Introduction

• Malaysian average CPO yields have been reported to be stagnating despite introduction of high yielding planting materials.

• Many reasons had been cited for such situations;
  • inadequate nutrient inputs
  • new plantings on marginal soils
  • general age profile of palms etc.,

• Oil palm nutrient management is crucial in sustaining high yields.

• Fertilisers are the most expensive cost element in FFB production.

• Current labour shortage causes disruption in completing annual manuring programmes and other agricultural activities.
Manuring: 59%
Weeding: 14%
Pest and Disease: 6%
Pruning: 7%
Upkeeps of Roads, Drains etc: 8%
Others: 6%

Harvesting, Collection and Transport: 38%
Processing: 11%
Manuring: 30%
Others: 3%
Upkeeps of Roads, Drains etc: 4%
Pruning: 4%
Pest and Disease: 3%
Weeding: 7%

Field Upkeep Cost
CPO Production Cost

UPB, 2016
Percentage Increase in Fertiliser Prices

- Urea
- MOP
- RP
- Ks
PRINCIPLE OF USING

1. Right source
2. Right time
3. Right place
4. Right rate
Fertiliser Sources

• Choice of fertilisers: cost per tonne of nutrient
• Focus was on sources of N
• Early studies had suggested use of AS for inland soils and urea for alluvial soils
• Urea found to be as efficient as other sources of N if applied under correct conditions
• Choice of fertilisers should also take into account its effects on soil quality parameters
## Fertiliser Sources

<table>
<thead>
<tr>
<th>Treatment</th>
<th>FFB yields (t ha(^{-1}))</th>
<th>Bunch Number</th>
<th>Average Bunch Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea (46%N)</td>
<td>28.8</td>
<td>17.6</td>
<td>12.0</td>
</tr>
<tr>
<td>Ammonium Sulphate (21%N)</td>
<td>28.4</td>
<td>17.0</td>
<td>12.3</td>
</tr>
<tr>
<td>Ammonium Nitrate (34.5% N)</td>
<td>27.9</td>
<td>16.6</td>
<td>12.5</td>
</tr>
</tbody>
</table>
## Effects on Soil pH

<table>
<thead>
<tr>
<th>Treatment / Depth</th>
<th>0 – 15 cm 2010</th>
<th>0 – 15 cm 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>4.5</td>
<td>4.1</td>
</tr>
<tr>
<td>Ammonium Sulphate</td>
<td>4.4</td>
<td>3.8</td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>4.5</td>
<td>4.1</td>
</tr>
</tbody>
</table>
Phosphorus Sources

- Phosphate rock was the preferred choice since the 1930s
- Various sources of PR had been evaluated under nursery and field conditions
- Reactive rock phosphate rocks had been preferred compared to natural PR for oil palm
- Use of MAP and TSP is gaining popularity especially in correcting P deficiency on marginal soils

(Foster et al., 1988; Ng, 1986; Goh, 1994; Foong, 1993; Zaharah, 1997).
Fertiliser Placement

- Ensure the applied fertilisers hit the target area within the rooting zone.

- Many methods of fertiliser application:
  - General broadcast
  - Sub-soiling
  - Palm circle only
  - Frond heaps
  - Burial / pocketing

- Goh and Foster (1975) had suggested broadcast application of fertilisers encourages wider growth of feeder roots and hence better nutrient uptake.

- Soon and Hoong (2002) compared burial application vs. general broadcast; broadcast application of fertilisers had significantly higher FFB yields compared to the burial method.
Broadcasting vs Burial using compound NPK fertilizer

Modified from Zakaria et al. 2006
Placement of fertilisers

- Apply fertilisers in areas with maximum feeder root distribution to ensure good nutrient uptake. Varies according to palm age.
- Young palms
  - spread fertilisers evenly over the weeded circle close to the palm base and gradually extend as the palms grows.
  - Advisable to verify the extent of rooting zone by superficial raking.
- As the palm matures, fertiliser application is up to the drip circle.
- In hilly terraced areas with mature palms, fertilisers should be broadcast in the terrace itself and between the palms.
- In areas with platform and mounds, the fertilisers should be placed around the palms.
Fertiliser Placement

**IMMATURE**
- **0 – 3 months**: 0.2m
- **4 – 6 months**: 0.3 – 0.6 m, 0.15m
- **7 – 12 months**: 0.5 – 1.0 m, 0.3 m
- **13 – 24 months**: 0.5 – 1.5 m, 0.3 m

**MATURE**
- **0 – 3 months**: 0.2m
- **4 – 6 months**: 0.3 – 0.6 m, 0.15m
- **7 – 12 months**: 0.5 – 1.0 m, 0.3 m
- **13 – 24 months**: 0.5 – 2.0 m, 0.9 m
Application Timing

• Ensure maximum uptake of nutrients take place with minimal nutrient losses

• Most fertilisers applied on a slope are washed off within few rainfall events after application.

