Nutrient Use Efficiency in Oil Palm Nurseries

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Soil tests are useful in selecting suitable topsoil for use as growth medium in oil palm nurseries to avoid differences in plant growth between sites.

Nutrient use efficiency (NUE) in oil palm nurseries can be improved with appropriate application rates and timing.

Further improvements in NUE in oil palm nurseries could come with more efficient irrigation and use of slow-release nutrient sources.

High quality seedlings are an important prerequisite for high yielding, mature oil palms. Oil palm seedlings are typically groomed for one year in the nursery before being planted into the field. Nurseries usually practice a two-stage system, in which a pre-nursery stage of 12 to 14 weeks is followed by the main nursery stage that lasts between 38 to 40 weeks.

Standardized fertilizer programs are used in both nursery stages. However, the nutrient supply capacity of the topsoil growth medium is not routinely determined, potentially causing suboptimal and inefficient application of nutrients. The International Plant Nutrition Institute (IPNI) analyzed samples of plants and topsoil growth medium, in a collaborative project with Wilmar Group in South Sumatra, Indonesia, to understand nutrient use efficiency (NUE) in two-stage oil palm nurseries.

The South Sumatra Project

The South Sumatra project was implemented at three separate sites. Pre-germinated hybrid oil palm seeds were sown in weekly batches at the pre-nursery. Ten batches of each were assessed in 2012 and 2013 at sites 1 and 2, involving a total of 63,500 plants. In 2014 at site 3, four batches were assessed totaling 9,200 plants. In each batch, one part was subjected to Best Management Practices (BMP) following the methods of Rankine and Fairhurst (1999), while the rest were managed using the Standard Estate Practices (SEP) of the partner plantation. BMP and SEP treatments continued in the main nursery, involving 26,108 plants at sites 1 and 2 and 4,750 plants at site 3. The main difference between BMP and SEP in the two nursery stages was the fertilizer program summarized in **Table 1**.

Table 1. Nutrients supplied in the oil palm nursery of the South Sumatra project.

	Pre-nursery application, g/plant		Main nursery application, g/plant	
Nutrient	BMP[1]	SEP[2]	BMP	SEP
N	0.9	2.2	24.4	30.1
P	0.6	1.2	24.7	26.2
K	0.3	0.8	31.5	35.4
Mg	0.1	0.4	4.5	3.0

[1]Best Management Practice; [2]Standard Estate Practice

Nutrient losses in each nursery system were estimated by comparing the total amount of nutrients retained in the growth medium and plants at the end of each nursery stage, with the total amount of nutrients in the growth medium at the start of each nursery stage and nutrients supplied by fertilizers during each stage. Initial values were determined for the growth medium by sampling the topsoil-filled, unplanted and unfertilized bags. Bags were sampled again at the end of pre- and main nurseries stages to obtain the final nutrient content.

Each sampled plant was measured (as described by Donough et al. 2014), then carefully removed from its bag and separated from the growth medium. All samples of air-dried soil and oven-dried plant portions were combined according

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; Mg = magnesium. IPNI Project SEAP-04

Seedlings are planted in polythene bags (polybags) filled with a suitable medium, usually topsoil. On the left, the pre-nursery bags (15 cm x 23 cm) are arranged in beds (10 bags wide and 100 bags long) and the main nursery (right) uses larger bags (38 cm x 45 cm) arranged in an equilateral triangular pattern (90 cm spacing). Seedlings are irrigated in the nursery, using a fine spray provided by perforated polythene tubes.

to site, giving a total of 24 samples for each nursery. This was comprised of six samples of dried plant tops (two treatments BMP and SEP, three sites per treatment), six samples of dried plant roots, and six samples each of initial and ending growth media.

Nutrient Losses

The nutrient balance was much better under BMP in the pre-nursery stage (**Table 2**). In the main nursery, the BMP nutrient balance was still superior but the absolute difference smaller. The Mg balance in the main nursery was better with SEP. The values for P appear low as only plant-available P, but not total soil P, was determined.

