Effect of nutrient application frequency on nutrient uptake in oil palm production on sandy soils

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ABSTRACT

Oil palm cultivation has expanded rapidly in Kalimantan, Indonesia, in recent years. Sandy soils are common in the region, in some areas coupled with inadequate and unevenly distributed rainfall. On such sandy soils, loss of nutrients by leaching can be high during times of high rainfall. Higher frequency of applications on such soils can be expected to increase the efficiency of applied fertilizers i.e. fertilizer recovery efficiency (FRE). In a project started in October 2011, blending of individual fertilizers prior to field application allowed for four rounds each of N, P, K, Mg, S, and B per year in the improved practice treatment (here referred to as nutrition best management practice, BMP), compared to the control treatment where the same fertilizers were applied individually according to standard estate practice (SEP). FRE was based on the ratio between (a) nutrients removed (in FFB) plus nutrients immobilized (in palm trunks), and (b) nutrients supplied from applied fertilizers.

After one year, the SEP treatment recorded a FRE of 53% for N, 71% for P, 37% for K and 62% for Mg. Applying each of these nutrients four times a year increased their efficiency by 10% and 18% for N and K, respectively, while the efficiencies of P and Mg were not affected. P and Mg recovery efficiencies were likely moderated by use of rock phosphate (RP) and dolomite (DOL), respectively, in the plantation prior to the project.

While the project continues for several more years, the encouraging first year results gives credence to the hypothesis that higher nutrient application frequency will improve FRE for oil palm grown in the type of conditions prevailing at the project site. This is especially important for the profitability of plantations and for sustainable intensification of oil palm production in similar conditions elsewhere.

INTRODUCTION

Oil palm productivity is influenced by several factors, an important one being nutrient management. Fertilizer is one of the largest items in direct on-farm production cost. Fertilizer recovery efficiency (FRE) is inherently low in the oil palm production system in view of the considerable nutrient inputs and the low nutrient export through palm kernels and crude palm oil. This is mainly due to nutrient losses by leaching and surface runoff, and poorly managed recycling of nutrient-rich post-milling residues.

Expansion of oil palm cultivation is increasingly being channelled towards marginal lands with lower conservation values, where growing conditions are poorer and soils have lower inherent fertility. In this scenario, sustainable intensification of production with proper management is essential for profitability. With respect to oil palm nutrition, practices based on sound scientific principles such as the 4R Nutrient Stewardship Concepts (right source, right rate, right time, right place) promoted by the International Plant Nutrition Institute (IPNI) are key elements of improved management.

In Indonesia, Kalimantan is where oil palm cultivation has been rapidly expanding in recent years. Sandy soils are common in the region, sometimes coupled with rainfall that is inadequate and unevenly distributed. IPNI Southeast Asia Program (IPNI SEAP), in collaboration with PT Sungai Rangit (a subsidiary of PT Sampoerna Agro Tbk), previously showed that by implementing appropriate best management practices (BMPs), particularly to improve crop recovery (Donough *et. al.*, 2011) and palm nutrition (Oberthür *et. al.*, 2012), fresh fruit bunch (FFB) yields exceeding 25 t ha^{-1} and approaching 30 t ha^{-1} could be obtained on very sandy soils in Central Kalimantan in an area with unevenly distributed annual precipitation averaging 2,067mm, resulting in occasional water deficits.

On such sandy soils, nutrient losses by leaching are expected to be particularly high especially during times of high rainfall. With reference to the 4R nutrient stewardship concept (IPNI, 2012), it is hypothesised that increasing the frequency of fertilizer application on such soils should reduce the losses of nutrients and increase the efficiency of the applied fertilizers. To test this hypothesis, a project was started at PT Sungai Rangit in Central Kalimantan by IPNI SEAP, K+S Kali GmbH and PT Sampoerna Agro Tbk.

MATERIALS AND METHODS

The project was established in 2011 with 12 full-sized commercial blocks (approx. 25 ha each) with very light textured soils (ca. 80% sand). The project includes 4 treatments, comparing increased application frequency with standard estate applications frequency for 2 fertilizer application rates (standard rate, reduced rate). The 12 blocks were thus grouped into sets of 4 blocks each with 3 replications. All blocks were planted in 1998 at similar plant densities with the same source of planting material.

