

MEOA LAB – Manuring: What You Need to Know

PAPER 1



The Basics of Oil Palm Nutrition

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Topics of Discussion

- Introduction
- Oil palm nutrition and its management
 - Major nutrients: N, P, K, Mg, Ca
 - Minor nutrients: B, Cu, Zn
- Timing of fertilizer application
- By-products of Oil Palm and their Utilization
- Soil Conservation and nutrient re-cycling
- Legume cover: Mucunna brateata
- Conclusion



- Oil palm requires high nutrient inputs for sustained high yield.
- Fertilizer 55%-65% of field upkeep costs and 30% of the cost of FFB production in Malaysia.
- Factors reducing fertilizer efficiency have been calculated in Malaysia such as nutrient imbalance, wrong timing of application, too low planting density, incorrect fertilizer placement, weed competition, pest and disease attack.



- The rapid expansion of the oil palm industry has resulted in more of this crop being planted on soils previously classified as marginal or unsuitable.
- Degradation in soil fertility is usually reflected in soil acidification and loss of soil organic matter
- To obtain good growth and sustain high yield, good balanced fertilization combinations fertilizers between organic and inorganic are essential
- This will minimize cost and ensure profitability. It also minimize potential negative impacts on the wider environment



- Labour is one of the most important issues in efficient fertilizer management, however, the problem of labour shortage is not a new issue in Malaysia.
- It is estimated that foreign workers account for some 75% to 90% of the plantation work force in Peninsular Malaysia, Sabah and Sarawak.

 Mechanization of field operations in particularly, has been become a major function programme in most plantation companies but to various degree of success.













OIL PALM NUTRITION AND ITS

MANAGEMENT

ESSENTIAL PLANT NUTRIENTS

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Required in large quantities
 Easily deficient

Secondary / Micronutrients

Required in small quantities
 Less frequently deficient

TROPICAL SOILS

Most nutrients often leached out by high rainfall
If crop requires particular nutrient easily deficient

*Deficiency in any one nutrient may affect others – chain reaction can affect yield

SOIL ORGANIC MATTER (SOM)

Plant material in various stages of decomposition

Adequate levels beneficial to soil:

- Improves physical condition
- Increase water infiltration
- Improves soil tilth (workability)
- Decrease soil erosion
- Supplies plant nutrient especially N
- Increases CEC
- Can temporarily fix N

Extremely important in Tropical Soils





COMMON SOIL CATIONS

Cation	Chemical Symbol	Ionic Form
Potassium	К	K+
Sodium	Na	Na ⁺
Hydrogen	Н	H+
Calcium	Ca	Ca ⁺⁺
Magnesium	Mg	Mg ⁺⁺

COMMON SOIL ANIONS

Anion	Chemical Symbol	Ionic Form
Chloride	CI	CI-
Nitrate	N	NO3-



Genetic yield potential



Site yield potential



Actual yield

Planting material Light distribution Soil Climate

Agronomic practices Management practices Economics Social-psychological factors

Factors Influencing the site yield potential and actual yield of oil palm (Goh Kah Joo , Chew ftoh Soon & Teo Chor Boo))

Oil Yield Potential

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Category of Production

BENCHMARK (YIELD), GAP AND BENCHMARKING PROCESS (managing and closing the yield gap (modified from Reider, 2000)





Nutrient Balance

- To summarize that, there are three major factors taken into need to be account for fertilizer recommendations:
- (1)initial leaf and soil nutrient level site potential yield;
- (2) optimum nutrients ratio demand and balance;
 (3)site yield potential efficient fertilizer recovery based on past fertilizer trials data
- This approach is taking into consideration the nutrient removal (demand) from the system and nutrient return (supply to the system)





- Nitrogen is a constituent of many essential organic compounds and some of these proteins act as enzymes that catalyze biochemical reactions in the plant.
- Chlorophyll also contained high nitrogen component, when the deficient is pronounced, then it will be resulting in pale green colour of palm and necrosis develops first on the tips and margins of pinnae.

N deficiency symptoms and effects on growth



Effects on oil palm

- 1) Small yellowish canopy
- 2) Shorter palm
- 3) Smaller stem diameter
- 4) Lower leaf area index
- 5) Lighter fronds

- 6)Smaller bunches
- 7) Less bunches
- 8) More male flowers
- 9)Higher abortion rate
- 10)Higher bunch failure

In N-deficient leaves, proteins are hydrolyzed (proteolysis) to produce amino acids which are redistributed to younger leaves.

Older fronds are affected first appearing uniformly pale green, before turning pale or bright yellow (chlorosis), and may suffer from die-back (necrosis)

The rachis and midrib of severely deficient fronds are yellowish orange

Lower assimilation rate
 Variable effects on O/B





The application rate recommended varied with palm age ranging from 0.25-1.75 kg/palm/yr for mature palms and 0.25-1.1 kg/palm/yr for young palms 2-3 years after field planting.



