Nutritional imbalance

in smallholder oil palm plantations in Indonesia

by Lotte Woittiez, **Plant Production Systems group, Wageningen University, Netherlands**

Oil palm (Elaeis guineensis Jacq.) is an exceptionally efficient producer of vegetable oil. Its potential production is estimated to be well over 10 tons of oil per hectare per year, at least three times more than the second most efficient vegetable oil producer, canola. The cultivation of oil palm provides a steady source of income for both plantation companies and smallholders. In Indonesia, the world's largest oil palm producing country, around 45% of the area under oil palm is owned by smallholders. The majority of the smallholders manage their plantations individually, applying inputs and implementing management practices as they see fit. Yields in smallholder plantations are estimated to be 3-4 tons of oil per hectare, which is lower than company-owned plantations and far less than the production potential. Poor fertilizer application practices come up in many studies as a key problem in smallholder systems. Farmers tend to over-apply cheap nutrients (especially N) and under-apply the more expensive ones (especially K), leading to nutritional imbalance. There are several obvious solutions to improve plant nutrition, but the implementation of these solutions in the complicated socio-economic context of the smallholders is challenging.

Depending on the definition, smallholder oil palm farmers own anything between a garden with a few palms and a plantation of up to 50 hectares. Unlike plantation companies, smallholders usually do not operate their own mill, so the nearby presence of a mill for the rapid processing of the harvested fresh fruit bunches is crucial.

In some cases, smallholders have a contract with one mill, often coupled with a loan for the (re)planting of the plantation. In this case, the smallholders are termed "scheme", "plasma" or "tied" smallholders. Farmers without a contract are the so-called "independent" smallholders. They are free to sell their fruit bunches to any mill, but often they are dependent on traders or middlemen, who will pay a lesser price for the bunches.

Fertilizers account for 50-70% of the variable production costs in smallholder oil palm plantations. The Indonesian government provides subsidized fertilizers aimed at smallholder farmers (less than two hectares) through a closed system of producers, retailers, and farmer groups placing requests. The subsidized products are urea, sulphate of ammonium, super phosphate (SP-36), NPK (usually Ponska: 15-15-15 + 10S) and certain organic fertilizers. Registered oil palm farmer groups can request the subsidized fertilizers, but they are also regularly (and illegally) traded on the market, for inflated prices. The subsidy policies are reflected in farmer practices; surveys among >500 oil palm farmers in Sumatra and Kalimantan showed that the majority relied on NPK Ponska, often supplemented with urea or SA and SP-36, for the mineral nutrition of their plantations. This combination of fertilizers is not sufficient to meet the nutrient demand of oil palm on most tropical soils, as large amounts of K are also removed from the plantation in the harvested bunches, and need to be replenished. While MOP is usually applied at rates of 300-550 kilogrammes per hectare in company plantations, most Indonesian oil palm farmers don't apply any because they consider it too expensive. This under-application of K is illustrated

in the graph, which shows the nutrient applications in smallholder plantations as calculated from several case studies. While N and P are often applied in excess compared with the estimated offtake rates, K is applied in insufficient amounts, both compared with N and with the offtake rates. A pilot sample collection among 48 smallholders in Sumatra and Kalimantan confirmed widespread K deficiency in the palm tissue, alongside with N and P deficiencies in some plantations.

Investment limitations

The current low crude palm oil (CPO) prices, combined with insecure relationships with mills, poor bunch quality, poor planting material, and increased climatic risks due to climate change, cause Indonesian smallholders to be less willing to invest in fertilizers. Under such conditions, aiming for maximum yields is risky, and it is not always the most profitable approach. However, there are numerous options to improve palm nutrition without requiring large additional investments in fertilizers.