Table 2. Nutrient balance in the oil palm nursery of the South Sumatra project.

	Pre-nursery nutrients retained[1], %		Main nursery nutrients retained[2],%	
Nutrients	BMP[3]	SEP[4]	BMP	SEP
N	76	52	70	65
P	9	7	12	10
K	76	18	47	43
Mg	39	24	70	91

[1]Nutrients in soil plus plant tissue at end of the pre-nursery period as a % of nutrients added in fertilizers plus initial soil contents; [2]Nutrients in soil plus plant tissue at end of the main nursery period as a % of nutrients added in fertilizers plus initial soil and plant tissue contents; [3]Best Management Practice; [4]Standard Estate Practice.

There were significant differences in the nutrient balances between sites. **Table 3** illustrates these differences for the K balances, which are attributable to site differences in the properties of the topsoil growth medium, including the clay, organic C, and soil N content, and the cation exchange capacity (data not shown). This clearly indicates the usefulness of soil tests in the selection of suitable topsoil growth medium.

Table 3. Potassium balance in oil palm nurseries at three sites of the South Sumatra project.

	Retained K (%) in pre-nurseries[2]		Retained K (%) in main nurseries[3]	
Site[1]	BMP[4]	SEP[5]	BMP	SEP
1	94	9	37	20
2	71	34	62	48
3	66	12	86	77

[1]Three different oil palm nurseries involved in the project; [2]K in soil plus plant tissue at end of the pre-nursery period as a % of K added in fertilizer plus initial soil content; [3]K in soil plus plant tissue at end of the main nursery period as a % of K added in fertilizer plus initial soil and plant tissue contents; [4]Best Management Practice; [5]Standard Estate Practice.

Plant Growth and Nutrient Use Efficiency

Plant growth under BMP and SEP was not significantly different (**Table 4**). This indicates sufficient nutrients were supplied by either treatment. In the pre-nursery, BMP plants were very similar in size to SEP plants despite receiving far less nutrients (**Table 1**). This indicates that nutrient supply was excessive with SEP, with the lower nutrient balance in the SEP pre-nursery (**Table 2**) suggesting that much of this oversupply is lost. Early applications in the SEP pre-nursery fertilizer program could be eliminated without any adverse effect on pre-nursery plant growth. This is shown by similar plant growth achieved with late applications in the BMP pre-nursery fertilizer program.

Table 4. Plant growth measures in the oil palm nursery stage of the South Sumatra project.

	Pre-nursery stage[1]		Main nursery stage[2]	
Growth Indicators	BMP[3]	SEP[4]	BMP	SEP
Stem diameter[5] (cm)	1.0	0.9	6.2	5.9
Plant height[6] (cm)	24	25	90	85
Fronds per plant[7]	4.7	4.7	14	14
Petiole cross-section[8] (cm^2)	-	-	1.2	1.1
Plant dry weight[9] (g)	2.5	2.9	636	534

[1]Growth measured once at end of PN period; [2]Data shown for measurements after 28 weeks in MN; [3]Best Management Practice; [4]Standard Estate Practice; [5]Stem diameter at soil level; [6]Height from soil surface to tip of longest frond; [7]Fully expanded green fronds only; [8]Product of width and depth of petiole at proximal end of frond, measured on the 3rd fully expanded frond, measured only in MN; [9]PN sampled at end of PN period, MN sampled at 36 weeks at 2 sites and 28 weeks at 1 site.

In the main nursery, BMP plants were marginally larger (**Table 4**) even though they received slightly less nutrients except for Mg. Donough et al. (2014), reporting early results from Sites 1 and 2 only, attributed this to the higher proportion of readily available P supplied in the BMP main nursery fertilizer program.

