Sulfur Nutrition of Oil Palm in Indonesia—The Neglected Macronutrient

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Little attention has been paid to the S nutrition of oil palm, despite a trend towards using fertilizers that contain no S.

Data show S concentrations can be far below the established critical value of 0.20%.

The established critical S concentration should be reduced to 0.15% based on a critical N concentration of 2.3% and an S:N ratio of 15.

There has been little research on S in oil palm compared with other plant macronutrients. This is because until recently most nutrition research on oil palm was done in Malaysia, where ammonium sulfate [$(NH_4)_2SO_4$] is the main source of N that, together with organic fertilizer and industrial and other air pollution, ensured adequate S supply. Oil palm requires similar amounts of S and Mg, with the literature putting critical levels of both nutrients in frond #17 at 0.2% (Fairhurst et al., 2005). Out of the several amino acids that make up plant protein, cysteine and methionine contain S, and the ratio of N to S in plant protein often is about 15. Sulfur is an important component of oil synthesis and many oil crops respond strongly to S supply although there are no reports of S responses in oil palm.

In contrast to Malaysia, urea is the main source of N for oil palm in Indonesia, while other fertilizers containing S such as single superphosphate ($Ca(H_2PO_4)_2 + 2CaSO_4$) are seldom used. As a consequence, the S status has declined in Indonesia due to its removal with the harvested fruit and S losses to leaching. Sumbak (1983) and then Ng et al., (1988) predicted that the trend towards high-analysis fertilizers and high-yielding palm varieties would lead to widespread S deficiency in Indonesia.

Abbreviations and notes: N = nitrogen; Mg = magnesium; S = sulfur.

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Measuring and preparing oil palm reference frond #17 sample for plant analysis.

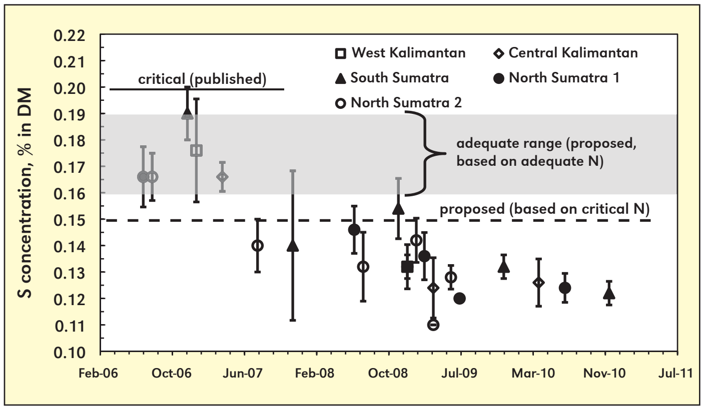

Figure 1. Change in sulfur concentration in frond #17 at selected sites sampled between 2006 and 2011 (means ± standard deviation).

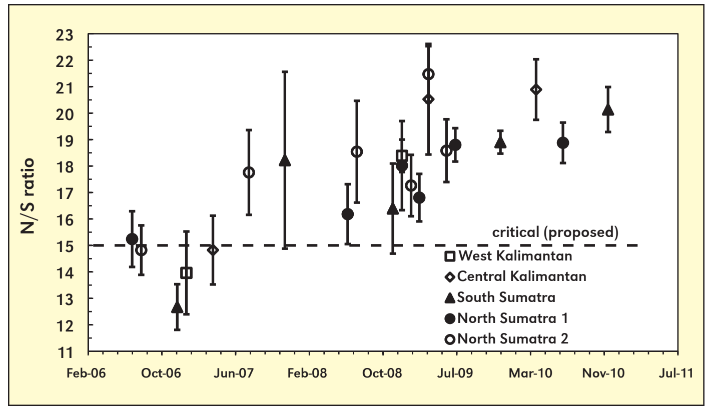

Figure 2. Change in nitrogen to sulfur ratio in frond #17 at selected sites between 2006 and 2011 (means ± standard deviation).

At this time there were a few reports of low leaf S concentration. Wigena et al., (2006) found 0.14% S in leaves in an S-free fertilizer treatment, who was preceded by Turner et al., (1983) indicating S deficiency in nursery seedlings in North Sumatra.