• As a guideline, fertiliser application should be avoided in the following circumstances:-
  • Period with high rainfalls exceeding 250 mm a month or low rainfall below 20 mm a month
  • Months with rainy days exceeding 15 rainy days a month or high rainfall intensity exceeding 25mm per day (especially the monsoon season)
  • Periods where soil is saturated with water.
• Take into consideration the synergistic and antagonistic effects of fertilisers
  • Nitrogen and potassium fertiliser application should be at shorter gaps to enhance uptake
  • Liming and urea application to be sufficiently separated
Based on 25 year records of rainfall from 1975 to 1999, the best months for fertiliser application for one of UPB’s estate: -

i. 1\textsuperscript{st} quarter : January

ii. 2\textsuperscript{nd} quarter : June

iii. 3\textsuperscript{rd} quarter : July and August

iv. 4\textsuperscript{th} quarter : December though not desirable
Optimum Fertiliser Rate

• To supply each palm with adequate nutrients in a balanced proportion
• To apply fertilisers in a prescribed manner for efficient nutrient uptake
• Integrate use of mineral fertilisers with palm residues
• To minimize the negative environmental impact due to over fertilisation
• Very much depends on the agronomist to recommend the right fertiliser rates to meet the oil palm nutrient requirement.

• Involves an understanding of:
  • Oil Palm nutrient demand
  • Oil Palm response to fertiliser inputs
  • Fertiliser recommendation systems
Nutrient Demand

• Four main categories
  • Nutrients for vegetative growth
  • Nutrients removed from the system entirely, exported in the fruit bunches harvested and taken away.
  • All nutrients recycled or added to the soil reserves by, for example, leaf litter and male inflorescences.
  • Nutrients lost by leaching, erosion, run-off and volatilisation (as ammonium-N for urea)

Khalid et al., 2011; Tinker 1976
Nutrient uptake of oil palm up to 10 years from planting

Source: Ng (1977)

Source: Ng (1977)
<table>
<thead>
<tr>
<th>Source</th>
<th>Age</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Mg</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarmizi et. al, 2006</td>
<td>9 - 12</td>
<td>97.6</td>
<td>10.0</td>
<td>105.4</td>
<td>18.2</td>
<td>nd</td>
</tr>
<tr>
<td>Hensen, 1999</td>
<td>-</td>
<td>114.10</td>
<td>14.70</td>
<td>149.10(10 years)</td>
<td>33.30</td>
<td>32.30</td>
</tr>
<tr>
<td>Patrick, et al., 1999</td>
<td>-</td>
<td>162.50</td>
<td>21.59</td>
<td>279.20(15 years)</td>
<td>nd</td>
<td>49.10</td>
</tr>
<tr>
<td>Pushparajah and Chew, 1998</td>
<td>-</td>
<td>192.20</td>
<td>26.00</td>
<td>251.00</td>
<td>89.00</td>
<td>61.00</td>
</tr>
<tr>
<td>Ng, S.K., 1977</td>
<td>-</td>
<td>192.5</td>
<td>26.00</td>
<td>251.50</td>
<td>nd</td>
<td>61.3</td>
</tr>
<tr>
<td>Tan, 1976</td>
<td>0-3 years</td>
<td>40</td>
<td>6</td>
<td>55</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Tan, 1977</td>
<td>3-9 years</td>
<td>191-267</td>
<td>32-42</td>
<td>287-387</td>
<td>48-67</td>
<td>85-114</td>
</tr>
</tbody>
</table>
Nutrient Responses

• Nitrogen inputs have shown the most significant responses to yields up to recent times in most environments.

• Maximum yield expression with N inputs was noted when inputs of P, K and Mg fertilisers are adequate.

• Full response for P fertiliser inputs on both coastal and sedimentary soils were only noted when N inputs are adequate. (Foster et al. 1988)

• Significant responses to K fertilisers were generally noted on less fertile soils such as in riverine and sedentary soils.
Nutrient Response – Marine Alluvial

Nitrogen

- 0-1-2
- 1-1-2
- 2-1-2

Phosphorus

- 2-0-2
- 2-1-2
- 2-2-2

Potassium

- 2-1-0
- 2-1-1
- 2-1-2
Nutrient Response – Riverine Alluvial

Nitrogen

Nitrogen levels show an increasing trend with age, peaking around palm age 9-10 years.

