, soil organic matter and soil extractable K differences (Table 5). Adjustments to fertiliser programmes taking these factors into account increased profits considerably. Further examples of variation in nutrient responses due to agronomic treatments and cropping history are in Chew and Pushparajah (1995).

Site-specific factors such as soil nutrient supply, cropping history and nutritional status of individual blocks are therefore important to prescribe nutrient requirements accurately. However there are often severe technical and practical difficulties in deciding on site characteristics and unit sizes.

1.1 Soil Variation. Most plantations organise by fields with similar planting materials, ages and practices which may vary from 10 to 100 ha sizes. These fields are usually marked out with land preparation and management considerations uppermost and often result in several soil types and terrain within fields.

In plantations with different landscapes and continuous soil changes, considerable variation may be expected in soil physical and chemical properties and behaviour. Interactions with the crop and cropping practices may also produce further variation e.g. surface wash in oil palm even on small areas of uniform terrain (Kee, pers. comm.). Nutrient run-off may also transport significant amounts of nutrients and moisture down slopes (Maene et al. 1979, Kee and Chew 1996).

TABLE 4. F.F.B. YIELD RESPONSES TO 1 KG AMMONIUM SULPHATE (A.S.) APPLIED PER PALM PER YEAR AND CORRESPONDING YIELD LEVELS AT NON-LIMITING RATES OF ALL OTHER FERTILISERS IN TRIALS ON SOME SEDENTARY SOILS. (adapted from Foster et al. 1985)

Trial	Soil	N1 Response (t ha^{-1} yr^{-1} FFB/kg $palm^{-1}$ yr^{-1} A.S.)	N1 Yield (t ha^{-1} yr^{-1} FFB)	N2 Response (t ha^{-1} yr^{-1} FFB/kg $palm^{-1}$ yr^{-1} A.S.)	N2 Yield (t ha^{-1} yr^{-1} FFB)	N3 Response (t ha^{-1} yr^{-1} FFB/kg $palm^{-1}$ yr^{-1} A.S.)	N3 Yield (t ha^{-1} yr^{-1} FFB)
45.1	Batu Anam	.53	28.06	.68	29.57		
45.2	Batu Anam	1.46	22.39	1.78	26.41		
46.1	Batu Anam	2.56	18.14	1.24	22.85		
46.2	Baru Anam	2.40	17.53	1.49	21.44		
23	Munchong	1.33	23.70	.47	24.60		
31	Munchong	1.02	30.4	.46	32.13	-.12	32.51
44.1	Munchong	-.65	27.59	-.75	25.40		
44.2	Munchong	.54	25.95	.43	27.09		
15.1	Rengam	1.38	25.03	.72	27.39	.07	28.28
15.2	Rengam	3.46	23.81	1.22	29.08		
21	Rengam	(-.88)	(23.04)	(-1.35)	(22.28)		
27	Rengam	1.92	24.31	.98	29.59		
32	Rengam	.78	26.49	.56	27.70	.07	28.27
33	Rengam	.82	27.19	.64	28.50	.47	29.50

TABLE 5. SUMMARY OF PREDICTED VARIATION IN FFB YIELDS AND FERTILISER REQUIREMENTS IN INDIVIDUAL TRIALS DUE TO DIFFERENCES IN SITE FACTORS (Foster and Tarmizi, 1988)

Trial No.	FFB yields (t ha^{-1} yr^{-1})			FFB Response(t ha^{-1} yr^{-1})		Fertilizer requirement (kg/palm/yr)	
	N0	K0	Optimum	N	K	A.S.	KC1
15.2	23.8 (higher age)	19.8 (lower O.M., higher T.E.B.)	28.7	4.9	8.9	5	8
27	23.2 (higher rain)	21.1 (lower O.M.)	29.1	5.9	8.0	7	7
32	26.6 (lower rain)	26.4 (higher O.M., higher extr. K)	27.1 (Steeper slope)	0.5	0.7	2	3
33	25.1	26.4 (higher O.M., lower T.E.B.)	29.1	4.0	2.7	5	5
71	26.3 (lower age)	23.6	28.8	2.5	5.2	2	7
(Mean)	(25.0)	(23.5)	(28.6)	(3.6)	(5.1)	(4.2)	(6)

N.B. O.M. = organic matter, T.E.B.= total exchangeable bases, extr. K = extractable K

Agronomists try to separate distinct soil and terrain types into 'manuring blocks' or 'correction areas' varying from 0.5 ha to 25 ha where possible to achieve 'uniform blocks' for different site-specific fertiliser applications and other agronomic practices. The success often rests on soil information available, accurate maps and management's capability to organise the work.