Firstly, the use of mill waste streams, especially empty fruit bunches, as organic fertilizer is necessary for improving the nutrient balance in smallholder plantations. Empty bunches can be applied in several ways: directly as a mulch; incinerated to produce bunch ash; or mixed with palm oil mill effluent (POME) and composted for two to four months. Empty bunches are very rich in K, and an application of 25-40 ton ha-1 as mulch can meet the K demand of a high-yielding plantation for one year. The positive effects of empty fruit bunch applications on soil quality are well documented, and include strong increases in organic matter content, water holding capacity and water infiltration, and nutrient content. In peat soils, bunch ash can provide large quantities of K and alleviate soil acidity. But empty fruit bunches are not much used by smallholders, for several reasons, such as lack of awareness among about the benefits, lack of access due to competition with company plantations, high transport and labour costs, and lack of a proper distribution system at mill level. When companies are allowed to buy up empty bunches at the expense of smallholders, this leads to a de facto stream of nutrients (especially K) from resource-constrained smallholder plantations to resource-rich company plantations. The commitment of leading trading and plantation companies (especially RSPO members) to ensure that their mills implement fair and proper distribution of empty bunches to smallholders would be a great step forward.

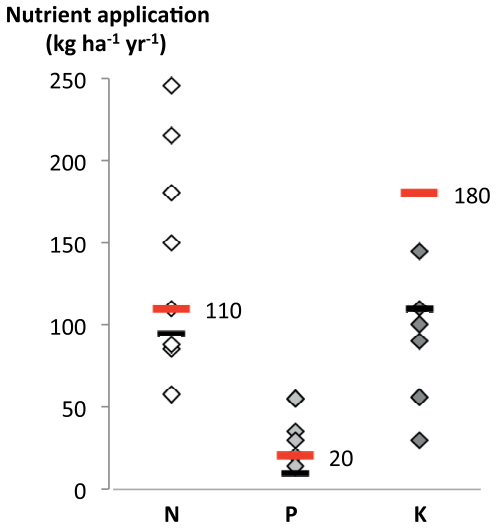
Nutrient deficiency symptoms in a mature smallholder plantation in West-Kalimantan

Management and applications

Secondly, plantation management needs to be optimized in order to achieve maximum nutrient capture. Problems in plantation management include the clear-weeding of fields (leading to soil erosion and fertilizer run-off) and the inefficient spreading of the available organic material (pruned fronds). Clear-weeding practices are often a consequence of lack of knowledge, but a certain

Figure 1. Nutrient applications in Indonesian smallholder oil palm plantations from case studies among >500 farmers in Sumatra and Kalimantan.

Each case study is represented with a dot. The red line shows the nutrient removal at a production of 24 ton fruit bunches ha^{-1} year^{-1}, and the black line shows the average fertilizer applications in oil palm plantations in Indonesia. Data from publications by Michael Euler, Janice Lee, Lifianthi, Irina Comte, Hereward Corley, and Patrick Heffer.



> *When farmers are not supported by companies, they usually cannot access adequate fertilizer*

preference for the aesthetics of a 'clean' plantation and the use of imprecise or poorly calibrated spraying equipment also play a role. Although path and circle weeding is more rapid and requires less herbicide use once the circles and paths have been established, clear-weeding is still perceived by farmers as necessary and useful to keep weeds under control. Frond stacking is normally done in piles or rows, but stacking in boxes is recommended to maximize the covered soil area, speed up decomposition, and reduce surface runoff. Harvesters cut most of the fronds, but they are paid per ton of harvested bunches and therefore have no incentive to implement proper frond stacking. This leads to limited implementation of box stacking, although it does not take more time or effort than stacking in a pile or row.

Thirdly, poor fertilizer application practices reduce nutrient capture. Farmers tend to apply all fertilizers in a narrow band around the palms (leading to increased leaching and run-off). They apply fertilizers only once per year, rather than in multiple splits, and mix them manually. While the available studies do not show any effect of fertilizer placement on oil palm yield, the even spreading of fertilizers on the largest possible soil area is recommended in mature plantations, based on agronomic principles.

