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Function and Nutrient Status of Sulphur in Oil Palm in Indonesia

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Introduction

The nutrient element sulphur (S) has received much less attention than other macro nutrients, although, S and, e.g., Mg are required in similar amounts by oil palm (OP). The published critical value for frond #17 is 0.2% for both nutrients (FAIRHURST et al., 2005). Sulphur fulfils numerous functions in plant metabolism. It is a component of S-containing amino acids, resulting in the physiological interaction between S and N. Sulphur is also involved in oil synthesis, and a strong response of oil crops to S supply has been reported (PASRICHA and AULAKH, 1991).
Sulphur as an essential nutrient has been largely neglected in OP nutrient management, partly because most of the early research on oil palm nutrition has been carried out in Malaysia, where ammonium sulphate (SOA) has for long been the most common N source. In addition, soil organic matter, organic fertilizers, S deposition from natural (volcanic eruption, fires) and man-made resources (industrial pollution), and ground water contribute to the S availability to a crop (PASRICHA and FOX, 1993). In oil palm, major losses of S are attributed to nutrient export by fresh fruit bunches (FFB) and leaching of sulphate. Leaching losses are governed by soil texture (high losses in sandy soils) and the water balance (high losses in high rainfall areas).

In Indonesia, urea has been the most often used N source for decades and for reasons of assumed savings dolomite has been used in preference to kieserite ($MgSO_4 \cdot H_2O$). Other S-containing fertilisers (single superphosphate, SOP) never played a major role in OP fertilisation. Burning of forest has also come under some control in recent years. In summary, over the years the S input has incidentally been reduced, despite continuous S removal with the FFB and losses by leaching. In fact, as early as the 1980's several publications already addressed the issue and predicted more widespread occurrence of S deficiency, as the trend towards using fertilisers low in S and increasing yields continues (NG et al, 1988, SUMBAK, 1983). Consequently, a decline of the S status of OP in Indonesia has been anticipated, but corresponding reports are missing. In the course of the BMP (Best Management Practice) projects on sustainable OP cultivation of the IPNI SEA programme (DONOUGH et al., 2009) nutrient status analysis were carried out and are used here to assess the S status of OP in Indonesia.

Material and Methods

Since July 2006, IPNI SEA has established 30 commercial blocks (total area 1080 ha) with BMP in partnership with five collaborating plantation groups at three locations in Sumatra (two in North, one in South Sumatra) and three locations in Kalimantan (West, Central and East). These six sites span a wide range of conditions where oil palm is currently grown in Indonesia (DONOUGH et al., 2009). At each site five reference blocks (REF) were managed following standard estate practices while another set of five blocks were managed according to BMP. As the BMP treatments did not specifically address the S status, only the results obtained for the REF blocks are presented here. The results obtained are considered highly representative for the majority of OP plantations in Indonesia. Measurements of plant nutrient status were taken between 2007 and 2011. Leaf sampling palms (LSP) were selected on a 10-in-10 fixed grid system and sampled as detailed by FAIRHURST and HÄRDTER (2003; Appendix 3). Dried leaves were sent to Asian Agri Laboratory (Tebing Tinggi, North Sumatra) for N and S analysis by the Kjeldahl and gravimetric procedure, respectively.

Results and Discussion

Frond #17 is typically used for assessing the nutrient status of mature OP, for which most complete sets of critical values are tabulated (e.g. CALVEZ et al., 1976, SUMBAK, 1983; FAIRHURST et al., 2005). The listed critical concentration for S of 0.2% is merely based on the early work of OLLAGNIER and OCHS (1972) and also agrees with RICHARDS (1972). A continuous decline in the S status was apparent at all sites (*Fig. 1*, left). From the very beginning all samples indicated a S status far below the published critical concentration of 0.2% S.