1.2 Soil Nutrient Variation. Soil nutrient contents vary considerably even within the same soil series (Law and Tan 1973, Ng and Ratnasingam 1970 for Peninsular Malaysia soils, Goh et al. 1994 for Sabah soils).

Ng and Ratnasingam (1970) showed large variation (Table 6 and Fig 4) for individual nutrients and soil types e.g. exchangeable K distribution in 11 ha of Selangor series, derived from marine alluvium and considered to be fairly homogenous by soil profile examination.

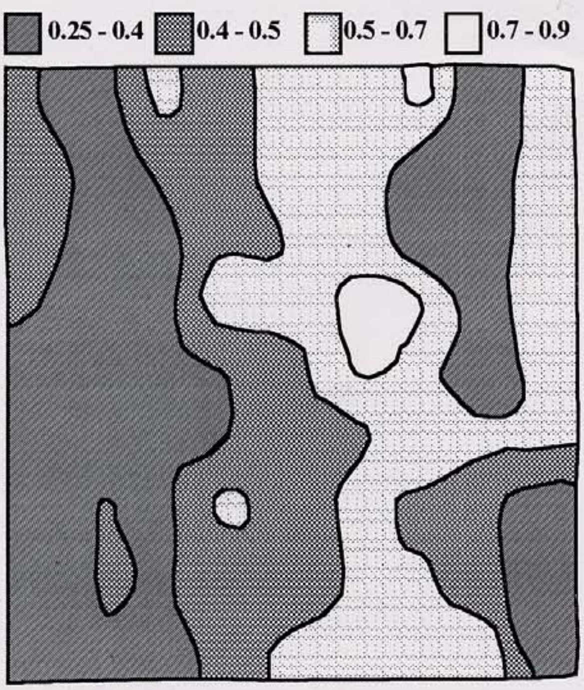


Fig.4. Distribution of exchangeable K values (m.e./100g.) in 27 acres oil palm field of Selangor Series Soil.(Ng and Ratnasingam, 1970)

TABLE 6. COEFFICIENTS OF VARIATION (C.V.%) OF MEANS OF NUTRIENT LEVELS IN THREE SOILS (adapted from Ng and Ratnasingam, 1970)

Analysis	Batu Anam	Prang	Selangor
pH	3.0	4.5	5.8
C	22.6	23.1	17.7
N	19.5	18.5	15.9
Acid fluoride P	54.4	68.0	46.6
Exch. K	30.1	18.2	13.7
Exch. Mg	37.7	33.0	17.7
Exch. Ca	89.9	29.6	12.6
6N HCl K	46.2	29.7	43.0
6N HCl Mg	26.5	23.6	16.9
6N HCl Ca	46.6	39.3	86.3
Total P	38.9	45.7	73.2
Avail. P	37.8	30.2	27.9

N.B. 3 core sample results

Soil variations were also seen from previous planting practices e.g. fertiliser application areas, frond placement and harvesters paths in the oil palm ecosystem (Kee et al. 1995, Goh et al. 1996) . Goh et al. (1996) found high spatial variability within microsites of palm circles, frond piles and inter-rows from previous fertilisation practices within single palm areas with resultant nutrient patches within 2m (the maximum distance between samples within sites) of each other (Table 7). Trends in fertilisation to mechanical spreaders and aerial application with widespread application and spreading of cut fronds in inter-rows may reduce nutrient variability within the palm areas.

1.3 Soil Physical Properties Variation. Nutrient availabililty and palm productivity may also be affected by soil physical properties which vary markedly e.g. soil moisture characteristics and water holding capacities within same soil series (Table 8)

TABLE 7. SCORE OF NUTRIENT PATCHES AROUND INDIVIDUAL OIL PALMS ON MUSANG SERIES SOIL (Goh et al. 1995)

Depth (cm)	Site	Treatment	
		N0K0	N2K2
0-15	Palm circle	8	12
	Interrow	8	6
	Frond heap	15	12
15-30	Palm circle	12	12
	Interrow	7	6
	Frond heap	11	12

Note: Maximum score of 15 for best soil fertility and minimum scoreof 5 for poorest soil fertility.