- NO (red): Moderate increase
- N1 (orange): Steady increase
- N2 (purple): Peak around age 8
- N3 (teal): Steady increase

Potassium

Potassium levels exhibit a fluctuating trend with age, with peaks around palm age 6-9 years.

- K0 (red): Steady decrease
- K1 (orange): Moderate increase
- K2 (purple): Fluctuating pattern
- K3 (teal): Steady increase

Magnesium

Magnesium levels display a gradual increase with age, peaking around palm age 9 years.

- Mg0 (red): Steady increase
- Mg1 (orange): Steady increase
- Mg2 (teal): Steady increase
# Yield Improvements with Fertilisers

<table>
<thead>
<tr>
<th>Soil Type/ Nutrient</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Briah Series</td>
<td>73</td>
<td>6.7</td>
<td>7.2</td>
<td>-</td>
</tr>
<tr>
<td>Banar Series</td>
<td>7</td>
<td>-</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Peat</td>
<td>-2</td>
<td>22.1</td>
<td>7.8</td>
<td>-</td>
</tr>
</tbody>
</table>

Percentage FFB yield gain (%)
Fertiliser Recommendation Systems

• Soil Analysis and Site Properties
• Foliar Analysis and Nutrient Ratios
  • Foster’s System
  • French System (CIRAD)
• Integrated System
  • MPOB OPENS System
  • INFERS (AAR)
Factors to consider

- Forms and types of fertilisers to be used for the fields
- Understanding of the soil types involved
- Understanding of potential nutrient losses involved
- Individual field assessment to understand site characteristics
- Knowledge of agronomic and management practices
- Current year weather pattern
- Replanting schedules
- Age of palms
- Past yield records
- Past foliar nutrient status
## Critical levels of N, P and K

<table>
<thead>
<tr>
<th>Optimum Levels</th>
<th>Deficient Levels</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>P</td>
<td>K</td>
</tr>
<tr>
<td>2.6 – 2.7</td>
<td>0.16-0.17</td>
<td>1.1 – 1.2</td>
</tr>
<tr>
<td>2.9 – 3.0</td>
<td>0.18 – 0.19</td>
<td>1.1 – 1.2</td>
</tr>
<tr>
<td>2.6 – 2.7</td>
<td>0.17 – 0.18</td>
<td>0.9 – 1.1</td>
</tr>
<tr>
<td>2.6 – 2.9</td>
<td>0.16 – 0.19</td>
<td>1.1 – 1.3</td>
</tr>
<tr>
<td>2.4 – 2.8</td>
<td>0.15 – 0.18</td>
<td>0.9 – 1.2</td>
</tr>
<tr>
<td>2.5 – 3.0</td>
<td>0.15 – 0.19</td>
<td>0.9 – 1.3</td>
</tr>
<tr>
<td></td>
<td>1.3 – 1.6</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>0.15 – 0.19</td>
<td>0.9 – 1.3</td>
</tr>
<tr>
<td>2.3</td>
<td>(&gt; 6 YAP)</td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>(&lt; 6 YAP)</td>
<td></td>
</tr>
</tbody>
</table>
18 - 20 years: generally minimal response to fertiliser increase, use maintenance dosage
21 – 23 years: yields dropping, 50% fertiliser rate
>23 years: no fertiliser recommendation
Micronutrient Deficiencies

3 and 4th generation planting have higher B requirements especially on marginal soils. Rates above 150g B48 are currently required to meet B demands of mature oil palms.
Iron deficiency
## General N Inputs in UPB

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>kg N palm(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inland</td>
<td>1.0 – 1.4</td>
</tr>
<tr>
<td>Coastal</td>
<td>0.8 – 1.2</td>
</tr>
<tr>
<td>Deep Peat</td>
<td>0.4 – 0.6</td>
</tr>
</tbody>
</table>
MANAGEMENT OF ACID SULPHATE SOILS

- **Water Management**
  - Maintain water table at 45 cm to 60 cm.
  - Periodic flushing of drains to remove accumulated toxic polyvalent ions ($A1^{3+}$) and extremely acidic water.

- EFB mulching to encourage rooting.

- Use of acid ameliorant fertilisers e.g. Bunch Ash.

- Higher rates of phosphorus and magnesium fertilizers.
MANAGEMENT STRATEGIES FOR OXISOLS

• Avoid moisture stress periods for planting of oil palm, cover crop and fertiliser application.

• Large hole plantings.

• Split application of fertilisers.

• Requires higher rates of phosphorus fertiliser application.