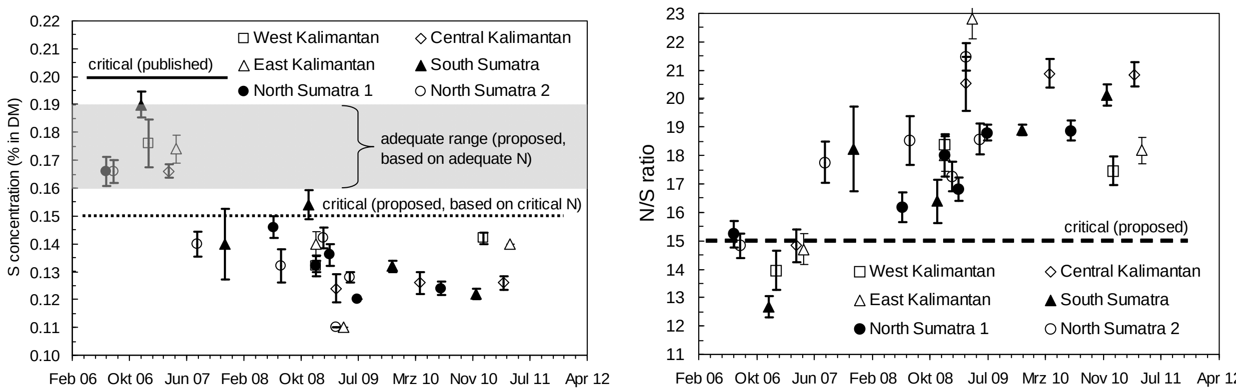

Fig. 1: Time course of the S concentration (left) and of the N/S ratio (right) of frond #17 (means ± SE, n = 5).

It may be argued that due to limited studies on the S requirement of OP the critical S level is not well supported. In addition, a range of alternative indicators have been discussed for other crops, mainly the sulphate concentration (ZHAO et al., 1996) and the N/S ratio. Although the use of the N/S ratio has its limitations (ZHAO et al., 1996) stemming partly from the low re-translocation of S as compared to that of N within the plant (PASRICHA and AULAKH, 1991), N/S ratios have been used for diagnostic purposes in a number of cases. In a recent compilation KHURANA et al. (2008) reviewed earlier studies for the Indo-Gangetic plain and listed critical N/S ratios of 16/1, 15.5/1, 11/1, and 16/1 for wheat, rapeseed-mustard, maize, and alfalfa, respectively. JULIANO et al. (1987) reported normal contents of S-containing amino acids in seed protein of brown rice grown in Bangladesh and Indonesia up to N/S ratios of 15/1 in the grain, which agrees well with the typical N/S ratio of plant proteins. In an earlier study on N × K interaction in OP, neither the FFB yield, nor the N or the S concentrations were significantly affected by the treatments (BREURE and ROSENQUIST, 1977). Based on these data the N/S ratio did not correlate with FFB yield, and on average a N/S ratio of 15.1±0.1 in frond #17 was observed. Overall, and in the absence of more appropriate studies in OP, a critical N/S ratio of 15/1 seems a fair estimate.

Considering a critical N/S ratio of 15/1 and a well-established critical N concentration in frond #17 of mature OP (≥6 years) of 2.3% (VON UEXKÜLL and FAIRHURST, 1991; FAIRHURST et al., 2005), a putative critical S concentration of 0.15% is deduced ((*Fig. 1*, left; see also NG et al., 1988). With reference to the more relevant adequate N concentration range of 2.4-2.8% (FAIRHURST and HÄRDTER, 2003; FAIRHURST et al., 2005), a critical S concentration range of 0.16-0.19% is obtained. Considering these adjusted critical S concentrations reveals that only during the initial phase of the BMP project the S status was in the adequate range, and continuously declined as the experiment proceeded until it stabilised at around 0.12% (*Fig. 1*, left). Correspondingly, N/S ratios increased steadily during the course of the experiment, reaching mean values of above 20/1 on several sites (*Fig. 1*, right). Values for N and S meeting the proposed critical ratio of 15/1 were not observed in recent years.