TABLE 8. RANGE AND AVERAGE AVAILABLE WATER HOLDING CAPACITY (0-90 cm) OF DIFFERENT SOIL SERIES AND SOIL GROUPS. (Foster et al. 1984)

Soil group	Soil series	Available water holding capacity (mm/m)	
		Range	**Mean**
1) Coarse grained acid-igneous and colluvium	Colluvium	94	94
	Rengam	72-122	101
	Overall:	**72-122**	**100±19**
2) Sedimentary	Munchong	99-122	111
	Serdang	124	124
	Durian	117-145	134
	Bungor	140	140
	Overall:	**99-145**	**127±36**
3) Estuarine and riverine alluvium	Carey	164	164
	Sedu	173	173
	Briah	160-204	178
	Sogomana	182	182
	Overall:	**160-204**	**175±16**
4) Marine alluvium	Kangkong	234	234
	Selangor	235-239	237
	Overall:	**234-239**	**236±3**
5) Organic	Peat	413	413

Monitoring of soil compaction (Mohktaruddin et al. 1993) from infield mechanisation could be essential in future to reduce the detrimental effects on palm productivity, perhaps with alternate path or resting systems which require spatial and temporal information.

1.4 Root Density and Activity Variation. Limited root studies indicate mature root spread of at least 2 palms away, i.e. approximately 0.10 ha area. Most of the roots are superficial and occur within 0.75 m depth but there is uneven distribution of the root mass and variation with soil types, fertiliser management and field practices (Chan, 1977). Little is known of the activity of the roots within different parts of the ecosystem but there are indications of different activity levels (Table 9). Studies on active root zone indicate that uptake of nutrients upto 30m (>3 palms away) by roots may be possible (Hussein and Zaharah, 1993).

TABLE 9: DIFFERENTIAL K UPTAKE BY OIL PALMS FROM VARIOUS MICROSITES ON RENGAM SERIES SOIL (Kee et al. 1993)

Microsite	Estimated K uptake (g plot^{-1})		
	6 months after treatment		Before treatment
	Manured	Unmanured	Unmanured
Palm circle	168	99	165
Harvesters' path	0	9	26
Interrow	144	9	-22
Frond heap	45	-35	56

1.5 Scale of Precision. The value of determining soil nutrient contents and physical properties at very detailed basis is therefore doubtful. Even if possible, variable nutrient distribution on per palm basis e.g. around the palms or all over the inter-rows has been shown to have little effect on yields (Teoh and Chew, 1985).

Fertilisation rates and techniques have been drawn up from studies on responses in 0.12 - 0.25 ha plots, and leaf analysis and soil analyses within the plots. From the earlier discussions, the scale for separation should be between 0.1 to about 5-10 ha. Other obvious separation levels should be terrain and drainage classes where the physical attributes are easily distinguished and agronomic significance is great.

The desirable scale for information therefore rests on the knowledge available and advantages possible, and management's ability to act. Conversely, uniform areas could be combined within estates which would facilitate some field operations e.g. aerial fertiliser applications or pest treatments. Uniform treatments across boundaries for adjoining estates of the same Company could also be feasible. The capability to handle the data collection and analysis requirements quickly is important in the whole system.

2. Agronomic Planting Practices. They usually affect productivity through effects on light capture and utilisation or effects on nutrient and water utilisation and efficiencies.

2.1 Monitoring and Census. Most results can be easily demarcated by visual means to take account of variation. Mapping by GPS, remote sensing or aerial photographs and transfer of information to GIS for corrective action quickly is possible.

2.2 Poor Growth Areas. Poor soil areas e.g. shallow soils or erosion prone areas may be separated through GPS and GIS or remote sensing for correction especially if no soil map is available or if these areas were too small to be mapped in the original survey.

These techniques are particularly useful to study drainage schemes in low-lying areas, in terms of intensity and pattern against requirements. Sugih et al.(1996) have demonstrated the usefulness of GIS in mapping flooding and water-table depths in low-lying estates.

3. Pest and Disease Management. Integrated pest management programmes practised now require pest monitoring by regular census, control measures with appropriate pesticide by appropriate application technology to infected areas only and follow-up as necessary. These are all greatly facilitated by the GPS and GIS technologies.

3.1 Monitoring and Census. The ability to survey affected areas quickly is a big advantage in P&D management. The common cause of lower yields is usually low leaf areas, either through loss of leaves to pests or palms to diseases which may be easily seen or demarcated with the new technologies to the individual palm level for treatment.

3.2 Temporal Data. GIS enables the study of the evolution of the pest outbreaks and other related data e.g. weeds present over time and space and evaluation of the various control strategies quickly. Besides defoliating pests, these are very useful for studies on Ganoderma outbreaks and spread of troublesome weeds.

From the quick survey, we therefore see that the main benefits are in reinforcing site-specific fertilisation techniques through better data and information available especially yield monitoring, trouble-shooting and solving agronomic problems on large scale at detailed levels as neccessary e.g. excessive light competition, drainage and P&D management.