• Use of EFB
MANAGEMENT OF SANDY SOILS

- Mulching with EFB.
- Higher frequency of fertilizer application.
- Higher rock phosphate to ensure good root development.
- GML applied to build up the soil Mg status and prevent Mg deficiency.
- Good ground vegetation.
- Shallow scupper drains to remove stagnant water in podzols.
MANAGEMENT OF PEAT SOILS

- Water management. Water level at 50 – 75 cm from surface at most times.
- Good ground vegetation.
- Good manuring programme.
- Mechanical compaction.
MANAGEMENT OF SKELETAL SOILS

• Maintain good ground vegetation.
• Terraces must have sufficient back-slope and regular stops.
• Appropriate stacking of fronds.
• EFB mulching.
• Large planting hole.
MANAGEMENT OF SKELETAL SOILS

Irrigation?
A rationally high well balanced fertilizer programme.
Application of high rock phosphate in lateritic soils.
MANAGEMENT OF STEEP TERRAIN

- Most important to carry out a soil suitability assessment.
- Ensure cover crops are established.
- EFB mulching.
- Stack oil palm fronds around the palms or along the interrow for terrace edges to minimize runoff and soil erosion.
MANAGEMENT OF STEEP TERRAIN

- Apply correct (types and amounts) of fertilizers.
- Inspect the terraces, roads, roadcuts regularly for evidences of soil erosion and take quick remedial action.
- Carry out selective thinning to allow better sunlight.
- Ensure crop harvested is evacuated.
Effects of Fertiliser Yield Variations

FFB MEAN CV (OVER REPS)

YEAR

FFB

15.0
20.0
25.0
30.0
35.0
40.0
45.0

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

0-0-0
2-1-2
Relationship of %CV and Yield

\[ y = 0.0174x^2 - 1.121x + 39.872 \]

\[ R^2 = 0.59 \]
$y = 0.1922x^2 - 15.804x + 501.89$

$R^2 = 0.6407$
### YIELD DIFFERENCE BETWEEN 2\textsuperscript{ND} AND 1\textsuperscript{ST} GENERATION

<table>
<thead>
<tr>
<th>JENDARATA</th>
<th>YR1</th>
<th>YR2</th>
<th>YR3</th>
<th>YR4</th>
<th>YR5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons/Ha</td>
<td>+7.6</td>
<td>+6.8</td>
<td>5.1</td>
<td>4.5</td>
<td>3.8</td>
</tr>
<tr>
<td>%</td>
<td>69.6</td>
<td>37.8</td>
<td>23.0</td>
<td>17.8</td>
<td>14.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>YR6</th>
<th>YR7</th>
<th>YR8</th>
<th>YR9</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons/Ha</td>
<td>3.5</td>
<td>1.4</td>
<td>3.2</td>
<td>0.2</td>
<td>4.0</td>
</tr>
<tr>
<td>%</td>
<td>13.1</td>
<td>5.2</td>
<td>12.5</td>
<td>0.6</td>
<td>21.5</td>
</tr>
</tbody>
</table>
Template for Yield Parameters

FFB Yields

kg FFB ha⁻¹

Year of Harvest

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Template for Yield Parameters

Average Bunch Weight

Year Of Harvest
<table>
<thead>
<tr>
<th>Age in Years</th>
<th>Prime</th>
<th>Good</th>
<th>Moderate</th>
<th>Acid sulphate soils, peat overlying acid sulphate, sedentary soils with impediments and others</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 - 3.0</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>3.0 - 4.0</td>
<td>23</td>
<td>22</td>
<td>21</td>
<td>20</td>
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<td>4.0 - 5.0</td>
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<td>29</td>
<td>27</td>
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<td>5.0 - 6.0</td>
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<td>7.0 - 8.0</td>
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<td>8.0 - 9.0</td>
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<tr>
<td>&gt; 25</td>
<td>22</td>
<td>21</td>
<td>20</td>
<td>18</td>
</tr>
</tbody>
</table>

**Soil Series**

- Briah Selangor Jawa
- Sabrang Cherang Hangus Sogomana Tepus Chempaka
- Gugut Holyrood Lunas Segari Bungor Serdang Erong Gondang Gali Lubok Klat Rengam
- Linau Sedu Penor Bayas Nipis Rudua Binjai Baging Sejacob Batu Lapan Seremban Colluvial Deposits
*UPB-PTSSS (Indonesia) yields included since 2011
Conclusion

- Important to understand nutrient demand, responses and fertiliser recommendations of oil palm for sound nutrient management.
- Planters and agronomists share equal responsibility
- Issues of soil and environment quality should also be considered in addition to economic benefits
- Yields above 35 t FFB ha\(^{-1}\) is possible in most environments with proper nutrient management