Potassium

 It appears to be of particular importance in the physiological activities of leaves and growing points, where it may function as a catalyst for important biochemical reactions, or as a more general regulator of palm processes.



- Potassium deficiency does not immediately result in the appearance of visible deficiency symptoms but may reduce leaf turgor and increase susceptibility to drought and diseases such as *Cercospora* leaf spot, *Ganoderma* basal stem rot and vascular wilt.
- Orange spotting is the most common K deficiency symptom and the early symptoms first appear as pale green spots on the interveinal areas of the pinnae of older fronds.

K deficiency symptoms and effects on growth

Three different symptoms:

- 1) confluent orange spotting
- 2) diffuse yellowing
- 3) orange blotch

Orange spotting



Start with pale yellow, irregularly shaped spots along the pinnae of older fronds

With increasing severity, spots turn yellowish orange and then fuse to form bright orange lesions before necrotic spots appear in the center

At advance stage, marginal necrosis of pinnae occurs and leaflets become brittle and fragmented



Orange Spotting



Diffuse yellowing



Pinnae in the lower to middle part of the canopy become pale (dull khaki or ochre coloured chlorosis) and then turn yellow or orange yellow.

Necrotic band then develops around the leaf margin of pinnae.

In severe cases, older fronds suddenly desiccate and die.



Hyperacidity



Hyperacidity

Orange blotch or Mbawsi symptom



Symptom starts with large, elongated diffuse olive- green blotches emerging in pairs half way along the pinnae of older fronds.

The blotches turn bright yellow to orange and eventually brownish yellow before the pinnae desiccate and die.

K deficient palms are:

- 1. Stunted
- 2. Smaller canopy
- 3. Decreased leaf turgor
- 4. Susceptibility to drought

- 5. Less bunches
- 6. Smaller bunches
- 7. Higher bunch failure
- 8. Higher oil per bunch



NK Imbalance



Orange spotting can be confused with other maladies

Red spider mites



Pestalotia palmarum





Genetic orange spotting



Potassium (K)

- Look at the leaf K and Rachis K trend (Rachis K > 1.4%)
- Soils that need more K
 ~ exchangeable K < 0.15 cmol/kg
 ~ peat, sandy soil and acid soils with low pH



The annual maintenance dosage of K fertilizer normally ranged from 1.2-1.5 kg K/palm but 1.8-3.0 kg/ palm are needed for high yielding mature palm. About 0.45-2.5kg/ palm are required for young palms
2-3 years after field planting.





 Phosphorus is an essential constituent of nucleic acids that are involved in storage and transfer of genetic information.

 P is contained in phospholipid compounds in cell membranes and is responsible for maintaining the necessary separation between the various physiological processes in plant cells.



- P deficiency is expected to cause considerable disruption to plant growth and functions such as decreased leaf expansion, leaf surface area and leaf number.
- The chlorophyll content of tissue is also affected and thus, the efficiency of photosynthesis is reduced.

 Although there are no clear symptoms of P deficiency, as an indication may be obtained from surrounding vegetation or leguminous cover (immature field).



Phosphorus (P)

 Look at the leaf P and Rachis P trend (Leaf P > 0.16%, Rachis P ⇒ 0.1%)

Take into account
 N : P relationship
 Critical leaf P% = 0.0487 x leaf N% + 0.039

Buffering capacity of various soils ~ soil needs vs palm needs?



Guidelines

TSP – RP comparison

Phosphorus Nutrition




Guidelines

TSP – RP comparison

Yield

LBE14-Yield 1994-95-96: Comparaison TSP / RP





 Phosphorus fertilizer requirements ranged from 0.2-0.45 kg P /palm/ yr (maintenance dosage) to 0.6-1.0 kg P/palm/yr (high yield dosage), while in Sumatra, recommended rates were 4kg rock phosphate /palm/yr on volcanic soils such as rhyolite and dacite.





 Magnesium has many functions in the metabolism of oil palm.

 The most important role of Mg is in the constituent of chlorophyll, the green pigment that converts light energy into biochemical energy during photosynthesis.

Mg deficiency symptoms and effects on growth



The first symptoms appear on older, basal fronds where sun-lit pinnae turn yellow to yellowish orange.

Under conditions of severe deficiency, the affected leaves turn ochre to bright yellow and become desiccated

A diagnostic feature that shaded parts of leaves remain green whilst tissue fully exposed to the sun turns yellow.