AAR is using the new technologies to improve implementation of its integrated site-specific fertiliser recommendation system (Kee et al. 1994, Chew et al., 1995). The scale for PPP for fertilisation is based on the soil maps available. This PPP is complemented by the site yield analysis technique when yield gaps are large. These basic approaches together with implementation of appropriate agronomic practices in problem soil areas have served their purpose well todate as evident from the marked yield increases reported for overall areas (Fig. 5) and problem soil areas (Fig 6).

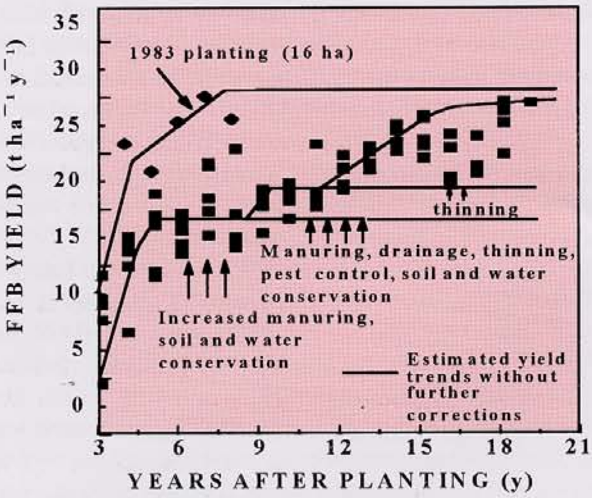
Increasing the Productivity of the Workers

A major cause of management problems is the size of areas to be maintained, harvested and supervised. The problems e.g. unpruned fronds, unharvested crop, or field neglect are usually obvious after an inspection. The important aspects here relate to

1. Quality of access i.e. location of roads and infield paths,

lengths of carry, slopes, and their conditions
2. Quality and quantity of man-power
3. Monitoring and supervisory aspects.

Almost all managers would identify their most pressing problem as shortage of workers. Although mechanisation appears the obvious solution, a holistic approach involving good planning, organisation, monitoring and feedback i.e. relating to the aspects discussed besides mechanising where possible, will be best overall. The capabilities of GIS and GPS in particular to provide detailed accurate information should be exploited.



Note : Based on 8757 ha in contiguous blocks planted between 1972 and 1976

Figure 5 : Maximising FFB yields in mature oil palm planting in Malaysia (adapted from, Goh K.J. *et al.* 1994)

1. Planning

The availability of accurate maps with details of terrain, soils, drainage and other important features enable optimal planning and location of
1. Main and field roads
2. Offices, stores and linesites
3. Ramps and mills
4. Nurseries
5. Field and Block boundaries

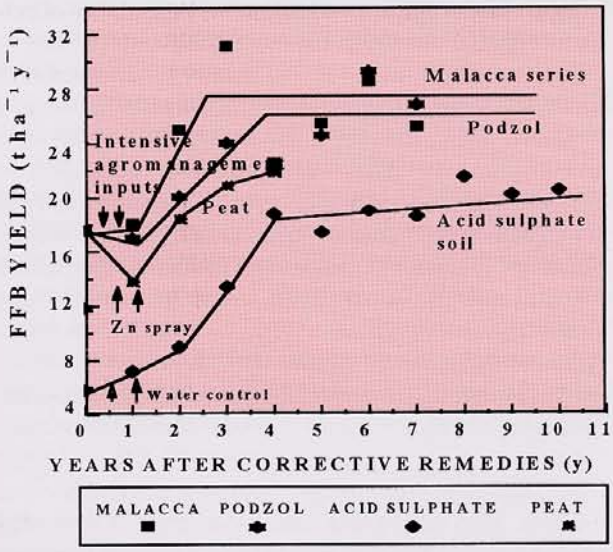
to minimise unproductive time on travelling and transporting produce. Existing estates may be replanned to improve the road layouts and field boundaries e.g. roads for mechanisation of infield collection of FFB with lower density, and for other mechanisation opportunities.

2. Organisation

The accurate data on each feature e.g. length of roads, drains, field areas allow good estimation of worker and material e.g. fertilisers and allocation for harvesting, FFB collection, maintenance and upkeep work. The workers' tasks can also be better defined and assessed. The GPS can pinpoint specific palms, objects e.g. culverts or areas which would save much time in traveling the shortest route.

3. Budgeting

With accurate information, there would be less disputes over budgets which are particularly important for maintenance of roads and drains which are sub-optimal frequently due to poor data. Improvements should ultimately lead to better productivity of the workers and also the fields.



1) After Poon and Bloomfield (1977)
2) After Gurmit et al. (1987)
3) Data for Malacca series and podzol soil from AAR's advisory estates

Figure 6 : Site-specific corrections of yield limitations in Malaysia (adapted from Goh K.J. *et al.* 1994)

4. Monitoring and Supervision

The days when managers are equipped with GPS units may not be far off. Progress reports, census and survey will be more accurate and less tedious. The other advantage is that the readings have actually to be taken i.e. the superviser (or an appointee) must have been there and this can be quickly double-checked by management without dispute.