Best Management Practice (BMP) projects conducted by the IPNI Southeast Asia Program (SEAP) on sustainable intensification of oil palm (Donough et al., 2009) have analyzed nutrient status, including S, of oil palm in Indonesia. From July 2006, IPNI SEAP has established BMP projects on 30 commercial blocks with a total area 1,082 ha in partnership with collaborating plantations at two sites in North Sumatra and one each in South Sumatra, and West, Central, and East Kalimantan. These sites span the range of conditions where oil palm is currently grown in Indonesia. Corresponding blocks with standard estate practices (SEP, total area 1,104 ha) were compared to the BMP blocks. Each block was sampled for plant nutrient status between 2006 and 2011. Leaf tissue from reference frond #17 was sampled from every tenth palm in every tenth row and analyzed for nutrient content. Results for N and S from the SEP blocks were used in this study.

Leaf Sulfur Status

From the start of sampling, S status was far below 0.20% S, the published critical concentration (Calvez et al., 1976; Fairhurst et al., 2005). Moreover, there was a continuous decline over time in leaf S status at all sites. The S concentration in leaves of adult oil palm in Colombia was below the 0.2% margin in most of the plantations surveyed (Dávila et al., 2000). These data challenge whether 0.20% S is a satisfactory critical value.

The N:S ratio is used for crop diagnosis with some limitations mainly because N is more mobile than S. Critical N:S ratios for wheat, rapeseed-mustard, maize, and alfalfa in the Indo-Ganges plain were 16, 15.5, 11, and 16, respectively (Khurana et al., 2008). This agrees with the typical N:S ratio of 15 for plant proteins. Mean N:S ratios in frond #17 of oil palm were measured at 15.1 (Breure and Rosenquist, 1977), which suggests that a critical N:S ratio of 15 would be reasonable for oil palm.

The critical N concentration in frond #17 of mature oil palm is 2.3% (Von Uexküll and Fairhurst, 1991). Applying the N:S ratio of 15 gives a critical S concentration of 0.15%. Khalid and Zakaria (1993) applied variable levels of S to oil palm, including an S-free control, for seven years. They saw no symptoms of S deficiency and measured leaf S concentrations between 0.16 and 0.30%—the lower concentration confirming the 0.15% proposed here.

The data from the BMP project show that the S status was marginal at the start and declined over time, approaching a baseline value of around 0.12% (**Figure 1**). Correspondingly, N:S ratios increased steadily during the course of the experiment reaching mean values of above 20 at several sites (**Figure 2**). N:S ratios on all sites in 2009 were above 15, ranging between 17.9 to 20.5, although the differences were not significant ($p > 0.05$). Sulfur concentrations were only 80% of the new critical value of 0.15% (**Figure 1**).

A yield response to S fertilizer can be expected, but this needs experimental validation. IPNI is therefore planning to establish field trials to (1) re-evaluate the critical S concentration in leaf tissue of oil palm and (2) assess the yield response to S supply.

The cost of applying fertilizer S is small compared with potential gains in oil yield. The expected impact of S on N use efficiency, oil synthesis and kernel quality will convince plantation managers to apply S fertilizer. Sulfur source options will depend on fertilizer cost and availability. In Indonesia, several mineral fertilizers containing S are available [e.g., $(NH_4)_2SO_4$, potassium sulfate (K_2SO_4), magnesium sulfate ($MgSO_4$), potassium magnesium sulfate ($K_2SO_4 \cdot 2MgSO_4$), single superphosphate], but are either expensive or of limited availability. Kieserite ($MgSO_4 \cdot H_2O$), which is easily available, is also a good immediate option. With 16% Mg and 21% S, it matches oil palm's requirements. As a general precaution against S deficiency it is suggested to include S at 10% of the N dose in the fertilizer regime.

Summary

Based on a critical N:S ratio of 15 in the leaf tissue of oil palm and a critical N concentration of 2.3%, we suggest that the critical concentration of S be decreased from 0.20% to 0.15%. Leaf samples taken from six sites across Indonesia had S concentrations of 0.12 to 0.13%, which are lower than even this new critical value. It is concluded that (1) oil palm plantations need to include S in their routine leaf analysis, particularly if they do not apply fertilizer containing S; (2) S concentration in frond #17 less than 0.15% requires remedial application of fertilizer containing S; and (3) researchers and agronomists should become aware that S is an essential nutrient for oil palm. BC

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Planters should be aware of sulfur deficiency.

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