Nutrient Use Efficiency (NUE) of Oil Palm

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Agriculture, Biotechnology and Sustainability (ABS) Conference
MPOB International Palm Oil Congress (PIPOC)
Kuala Lumpur, Malaysia
November 14-16, 2017
IPNI Southeast Asia Program

1. Why NUE Matters
2. Examples of NUE in Oil Palm
3. Generating NUE Indicators
Why NUE Matters
Contribution of Nutrition to Yield Formation

1951 – 1.3 t/ha
1991 – 5.4 t/ha

- Improved nutrition: 30%
- Improved genotype: 9%
- Improved milling: 10%
- Improved management: 51%

Source:
Analysis of Improvement in CPO yield (t/ha) 1951-1991 at Pamol Estate, Kluang (Davidson, 1993)
Contribution of Nutrition to Yield Formation

Coastal inceptisol  Inland ALL  Inland inceptisol  Inland oxisol  Inland ultisol  Inland colluvium

Maximum Yield Plots
Control Plots

Source:
Sub-optimal Nutrition: The Example of K in FFB

'000 tons of FFB and K₂O
FFB: USDA (2010/11 CPO converted to FFB at 20% OER)
Applied K₂O: Heffer, IFA (2013)Q
2 NUE Examples
Practical NUE Indicators to Guide Field Nutrition
Practical NUE Indicators to Guide Field Nutrition

**Partial Factor Productivity (PFP)**
kg FFB per kg nutrient applied
PFP = Y/F

How productive is this cropping system in comparison to its nutrient input?

**Partial Nutrient Balance (PNB)**
kg nutrient removed per kg applied
PNB = U/H/F

How much nutrient is being taken out of the system in relation to how much is applied?

**Agronomic Efficiency (AGE)**
kg yield increase per kg nutrient applied
AGE = (Y-Y₀)/F

How much productivity improvement was gained by use of nutrient input?

**Recovery Efficiency (REF)**
kg nutrient uptake per kg nutrient applied
REF = (U-U₀)/F

How much of the nutrient applied did the plant take up?

**NPK**
Nutrient indicators:
- N: Nitrogen
- P: Phosphorus
- K: Potassium
- Mg: Magnesium

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Practical NUE Indicators: Worked Examples

Practical use of oil palm nutrient physiological efficiency with regard to nutrient recovery and agronomic efficiency at different Sumatran sites.
XVII Conf. Int. sobre Palma de Aceite, Cartagena, Colombia

Tarmizi AM, Tayeb MD & Zin ZZ (1992)
Maximum yield of oil palm in Peninsular Malaysia: Yield response and efficiency of nutrient recovery.
1990 ISOPB Int’l Wkshp on Yield Potential in Oil Palm, Phuket, Thailand

IPNI & Plantation Partners
Ongoing and completed work in Malaysia and Indonesia
Practical NUE Indicators: PFP Nitrogen

PFP N1 Tarmizi
- Coastal inceptisol
- Inland ALL
- Inland inceptisol
- Inland oxisol
- Inland ultisol
- Inland collovium
- Rhyolite
- Rhyolite
- Rhyolite
- Sandstone
- Dacite/claystone
- Dacite/claystone
- Dacite/claystone

PFP N1 Prabowo
- Coastal inceptisol
- Inland ALL
- Inland inceptisol
- Inland oxisol
- Inland ultisol
- Inland collovium
- Rhyolite
- Rhyolite
- Rhyolite
- Sandstone
- Dacite/claystone
- Dacite/claystone
- Dacite/claystone

PFP N2 Prabowo
- Coastal inceptisol
- Inland ALL
- Inland inceptisol
- Inland oxisol
- Inland ultisol
- Inland collovium
- Rhyolite
- Rhyolite
- Rhyolite
- Sandstone
- Dacite/claystone
- Dacite/claystone
- Dacite/claystone
Practical NUE Indicators: PNB Nitrogen
Practical NUE Indicators: PFP Nitrogen

PFP N 2016
kg FFB 2016 per kg N Applied (2014-2016)

- < 50 kg FFB/kg N Applied
- 50 - 100 kg FFB/kg N Applied
- 100 - 150 kg FFB/kg N Applied
- 150 - 200 kg FFB/kg N Applied
- 200 - 250 kg FFB/kg N Applied
- 250 - 300 kg FFB/kg N Applied
- > 300 kg FFB/kg N Applied
Practical NUE Indicators: PFP Potassium

PFP K 2016
kg FFB 2016 per kg K Applied (2014-2016)