GPS units may be mounted on company vehicles such as tractors and lorries especially those involved in transporting workers and materials with illuminating results. The greatest advantage may be for fertiliser spreaders and EFB mulching machines where complete coverage in the fields is essential.

Finally, the speed of available data for appropriate follow-up and action which may be critical e.g. P&D work is invaluable. Less time checking the data will be also required as due to the relative ease, the data collection is likely to be more reliable.

Implementation of 'Worker-Friendly' and 'Manager-Friendly' Practices

The performance of a plantation should be mainly in the hands of the manager through the consequences of his action and decisions made. The outstanding yield constraints nowadays are often management factors which result from inability to implement the required practices on time for various reasons including shortage of manpower and machine resources, materials. Occasionally budgetary or economic constraints are cited.

1. Worker-Friendly Practices.

The reduction of frustrating and tedious work, relief of burdensome work through greater mechanisation and possible reduction of waiting and travelling time to go home after work should result in a more productive and 'happy' labour force. In addition, the availability of better information for planning, monitoring and feedback of accomplishments and making decisions should result in better results and relations between managers, staff and workers.

2. Manager-Friendly Practices.

The removal of frustrating uncertainty of work accomplishment and tedious aspects of the jobs should result in improvement of morale of all the workers and staff and the manager. Better decisions and greater efficiency should also result from improved information on the plantation resulting in higher productivity all round.

2.1 Decision Support Systems (DSS). All the new advances and large amounts of data and information require computerisation and development of a DSS for Oil Palm Management (Goh et al. 1996) to manage and analyse the data. This involves a database of basic information and production factors for individual blocks of the plantations, production functions simulating the effects of changing inputs or key production factors, and expert systems to predict or simulate the results and impact on individual block and estate basis which may then be displayed spatially and over time. Economic models to calculate the impact on profitability may be included as well. The manager is thus empowered to take sound decisions for his estate, possibly only consulting his Planting and Agronomic advisers on the soundness of his decisions i.e. a development similar to that of the modern corn precision farmer in the USA (Dibb and Darst, 1996). The path to business-like decisions and improved budgeting and planning for programmes and reaction to changes will be opened. This situation will enable a more 'factory-like' approach for work operations and use of stocks etc., resulting in a better image and self-esteem for the managers and and higher profitability for the industry.

As online monitoring for all areas from HQ will be feasible in future, Planting Advisers and Agronomists will benefit more from the DSS and can return accountibility for performances to the managers which should result overall in improved performances and morale on the plantations. It also appears feasible to manage larger hectarages in future with the use of the new technologies with better control and monitoring of work and ultimately, with fewer people working on each plantation.

Discussions and Conclusions

The possibilities for better yield predictions and PPP implementation especially for site-specific fertiliser applications and problem soil improvement are much improved now with GPS/GIS technologies. However, major problems remain with knowledge of the critical factors and their effects on growth and yield as well as knowledge of important nutrient budget components in the oil palm systems to draw up realistic growth and yield models and nutrient balance sheets e.g. AAR agronomists are still advised to check against known fertiliser response functions to double-check simulated results from the models developed todate.

The new and exciting technologies available are likely to have greatest impact on management of the plantations immediately. Use of available GIS and GPS should result quickly in improved availability of information for planning, organisation, monitoring and supervision of work. This should contribute significantly with the use of existing PPP techniques to close the large yield gaps seen in the industry still.

Workers and staff should benefit from the better upkeep, maintenance, access and less tedious work. Managers should find it less frustrating with accurate information, objective techniques for evaluation and budgeting of planting practices. They will be better equipped to manage and overcome some of the problems faced now.. It is likely that with increased experience and need, further developments by management and researchers in utilisation of the new technologies will be made for the advancement of the plantations in future.

The most pressing application will be the integration of agronomic and management information in the establishment of a Decision Supporting System (DSS) for Oil Palm Management to assist in site-specific decision making to individual blocks. It is likely that as the results may be expressed in graphical spatial format and in what-if economic terms, the decision makers will be better able to appreciate the problems and make the correct decisions.

Success will however not be easily accomplished as many inter-disciplinary aspects and problems requiring cooperation and R&D between the researchers and management are involved. There are still major gaps in our agronomic knowledge of oil palm and its responses to important production inputs with many problems of gathering the necessary data and analysis to develop robust models for simulation of effects and responses. There are also still a few technical problems in the uses of the GPS systems especially in old palm and in between high hills and GIS mapping which are not yet fully resolved.