Table 1: Leaf S and N concentrations, and N/S ratios of frond #17 in 2009 (means ± SE, n = 5).

	North Sumatra 1	North Sumatra 2	South Sumatra	West Kalimantan	Central Kalimantan	East Kalimantan
S conc.	0.129 ± 0.002	0.127 ± 0.001	0.132 ± 0.002	0.132 ± 0.002	0.124 ± 0.005	0.125 ± 0.002
N conc.	2.30 ± 0.04	2.39 ± 0.04	2.49 ± 0.03	2.43 ± 0.04	2.53 ± 0.05	2.52 ± 0.06
N/S	17.87 ± 0.37	19.11 ± 0.26	18.90 ± 0.19	18.39 ± 0.27	20.52 ± 0.93	20.44 ± 0.67

For the year 2009 most complete data sets were available to compare the S status at different sites (*Table 1*). The proposed critical N/S ratio of 15/1 was not met on any site as mean values ranged from 17.9 to 20.5. Highest values were reported for Central and East Kalimantan, but means differed not significantly. The corresponding S concentration indicates that the S status of OP was far below published or proposed critical concentrations at all sites. Highest values were observed in South Sumatra and West Kalimantan, while lowest values were recorded in Central and East Kalimantan. These results show that the S status of all sites evaluated is currently strongly deficient, based on established knowledge, irrespective of whether the evaluation is based on the published or the proposed critical concentrations. For 2009 it was calculated that the S status on average of all six sites fell short by 20% of the proposed lower end of the adequate S concentration range (0.16%). A strong FFB yield response to S fertilisation is thus to be expected. The well-known significance of S supply for oil formation further strengthens the importance of securing the S supply. Therefore, experiments are currently being established (1) to re-evaluate the critical S concentration and (2) to assess the yield response to S supply at commercial block scale.

Even though a yield response to S fertilisation has not yet been established at full commercial block scale, the substantial impact of S on N use efficiency and oil synthesis should urge OP plantations to consider securing the S supply. This becomes even more obvious in view of the moderate extra costs associated with additional supply of S. Apart from elementary S, which is not immediately available for plant uptake and has a strong acidifying effect, S is usually applied in sulphate form as a component of other fertilisers. Potentially the following sources could be used: SOA, kieserite ($MgSO_4 \cdot H_2O$), single superphosphate, potassium sulphate (SOP), gypsum, and S containing NPKs. Some of these sources are fairly costly and therefore not routinely used in OP cultivation (e.g. SOP, S containing NPKs), while others are not widely available to OP plantations in Indonesia (SOA, single superphosphate). In addition, SOA (24% S, 21% N) and SOP (42% K, 18% S) provide unnecessary high amounts of S when used to satisfy the N and K requirement, respectively. In view of the critical N/S ratio of 15/1 as discussed above and the high leaching losses of sulphate, a N/S ratio in the fertiliser regime of 10/1 should be adequate to secure the S demand of OP. In this regard, kieserite ($MgSO_4 \cdot H_2O$), providing similar amounts of Mg and S (16 % Mg, 21 % S), is expected to match well the Mg and S requirement of OP.

Conclusions and Outlook

Leaf samples taken from six estates under management considered representative for Indonesia indicate that the S status is very low (range 0.12-0.13%). Despite uncertainty as to the exact critical S concentration in frond #17, even the lower estimate (0.15%) based on a critical N/S ratio of 15/1 and a critical N concentration of 2.3% is not satisfied. It is concluded that (1) OP plantations should pay more attention to S and include the determination of the S status in their routine leaf analysis, (2) a S concentration in frond #17 of below 0.15% calls for immediate remedy by application of S-containing fertilisers, (3) a S concentration between 0.15% and 0.16% needs careful attention and the application of S-containing fertilisers might be considered depending on the N status and N/S ratio until further research is conducted, and (4) private and public research institutions and agronomists should pay more attention to S. In case S application is called for, several S-containing fertilisers are principally suitable, but – for reasons of market availability and S dose required – kieserite ($MgSO_4 \cdot H_2O$) seems particularly suitable.