Under acute Mg deficiency, the frond dry weight, leaf area, leaf production and yields are smaller. More importantly,

Mg fertilizer sources

Common Mg fertilizer sources:

- 1. German kieserite
- 2. China kieserite
- 3. Dolomite (calcium Magnusium Cabornate)
- 4. Ground magnesium limestone (GML)
- 5. Magnesite (Mg carbonate)
- 6. Calcined magnesite e.g. EMag
- 7. KMag which is a potassium magnesium salt
- 8. Magnesium oxide

Important to note that the total Mg contents in these fertilizers are not the sole determinant of Mg availability to the palms.

The solubility and other properties of the fertilizers and soils are probably just as important.



Magnesium (Mg)

- Look at the leaf Mg trend
 (> 0.20% inland)
- Soils that need more Mg

 exchangeable Mg < 0.3 cmol/kg
 sandy soils with shallow topsoil
 very high rainfall areas (> 3500 mm/yr)

 Nutrient imbalance occur
 - Ca : Mg > 5 : 1 (volcanic soils) Mg : K > 1.2 : 1



 An annual application of 0.20-0.27 kg Mg/palm is sufficient for maintenance. Where acute Mg deficiency is noted, higher dosage of 0.36-0.54 kg Mg /palm/yr is needed.



Minor Nutrients: B, Cu, Zn Fe

Boron deficiency

- Slows growth root and leaf tips causing abnormalities in leaf development like ,crinkle leaf', ,hook leaf', ,little leaf'
- B deficient leaves split at the tips
- An early symptom of B deficiency is the formation of shortened leaves, giving the palm a ,flat top' appearance.
- Yield is reduced due to floral abortion.





Hook Leaf



Healthy & B deficient roots - a close up...



REF: Kwast, Research Center Hanninghof, Yara



Fe Deficiency

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Nutrient contents in bunch analysis crude palm oil - with and without fertilizers, in g per tonne

Nutrient	N	Р	К	Mg	Са	S	Fe	Zn	Cu
Fertilized ¹ plots	79	142	22	61	45	33	55	2.6	0.5
Unfertilized ² plots	77	128	17	50	45	35	57	2.6	0.5

¹ Embedded plot in each block receiving the same fertilizer treatment as rest of the block. ² Unfertilized plot in each block

From: Plant Nutrients in Palm Oil. Donough CR et al., 2016 IPNI.

Nutrient contents in fresh fruit bunches (FFB) and in crude palm oil (CPO), in kg per tonne.

Nutrient	Ν	Р	К	Mg	Са	S
Whole FFB ¹	3.07	0.38	3.84	0.62	0.51	0.28
Proportion in CPO ²	0.02	0.04	0.01	0.01	0.01	0.01
Proportion in CPO in %	0.8	9.5	0.1	2.3	2.1	3.3

¹ Contents in whole bunches, including CPO still in mesocarp. Mean of all four treatments ² Contents in the oil extracted from whole bunches (bunch analysis CPO) and assuming an oil content of 25% in FFB.

¹ Embedded plot in each block receiving the same fertilizer treatment as rest of the block. ² Unfertilized plot in each block

From: Plant Nutrients in Palm Oil. Donough CR et al., 2016 IPNI.





Timing and Frequency of Fertilizer Application

 Uptake efficiency increased with more frequent applications of fertilizer. However, the frequency of fertilizer application might be constrained by (1) the duration of single fertilizer application; (2) the number of fertilizer rounds to be applied in a year; (3) the requirement for a period of two months without fertilizer application prior to leaf sampling.



- The common practice is to apply N and K fertilizers 2-3 rounds per year to reduce the risk of leaching.
- Mg and P are applied once in a year.
- The frequency of fertilizer application is usually higher during the immaturity period, compound fertilizer is recommended to be used in immature stage.



Mechanical Application

- Manuring is traditionally carried out manually by broadcasting fertilizer over the palm circle area.
- labour shortage is currently a serious constraint.
- The mechanical spreader broadcasts the fertilizer in the interrows.
- It is usually the cheapest and most effective method and should be the first choice except in immature plantings and terraced areas.







Byproducts of Oil Palm

 30-35% of the palm oil and kernel are fully utilized and the rest of the byproducts such as empty fruit bunches (EFB), palm oil mill effluent (POME), kernel shell and mesocarp fibre are mostly discarded until recent years.



- The utilization of EFB and POME in oil palm plantations is now widely accepted as an economically viable and environmentally acceptable waste management technique.
- EFB mulching on immature palms immediately after planting enhances vegetative growth and also higher subsequent yields. Recommended rate is at 250 kg/palm.
- In mature field, applications of 25-50 tons ha-1 are typical, spread at 1 foot thick and shared between four palms.