Overall, this talk has enabled us to refocus on our agronomic achievements or otherwise in terms of satisfactory quantification and understanding of the important processes occurring in the oil palm ecosystem. Sadly, many areas remain lacking still for the new objectives of DSS and possible new PPP to improve agro-management practices and productivity.

Finally, this talk will have served its purpose if it makes our agronomists and R&D Directors think again if they think they already know enough about the oil palm. Good agro-management remains vital to exploit the high quality planting materials in the pipe-line from our massive investments in breeding and biotechnology R&D.

Acknowledgements

This talk outlines some of the R&D developments which are ongoing at AAR, for which I must acknowledge the far-sightedness and wisdom of our Directors at AAR and Principals, Messrs Boustead Holdings Bhd and Kuala Lumpur Kepong Bhd. A large part of the talk has come from discussions with Dr.Kee K.K., our Oil Palm Section Leader, Mr.Goh K.J. our DSS project team leader, other team members, Mr.Tey S.H. GIS/GPS specialist, Mr.Heng Y.C. analyst/ programmer and Ms.Gan H.H. biomathematician; Dr. Soh A.C. and my other colleagues at AAR, past and present. I must also acknowledge the ideas and contributions by our colleagues in management and R&D in the Industry and also Dr. P. B. Tinker who has stimulated us with ideas for the projects.

References

Chan, K.W. (1977). A rapid method for studying the root distribution of oil palm and its application. Malaysian International Agricultural Oil Palm Confer ence.

Chew, P.S.; Kee, K.K.; Goh, K.J.; Quah, Y.T. and Tey S.H. (1995). An integrated fertiliser management system for oil palms. IFA - Fadinap Regional Conference for Asia and the Pacific.

Chew, P.S. and Pushparajah E. (1995). Nitrogen Management and fertilisation of tropical plantation tree crops. In Nitrogen fertilisation in the Environment (ed. P.E. Bacon) Marcel Dekker New York: 225-293.

Corley, R.H.V., Hew, C.K., Tam, T.K. and Lo K.K. (1973). Optimal spacing for oil palms. In Advances in Oil Palm Cultivation, (ed. R.L. Wastie and D.A. Earp). Incorporated Society of Planters. Kuala Lumpur : 52-71.

Dibb, D.W. and Darst, B.C. (1996). Nutrient utilisation : Balanced nutrition for crop plants and people. The Planter : Vol. 72 No. 847, October 1996 : 550-566.

Foster, H.L., M. Zaki Ghazalli and Mohd Tayeb Hj. Dolmat (1984). The available water holding capacity of oil palm soils in Malaysia. PORIM Bull. Palm Oil Res. Inst. Malaysia No. 8 : 1-9.

Foster, H.L., Chang, K.C., Mohd Teyeb Hj. Dolmat, Ahmad Tarmizi Mohammed and Zin Z. Zakaria (1985). Oil palm yield responses to N and K fertilizers in different environments in Peninsular Malaysia. PORIM Occasional Paper No. 16 Palm Oil Res. Inst. Malaysia No. 8 : 1-23.

Foster, H.L. and Ahmad Tarmizi Mohammed (1988). Variation in the fertiliser requirements of oil palm in Peninsular Malaysia. I. Within the same soil series. PORIM Bull. Palm Oil Res. Inst. Malaysia No. 16 : 1-9.

Goh, K.J., Kee, K.K. and Chew, P.S. (1993). Soil fertility of some common soils in Sabah, Malaysia. Soil Science Conference of Malaysia. Malaysian Society of Soil Science,

Goh, K.J., Chew, P.S. and Teo, C.B. (1994). Maximising and maintaining oil palm yields on commercial scale in Malaysia. In : ISP Planters' Conference on Managing Oil Palms for Enhanced Profitability (ed. Chee K.H.). ISP: Kuala Lumpur: 121-141.

Goh, K.J., Chew, P.S. and Kee, K.K. (1996). Spatial Soil fertility in mature oil palm agroecosytem and its implications on fertiliser management. MSSS Annual Conference 1995, Malaysian Soil Science Society, Langkawi.

Goh, K.J., Chew, P.S., Heng, Y.C. and Tey, S.H. (1997). Decision support system for oil palm plantations. Proc. AAR Seminar/Field Day at KDC and Segaria Estate, Tawau : 33-44.

Goh, K.J., Chew, P.S. and Gan, H.H. (1997). Quantitative land evaluation for sustainability of oil palm plantations. Paper submitted to 1997 International Planters Conference on Plantation Management for the 21st Century. Incorporated Society of Planters, Kuala Lumpur.