In the pre-nursery stage, partial factor productivity [PFP = plant dry weight (g) per g nutrient applied] was better with BMP, especially for K (**Figure 1a**). Internal efficiency [IE = plant dry weight (g) per g nutrient uptake] was only marginally different between the two treatments (**Figure 1b**). Again, this is an indication of excessive and untimely supply of nutrients through SEP. BMP nutrients were applied near the end of the pre-nursery period. SEP nutrients, on the other hand, were applied regularly after sowing. This suggests losses of nutrients that were applied during the early stage of the pre-nursery. In the main nursery, differences between treatments were small for both PFP and IE (**Figure 2a** and **2b**), indicating similar nutrient use efficiency in BMP and SEP fertilizer programs.

Conclusions

The loss of nutrients from the oil palm nursery system, especially in the pre-nursery stage, can be high if generous fertilizer rates are applied and not appropriately timed. Further improvement in nutrient retention in the pre-nursery stage should be possible with the adoption of irrigation methods that supply water more efficiently and are possibly grouped with slow-release nutrient sources.

The difference between current practices and BMP are smaller in the main nursery stage. Yet, as in the pre-nursery, improvements in irrigation and use of slow-release nutrient sources will further help reducing nutrient loss and improve nutrient use efficiency in the main nursery.

Use of standardized fertilizer programs at various locations may lead to differences in plant growth between locations. Soil tests should be used to guide selection of suitable topsoil growth medium for planting in oil palm nurseries. BC

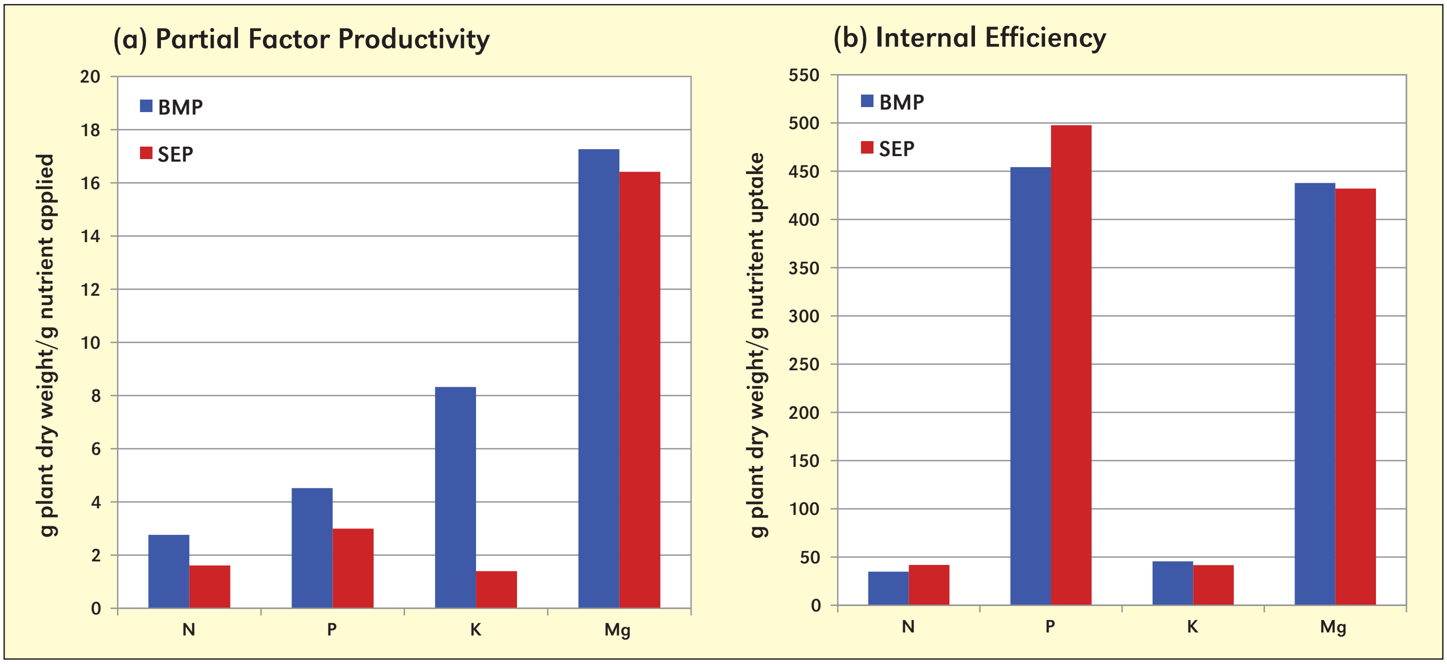

Figure 1. Partial factor productivity and internal efficiency for nutrients applied under best management (BMP) and standard estate (SEP) practices in the pre-nursery of the South Sumatra project.