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References

BREURE, C J and ROSENQUIST, E A (1977) Oil palm fertiliser experiment on volcanic soils in Papua, New Guinea. Oleagineux 32, 301-310.

CALVEZ, C; OLIVIN, J and RENARD, J L (1976) Study of a sulphur deficiency on young oil palms in the Ivory Coast. Oleagineux 31, 251-257.

DONOUGH, C R; WITT, C and FAIRHURST, T H (2009) Yield intensification in oil palm plantations through best management practice. Better Crops 93, 12-14.

FAIRHURST, T H and HÄRDTER, R (2003) (eds.) Oil Palm – Management for large and sustainable yields. International Plant Nutrition Institute (IPNI) and International Potash Institute (IPI).

FAIRHURST, T H; CALIMAN, J-P, HÄRDTER, R and WITT, C (2005) Oil Palm Series Volume 7, Pocket Guide: Nutrient Disorders and Nutrient Management. PPI/PPIC: Singapore and AgriSoft Systems Pte Ltd: Australia.

GOH, K J and HÄRDTER, R (2003) General oil palm nutrition. In: Fairhurst, T H and Härdter, R (eds.) Oil Palm – Management for large and sustainable yields, p. 191-230. International Plant Nutrition Institute (IPNI) and International Potash Institute (IPI).

JULIANO, B O; IBABAO, M G B; PEREZ, C M; CLARK, R B; MARANVILLE, J W; MAMARIL, C P; CHOUDHURY, N H; MOMUAT, C J S and CORPUZ, I T (1987) Effect of soil sulphur deficiency on amino acids and elements in brown rice. Cereal Chemistry 64, 27-30.

KHURANA, M P S; SADANA, U S and BIJAY-SINGH, 2008 Sulfur nutrition of crops in the indo-gangetic plains of south Asia. In: Jez J. (ed.) Sulfur: A Missing Link Between Soils, Crops, And Nutrition, p 11 - 24. Agronomy Monographs No. 50. Madison, USA.

NG, S K; THONG, K C; WOO, Y C and OOI, S H (1988) A Preliminary survey of leaf sulphur status of oil palms in Malaysia. Sulphur in Agriculture 12, 19-21.

OLLAGNIER, M and OCHS, R (1972) Sulphur deficiencies in the oil palm and coconut. Oleagineux 27, 193-198.

PASRICHA, N S and AULAKH, M S (1991) Twenty years of sulphur research and oilseed production in Punjab, India. Sulphur in Agric. (Washington) 15, 17-23.

PASRICHA, N S and FOX, R L (1993) Plant Nutrient sulphur in the tropics and subtropics. Advances in Agronomy 50, 209-269.

RICHARDS, L (1972) Sulphur deficiencies in certain tropical crops. A review of the conditions under which they occur and develop. International Symposium on Sulphur in Agriculture. Annales Agronomique, Numero Lors Serie 72, 1.

SUMBAK, J H (1983) Sulfur requirements of tropical tree crops. In: Blair G J and Till A R (eds.) Sulfur in South-East Asian and South Pacific agriculture, p. 65-75. Australian Development Assistance Bureau (ADAB), Armidale, New South Wales, Australia.

VON UEXKÜLL, H R and FAIRHURST, T H (1991) Fertilizing For High Yield and Quality - The Oil Palm. IPI-Bulletin No. 12. International Potash Institute, Worblaufen-Bern, Switzerland.

ZHAO, F J; HAWKESFORD, M J; WARRILOW, A G S; MCGRATH, S P and CLARKSON, D T (1996) Responses of two wheat varieties to sulphur addition and diagnosis of sulphur deficiency. Plant and Soil, 181, 317-327.