Guha, A. and Guha, J. (1997). Design of a plantation agriculture expert system for oil palm. Paper submitted to 1997 International Planters Conference on Plantation Management for the 21st Century. Incorporated Society of Planters, Kuala Lumpur.

Hussein, M.Y. and Zaharah A.R. (1993). Management of the oil palm agroecosystem with special reference to pollination and fertiliser application. PORIM International Palm Oil Conference - Agriculture (Mod ule 1): 524-528.

Kee, K.K., Goh K.J. and Chew P.S. (1995). Effects of NK fertiliser on soil pH and exchangeable K status on acid soils in an oil palm plantation in Malaysia. In: 3rd International Symposium Plant - Soil Inter actions at low soil pH. Brisbane, Australia : 809-815.

Kee, K.K., Goh, K.J., Chew, P.S. and Tey, S.H. (1994). Integrated Site-specific fertiliser recommendation system (INFERS) for high productivity in mature oil palms. In : ISP Planters' Conference on Managing Oil Palms for Enhanced Profitability (ed. Chee K.H.). ISP: Kuala Lumpur: 83-100.

Kee, K.K. and Chew, P.S. (1996). Nutrient losses through surface run-off and soil erosion - implications for improved fertiliser efficiency in mature oil palms. Proc. 1996 PORIM International Palm Oil Congress - Competitiveness for the 21st century : 153-169.

Ludlow, A.R. (1993). Modelling as a tool for oil palm research. 1991 PORIM International Palm Oil Conference - Agriculture (Module 1): 273-289.

Lukman, F.M. and Poeloangan, Z. (1996). Application of Remote Sensing technique for oil palm plantation management. 1997 PORIM International Palm Oil Congress "Competitiveness for the 21st Century" : 460-467.

Maene, L.M., Thong K.C., Ong T.S. and Mokhtaruddin A.M. (1979). Surface wash under mature oil palm. Proc. Symposium on water in agriculture in Malaysia. MSSS, Kuala Lumpur : 203-216.

Mokhtaruddin, A.M., Teo, L., Ong, K.P. and Zainurah, A. (1993). Inter-row compaction due to mechanisation in mature oil palm. In. Proc. Soil Science Conf. of Malaysia 1992 (eds. Aziz, A. and Ahmad A.R.) MSSS, Kuala Lumpur : 116-126.

Ng, S.K. (1983). Advances in oil palm nutrition, agronomy and productivity in Malaysia. PORIM Occasional Paper No. 12, Kuala Lumpur : Palm Oil Research Institute of Malaysia.

Ng, S.K. and Selvadurai, K. (1967). Scope of using detailed soil maps in the planting industry in Malaysia. Malaysian Agricultural Journal 46:158-163.

Ng, S.K. and Thamboo, S. (1968). Nutrient costs of oil palms in Malaya. I. Nutrients required for reproduction. Fruit bunches and male inflorescences. - Malaysian Agricultural Journal 46.1 :3-45.

Ng, S.K., Tamboo, S. and de Sousa, P. (1968). Nutrient contents of oil palms in Malaya. II Nutrients in vegetative tissues. Malaysian Agricultural Journal 46.3 : 332-391.

Ng, S. K. and Ratnasingam, K. (1970). Soil heterogeneity and field sampling for chemical analysis of Malaysian soils. Paper 40. In First ASEAN Soils Conference, Bangkok, Thailand.

Sugih, W., Achmad Fathoni, Budiono Rakhmad, I.B. Mayun and Heru Setyobudi (1996). Contribution of Geographic Information Systems on oil palm plantation management. ISOPA/IOPRI Seminar on Agronomic update in oil palm management : 13-22.

Tey, S.H. and Chew, P.S. (1997). GIS and GPS technologies for management and research in plantation crops. Paper submitted to 1997 International Planters Conference on Plantation Management for the 21st Century. Incorporated Society of Planters, Kuala Lumpur.

Teoh, K.C. and Chew, P.S. (1985). Investigations on areas and frequencies of fertiliser application in mature oil palm. Proc. International Conference on Soils and Nutrition of Perennial Crops (Bachik, A.T. and Pushparajah, E., ed.). The Malaysian Society of Soil Science, Kuala Lumpur: 375-387.

Tarmizi, A., Zin, Z.Z., Mohd Tayeb Dolmat, Foster, H.L., Hamdon, A.B. and Khalid, H. (1993). Relative efficiency of urea to sulphate of ammonia in oil palm : Yield response and environmental factors. International Oil Palm Conference, Kuala Lumpur : 340-348.