Fertilizer equivalents of EFB

Nutrient	% DM	Fertilizer	Kg ton ⁻¹ EFB		
N	0.41	Urea	4.10		
Ρ	0.046	RP	0.46		
K	1.83	MOP	18.30		
Mg	0.14	Kieserite	1.40		



Average nutrient composition (% on dry matter) of EFB (empty fruit bunches)

N	utrient	Corley <i>et al.</i> , 1971	Gurmit Singh <i>et</i> <i>al.</i> , 1989	Chan <i>et al</i> ., 1981	Kulim	Mean
	Ν	0.35	0.80	0.35	0.15	0.41
	Ρ	0.012	0.096	0.026	0.05	0.046
	K	1.90	2.41	2.28	0.73	1.83
	Mg	0.11	0.18	0.17	0.09	0.14



Average composition of POME

Nutrient N K₂O MgO (mg/L) 2500-5100 1600-3000 400-700



SOIL CONSERVATION AND NUTRIENT RECYCLING

- Soil plays a vital role in dictating the performance of oil palm grown. The nutrient availability in the soil is influence by factors such as pH, cation exchange capacity, base saturation, sesquioxide content and physical characteristics of the soils. In the acid soils in the tropics, the inherent fertility or mineral resources are low. Thus, large fertilizer inputs are needed.
- In view of the escalating fertilizer prices, it is also useful to maximize nutrient recycling especially through pruned fronds and legume cover crops.

Conventional Fronds Stacking Practice

- Proper placement of fronds in the field is a common practice in oil palm plantations. Fronds are removed during harvesting and periodic pruning rounds (1-3 rounds in a year).
- In mature field, each palm produces about 20-30 fronds annually and approximately 10 tons dry matter per year.
- For practical purposes, pruned fronds are stacked in heaps along the alternate interrow across the slope gradient and also conserve soil moisture.
- 43% N, 76% K, 63% P and 60% Mg contained in pruned fronds was mineralized (mainly from pinnae) by the 24th week after pruning





- The establishment of legume cover in young oil palm planting is a common agronomic practice in Malaysia. The palm interrow covered by natural vegetation was known to produce higher yield than bare ground.
- Legumes; because they fix atmospheric nitrogen and make it available to the main crop.
- Mucuna bracteata was introduced as an ideal legume cover into oil palm plantation recently due to its ability to produce large biomass.



Mucuna bracteata

- Its vigorous growth also enables it to compete with noxious weeds.
- It was found that ground cover provides better soil erosion control and also minimizes leaching losses of nutrients.
- The main root of *M. bracteata* grows to a depth of 2-3 metres and will possibly increase the fertility of the surface soil by extracting nutrients from the deeper layer of the soil and depositing them on the surface in the form of mulch or organic matter.
- *M. bracteata* is able to conserve soil moisture especially during dry spell. This will probably enhance the mineralization of nutrients during the drought season.
- They also showed that it was able to enhance the growth and yield of oil palms.








Dry matter production of *Mucuna bracteata* on different soil types

Soil series	Age	Dry matter (tons ha-1)			Reference
	(month)	shoot	litter	Total	
Bungor	6	1.51	0.05	1.56	Ng <i>et al</i> ., 2006
Bungor	12	2.28	0.13	2.41	Ng <i>et al.</i> , 2006
Munchong	12	6.09	4.03	10.12	Lee <i>et al</i> ., 2005
Apek	18	4.56	7.13	11.69	Lee <i>et al.</i> , 2005
Mostyn	18	10.90	8.22	19.12	Shaharudin and Jamaluddin, 2006
Rengam	24	8.20	3.00	11.20	Chua <i>et al</i> ., 2005
Bungor	24	7.80	9.17	16.96	Ng <i>et al</i> ., 2006
Malacca	24	4.66	6.83	11.49	Mathews and Leong, 2000
Alluvial	36	8.73	19.60	28.33	Chiu <i>et al</i> ., 2001
Nil	36	9.68	7.31	16.99	Mathews 1998
Binuang	41	6.60	1.96	8.56	Mathews and Saw, 2006
Bungor	48	5.32	3.23	8.55	Chiu and Bisad, 2006



CONCLUSIONS

- The oil palm industry has to increase productivity as well as lower costs to enhance its competitive and sustainable position in oils and fats industry.
- As manuring remains to be the single largest cost, it is a focus for refinement particularly on fertilizer use efficiency which can be achieved by intensifying the following approaches.



- 1. greater appreciation of the nutrient balance concept in the overall assessment of fertilizer needs;
- 2. better understanding of gross nutrient uptake and minimizing nutrient losses through leaching by splitting huge doses of fertilizers and applying during low rainfall intensity period;
- 3. spreading fertilizers as widely as possible by mechanical spreader for efficient root absorption;
- 4. greater use of by-products of oil palm such as EFB, POME and bio-compost for soil conditional improvement;
- 5. paying greater attention to soil conservation to maximize nutrient recycling through pruned fronds and legume cover crops.







THANK YOU