Roots of mature palms are well able to colonize the area between palms, and the application of fertilizers on top of decomposing fronds, rather than on the dry and bare soil in the palm circle close to the trunk is recommended to improve fertilizer infiltration and reduce leaching and run-off. The application of N, K and Mg fertilizers in at least two splits reduces leaching and ensures nutrient availability throughout the year. The use of multiple rounds is especially important on light soils and in high-rainfall areas. The manual mixing of straight fertilizers is obviously not recommended. Farmers use this as a labour-saving option, and are not aware of the poor fertilizer distribution that will result.

Empty fruit bunches

Nutrient requirement knowledge

The application of sufficient quantities of good-quality fertilizers remains an important challenge for the smallholders. If the over application of N is reduced and the resources are re-invested in K fertilizer, then the overall palm nutrition could be improved without requiring additional investments. But when farmers are not supported by companies, they usually cannot access adequate fertilizer recommendations. It is considered good practice in oil palm cultivation to rely on leaf sampling in order to provide recommendations, but for many farmers this is prohibitively expensive, due to their smaller scale. In addition, training and experience are required to identify the correct leaf for sampling, and to collect and process the samples. Many farmers have limited knowledge about the nutrient requirements of their crop, which limits their ability for critical selection of proper fertilizers. They rarely have access to well-trained extension workers who can provide best-estimate recommendations. Fake fertilizers are a common problem throughout Indonesia, with the expensive fertilizers being replaced with cheaper materials, such as ground bricks in case of MOP. When farmers work together as a group, they can afford to test the fertilizers they purchase, but for individual farmers this is not feasible. The purchase of expensive fertilizers therefore becomes risky, and many farmers are not aware of simple tests such as dissolving fertilizers in water. In addition to fake fertilizers, there are many 'snake oil' fertilizers on the market, such as bacterial and hormonal solutions. These are sold to the farmers through smart sales campaigns and because the farmers lack background knowledge about plant physiology and nutrition, they are not well able to detect nonsense products. It is very worrying to see farmers invest in

A smallholder farmer in Jambi applies dolomite in the palm circle

overpriced bacterial solutions, which also require large labour-investments for their application, but fail to invest in proper mineral fertilizers such as MOP because they are considered too expensive.

Access to fertilizers

There is currently much attention from industry, government and NGOs to include smallholder oil palm producers in the supply chain and promote the use of good agricultural practices. In order to achieve lasting improvements in plant nutrition, partnerships with farmers, mills, fertilizer dealers, banks, and extension services are required. An early and affordable win is to encourage mills to ensure the availability of empty fruit bunches and to promote their use among smallholders. Also, farmers need to be encouraged to work together as a group to access subsidized fertilizers. Although the benefits of subsidized fertilizers may be debated, it is clear that the lower costs can stimulate farmers to buy fertilizers, especially when returns on investments are expected to be small due to constraints such as poor planting material and low prices for fruit bunches. Subsidized fertilizers alone are not sufficient to provide the correct nutrient balance and therefore it is essential that farmers are connected with a reliable fertilizer dealer, or are provided with good-quality fertilizers by the mill they deliver to. In order to purchase the fertilizers, some farmers will need access to credit through banks, cooperatives, or traders. The use of mobile devices and apps can help farmers to implement proper yield recording, which is necessary to support decision-making with regards to fertilizer applications. Finally, good trainings and extension materials (such as posters and movies) dealing with the basics of soil science, plant physiology, and plant nutrition should be made available for those farmers who interested in becoming more knowledgeable.

The smallholder oil palm sector in Indonesia is an important driver of rural development and continues to expand its market share. Addressing the numerous issues related to plant nutrition can provide large benefits to smallholders and improve the profitability and sustainability of the Indonesian oil palm sector as a whole. ■

Lotte Woittiez is a PhD student with the Plant Production Systems group of Wageningen University in the Netherlands. Her work focuses on yield gaps in smallholder oil palm plantations in Indonesia. The project is co-funded by K+S Kali, Johnson & Johnson, SNV, and IDH. The commercial partners played no role in the collection, analysis and interpretation of the data, nor in the writing and the decision to publish.