Tinker, P.B. 1984. Site specific yield potentials in relation to fertilizer use. Nutrient balances and fertiliser needs in Temperate Agriculture.Proc. 8th Colloquium International Potash Institute, Gardone -Riviera, Italy :

SOCIAL AND PERSONAL

Staff Recruitment/Promotion

Name	Date joined	Section	Designation
Zulkifli Bin Zakaria	18/2/97	Chem. Lab.	Tech IV
Shabry Bin Ahmad	17/2/97	Chem. Lab.	Tech IV
Mohd Rahisam Bin Che Mud	1/3/97	Field Section	RA IV (Promoted from Recorder)
Zurinawati Bt. Awang Saad	1/4/97	Accounts	Clerk III
Mohd Nordin Bin Husin	3/5/97	Field Section	RA III

Congratulations to :-

Masitta Bt. Ramli (T/Culture) - Birth to a baby boy Mohd Faez B. Mohd Jafri on 1/2/97.

Aminah Bt. Othman - Birth to a baby boy Mohd Amir Firdaus B. Rahim on 15/3/97.

Norlela Bt. Nordin - Birth to a baby girl Nur Amanina Farahain on 9/3/97.

Sahalawati Bt. Mohd Rapiai - Married to Mohd Nazib B. Bharum on 10/5/97.

- **Mr. Periasamy Arunasalam** on his promotion to Oil Palm Seed Production Manager on 1-1-97. Samy was born in 1948 and joined HRU in 1969 after completing his Senior Cambridge. He is now based at AAR Sg. Buloh oil palm seed production unit.

Periasamy Arunasalam

Joyce Chong

- **Madam Joyce Chong Siew Peng** on her promotion to Tissue Culture Lab. Manager on 1-1-97. Joyce joined Highlands Research Unit (HRU) in Jan'83 as a pioneer Tissue Culture Lab. Assistant and contributed much to the development of the oil palm tissue culture at AAR. Prior to joining HRU, she worked with USM as a research assistant and was involved in research project on fractionation of palm oil and extraction of beta-carotenes.

Chen, K.C.

AAR KDC SUB-STATION SPORTS CLUB CROSS-COUNTRY RUN AND ANNUAL DINNER

AAR KDC sub-station Sports Club held its inaugural cross-country run on the 2nd January 1997. Forty eight participants from KDC Head Office, Pang Burong, Sri Kunak and Sigalong I estates, KDC Laboratory and AAR staff and workers took part in the event which was divided into 3 categories i.e. Men's Junior (below 35 years), Men's Senior (above 35 years) and Ladies. The winners were:-

Men's Junior -	1st -	Darwis Mohd Ali	(Sri Kunak)
	2nd -	Alkan	(AARSB)
	3rd -	Gerard Gansupit	(Sri Kunak)
Men's Senior -	1st -	Sahibul Kadim	(Pang Burong)
	2nd -	Teh Sar Moh Nee	(KDC Head Office)
	3rd -	Robert Kimin	(Sri Kunak)

All the lady participants were given a souvenir each. We wish to thank all participants for making this event a memorable one. We wish to make this event an annual affair and hope to invite all AAR advisory estates in the Tawau region to participate next year.

Subsequently, a dinner was held on the 18th January 1997 at AAR sub-station office at Sri Kunak estate. AAR staff, workers and executives from Sri Kunak estate had an enjoyable evening. Barbequed chicken and fish, the main menu of the evening were prepared by AAR workers. The evening also saw the hidden talents of some AAR workers in 'karaokeing'. The evening's highlight was the presentation of long service award to our Research Assistant, En. Bacho Ambo Suppe who has been with us for 10 years. The award was presented to him by Goh Kah Joo on behalf of our Head of Agricultural Research.

TEO, C.B.

Bacho receiving his 10 years long service award from Goh Kah Joo

Teh Sar Moh Nee at AAR KDC substation cross-country run.

Fertilizer application with tractor mounted fertilizer spreader and crane to handle the fertilizers in 500 kg bags on Bebar Estate

Emdek Turbo Spin (600-800 kg capacity) spreading granular ammonium nitrate covering 4 rows of oil palms in one pass.

Potential benefits :

1) *Ten-fold improvement in worker productivity*
2) *50% reduction in application cost*
3) *Minimises fertilizer spillage*
4) *Timely and improved placement of fertilizers leading to better results*

Emdek E-Z lift and fertilizer in 500 kg bag facilitates fertilizer handling and minimises spillage

Emdek Mini Turbo Spin (300 kg capacity) mounted on mini-tractor for use on terraces and areas inaccessible to the big tractors. The spreader can be adjusted to apply fertilizers either to the left, right, both sides (as shown) or to the rear of the spreader. (Photo taken elsewhere)

Ooi, L.H.