Apart from the nutrient management treatments, all other management and agronomic practices in each block were standardized according to the management practices proven to support high FFB yield in the earlier IPNI SEAP project in the same conditions at the same location (Donough *et. al.*, 2011). FFB yield per block was recorded by the estate teams in the usual way i.e. daily harvested bunches counted, then total bunch weight assigned from mill weighbridge records.

The nutrient management treatments started in October 2011. In the improved practice (here referred to as the nutrition best management practice, BMP, treatment), blending of individual fertilizers viz. granular Urea (N=46%), Ammofos (N=16%, P_2O_5=20%, S=12%), and Korn-Kali+B (K_2O=40%, MgO=6%, S=4%, B_2O_3=0.8%), allowed for four applications of N, P, K, Mg, S, and B per year at reasonable labour requirements, while the control treatment was managed according to standard estate practice (SEP) with two applications of N (as granular Urea), K, Mg, S and B (as Korn-Kali+B) and one application of P, N and S (as Ammofos) per year using the same nutrient sources in the first year reported here.

Blending of fertilizers was a key change from current practice. The nutrient sources used were chosen firstly for their compatibility in blending. Secondly, by using multi-nutrient fertilizers such as Ammofos and Korn-Kali+B, blending done on-site was facilitated. Lastly, there was evidence from an ongoing field experiment in the region indicating that uptake of minor nutrients like B was improved when supplied as a component of a complex fertilizer, compared to the common practice of applying B as a straight fertilizer (K+S Kali GmbH, unpublished data).

In addition to blending, timing of applications in the BMP treatment was scheduled on the basis of historical rainfall records, avoiding the wettest periods.

In the absence of information on yield response to applied nutrients from rate-response trials in the region, the standard fertilizer rates were determined using a balance sheet approach taking into account estimates of nutrient immobilization and removal from published sources (Ng & Thamboo, 1967; Ng *et. al.*, 1968; Tarmizi & Tayeb, 2006). With clay content of only ca. 10-11%, the soil supply of nutrients was ignored in the calculations. Assumed values were used for nutrients added via rainfall based on survey of published (examples: Lara *et. al.*, 2000; Scheer, 2009) and unpublished data (Applied Agricultural Research; IOI Research Department). In the first year, the reduced rate treatments received 80% of the standard rate.

All fertilizers used in the project were sampled for analysis following sampling guidelines outlined in Appendix 8 of Fairhurst and Härdter (2003). All fertilizers were manually applied in the field by the fertilizer application teams of the estates where the project blocks are located. In the BMP treatments, the fertilizer blend was broadcast onto pruned fronds arranged between the palms rows and between palms within each row. In the SEP treatment, applications were done the same way, except that urea was applied within the palm circles so as to come into direct contact with the soil.

Samples of leaf, rachis and trunk tissues were taken annually, starting with baseline samples in September 2011, for determination of nutrient contents. Sampling and sample preparation for leaf and rachis tissues followed guidelines as described in Appendix 3 of Fairhurst and Härdter (2003). Procedure for sampling and preparation of trunk tissue was based on Prabowo and Foster (2006). All prepared samples were sent to the Asian Agri Laboratory for analysis.

Growth measurements were recorded annually, starting with baseline measurements in September 2011, using procedures described in Appendix 6 of Fairhurst and Härdter (2003).

FRE was derived from the ratio of nutrients utilized (i.e. nutrients removed in FFB plus nutrients immobilized in palm trunks) in relation to nutrients supplied from applied fertilizers. While the widely used difference method would overestimate the fertilizer efficiency during the initial treatment phase, the ratio method employed here is more appropriate for use in permanent cropping systems under continuous management (Finck, 1982).

RESULTS AND DISCUSSION

Results on FRE are presented here for the standard rate treatments for the first year (Oct-2011 to Sep-2012) of the project, as part of an ongoing monitoring and assessment process that is meant to allow adjustments to management as required.

Using this approach the SEP treatment reached a FRE of 53% for N (from Urea and Ammofos), 71% for P (from Ammofos), and 37% for K and 62% for Mg (both from Korn-Kali+B) (*Table 1*). Applying N and K sources four times in a year increased their efficiency by 10% and 18%, respectively. However, the efficiencies of the P and Mg sources was not improved with increased frequency of application.