- 0 - 50 kg FFB/kg K Applied
- 50 - 75 kg FFB/kg K Applied
- 75 - 100 kg FFB/kg K Applied
- 100 - 125 kg FFB/kg K Applied
- 125 - 150 kg FFB/kg K Applied
- 150 - 175 kg FFB/kg K Applied
- > 175 kg FFB/kg K Applied
Practical NUE Indicators: PNB Nitrogen 2014-16
Practical NUE Indicators: PNB Nitrogen 2014-16

PNB N

- < 0.15
- 0.15 – 0.30
- 0.30 – 0.45
- 0.45 – 0.60
- 0.60 – 0.75
- 0.75 – 0.90
- > 0.90

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Practical NUE Indicators: PNB Nitrogen 2014-16

PNB N
- < 0.15
- 0.15 – 0.30
- 0.30 – 0.45
- 0.45 – 0.60
- 0.60 – 0.75
- 0.75 – 0.90
- > 0.90
Practical NUE Indicators: PNB Potassium 2014-16

PNB K

- < 0.15
- 0.15 – 0.30
- 0.30 – 0.45
- 0.45 – 0.60
- 0.60 – 0.75
- 0.75 – 0.90
- > 0.90
Practical NUE Indicators: PNB Potassium 2014-16
Practical NUE Indicators: PNB Potassium 2014-16
Developing NUE Indicators
Generating NUE in the Field

Decision

Linear Transfer

Knowledge

Analyses

Data

Experimentation

OFE
Generating NUE with Field Information

**PFP** (Partial Factor Productivity)
kg FFB per kg nutrient applied
PFP = \( \frac{Y}{F} \)

**AGE** (Agronomic Efficiency)
kg yield increase per kg nutrient applied
AGE = \( \frac{(Y-Y_0)}{F} \)

**PNB** (Partial Nutrient Balance)
kg nutrient removed per kg applied
PNB = \( \frac{U_H}{F} \)

**REF** (Recovery Efficiency)
kg nutrient uptake per kg nutrient applied
REF = \( \frac{(U-U_0)}{F} \)
Generating NUE with Field Information
Generating NUE with Field Information
Generating NUE with Field Information

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Sub Block B

Collection Road

Sub Block A
Generating NUE with Field Information
Generating NUE with Field Information

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Sub Block B

Sub Block A

Collection Road
## NUEs that Support Practical Management

<table>
<thead>
<tr>
<th>Measure</th>
<th>Typical level in Annual Crops</th>
<th>Interpretation</th>
</tr>
</thead>
</table>
| Partial factor productivity (kg grain/kg nutrient) | N: 40 - 90, P: 100 – 250, K: 75 – 200 | Lower levels: less responsive soils or over application  
Higher levels: nutrient supply is likely limiting productivity. |
| Agronomic efficiency (kg grain/kg nutrient)     | N: 15 - 30, P: 15 – 40, K: 8 – 20 | Lower levels: changes in management could increase crop response or reduce input costs |
| Recovery efficiency (%)                         | N: 40 - 65, P: 15 - 25, K: 30 - 50 | Lower levels: changes in management could improve efficiency or nutrients are accumulating in the soil |
| Partial nutrient balance (kg nutrient/kg nutrient) | N: 0.7 – 0.9, P: 0.7-0.9, K: 0.7 – 0.9 | Lower levels: changes in management improve efficiency  
or fertility is increasing  
Higher levels: soil fertility may be declining |

# NUEs that Support Practical Management

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Source</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Mg</th>
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<tbody>
<tr>
<td><strong>PFP</strong></td>
<td>IPNI trial 2</td>
<td>28 – 279</td>
<td>125 – 1587</td>
<td>16 – 145</td>
<td>423 – 7811</td>
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<td>Tarmizi trials</td>
<td>153 - 257</td>
<td>953 - 1851</td>
<td>100 - 143</td>
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<td>Prabowo trials</td>
<td>213 - 324</td>
<td>540 -1009</td>
<td>151 - 265</td>
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<td>IPNI trial 1</td>
<td>47 - 89</td>
<td>531 – 994</td>
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<td>Tarmizi trials</td>
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<td>Prabowo trials</td>
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<td>88 - 262</td>
<td>21 - 54</td>
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<td><strong>PNB</strong></td>
<td>IPNI trial 2</td>
<td>0.10 – 0.93</td>
<td>0.04 – 0.83</td>
<td>0.06 – 0.64</td>
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<td>IPNI trial 1</td>
<td>0.64 – 0.93</td>
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<td>0.44 - 0.74</td>
<td>0.44 - 0.85</td>
<td>0.37 - 0.53</td>
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<td>0.62 - 0.94</td>
<td>1.57 - 2.93</td>
<td>0.44 - 0.77</td>
<td>2.03 - 2.89</td>
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<td>IPNI trial 2</td>
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<td>0.12 – 0.25</td>
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Thank you.