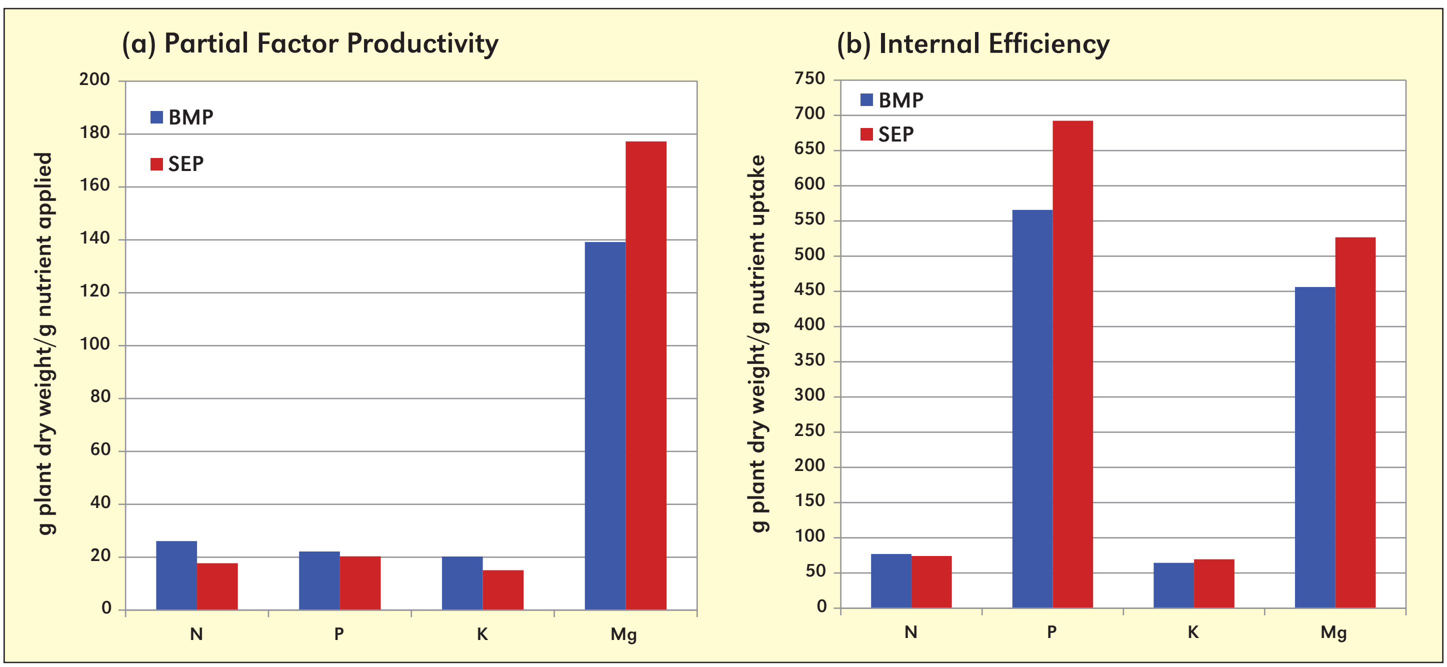

Figure 2. Partial factor productivity and internal efficiency for nutrients applied under best management (BMP) and standard estate (SEP) practices in the main nursery of the South Sumatra project.

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References

Donough, C.R., S. Mohanaraj, Rahmadsyah, T. Oberthür. 2014. Poster presented at International Oil Palm Conference, June 2014, Bali, Indonesia.

Rankine, I. R. and T.H. Fairhurst. 1999. Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC) and 4T Consultants. 109 pp.