TABLE 1. EFFICIENCY OF RECOVERY OF NUTRIENTS IN THE FIRST YEAR IN A NUTRIENT MANAGEMENT PROJECT IN CENTRAL KALIMANTAN

	N	P	K	Mg
BMP[1] treatment (fertilizers blended, then applied 4x per year)				
Nutrients supplied i.e. applied in fertilizers (kg/ha)	134.6	12.2	243.0	26.5
Nutrients removed in FFB[3] & fixed in trunk growth (kg/ha)	78.7	8.7	107.2	16.1
Fertilizer recovery efficiency (FRE, in %)	*58.5*	*71.5*	*44.1*	*60.8*
SEP[2] treatment (fertilizers applied singly as straights)				
Nutrients supplied i.e. applied in fertilizers (kg/ha)	129.2	11.7	233.3	25.4
Nutrients removed in FFB[3] & fixed in trunk growth (kg/ha)	68.5	8.3	87.2	15.9
Fertilizer recovery efficiency (FRE, in %)	*53.0*	*71.2*	*37.4*	*62.3*
% Difference BMP versus SEP treatments	*+10.3%*	*+0.5%*	*+18.0%*	*-2.5%*

1 – BMP = best management practice; 2 – SEP = standard estate practice; 3 – FFB = fresh fruit bunches

The lack of effect on the P and Mg recovery efficiency is most likely attributable to the use of rock phosphate (RP) and dolomite (DOL), respectively, by the plantation prior to treatment initiation. Both of these nutrient sources are known for their slow dissolution, so residual release of P and Mg from previously applied RP and DOL is likely to have masked the P and Mg treatment effects in this initial period of the project. However, as RP and DOL are not used in the project, if the increased frequency of application does improve the P and Mg recovery efficiencies, it can be expected to show as the project progresses in the coming years.

Nutrient concentrations in trunk tissue were much higher with the BMP (i.e. higher application frequency) treatment (*Table 2*). On the other hand, nutrient contents in leaf (i.e. pinnae) tissue were comparable for both BMP and SEP treatments, and generally falling within the optimal range as defined in Appendix 3 of Fairhurst and Härdter (2003). FFB yield (*data not shown*) averaged 24.8 tons per ha, with no significant difference between the treatments during this first year.

TABLE 2. NUTRIENT CONTENTS IN PLANT TISSUES IN THE FIRST YEAR IN A NUTRIENT MANAGEMENT PROJECT IN CENTRAL KALIMANTAN

	N	P	K	Mg
Nutrients in leaf tissue (% of dry matter)				
BMP[1] (fertilizers blended, then applied 4x per year)	2.63	0.159	1.15	0.23
SEP[2] (fertilizers applied as straights/compounds)	2.59	0.156	1.25	0.22
% Difference BMP versus SEP treatments	*+1.5%*	*+1.9%*	*-8.0%*	*+4.5%*
Nutrients in rachis (% of dry matter)				
BMP1 (fertilizers blended, then applied 4x per year)	0.37	0.058	1.61	NA
SEP2 (fertilizers applied as straights/compounds)	0.34	0.044	1.63	NA
% Difference BMP versus SEP treatments	*+8.8%*	*+31,8%*	*-1.2%*	
Nutrients in trunk tissue (% of dry matter)				
BMP[1] (fertilizers blended, then applied 4x per year)	1.08	0.071	2.40	0.09
SEP[2] (fertilizers applied as straights/compounds)	0.92	0.059	2.02	0.07
% Difference BMP versus SEP treatments	*+17.4%*	*+20.3%*	*+18.8%*	*+28.6%*

1 – BMP = best management practice; 2 – SEP = standard estate practice; NA = not analyzed

While these are just the early results from the ongoing project, the indication is that improved FRE may not be well reflected in standard indicators like FFB yield and leaf nutrient concentrations. For better nutrient management, determination of the nutrient contents of storage tissues (rachis currently being the most practicable) may become necessary to provide additional indicators.

CONCLUSION

This first assessment from the ongoing project suggests that increasing the nutrient application frequency using a multi-nutrient fertilizer blend improves the efficiency of nutrient management for oil palms grown in the sub-optimal conditions prevailing at the project site. This is particularly important for plantation profitability in view of the large contribution of fertilizers to field maintenance costs. In a larger context, the results are important for the sustainable intensification of oil palm production under similar sub-optimal conditions elsewhere.

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