Managing Sulfur for Enhanced Productivity in the Irrigated Oil Palm Plantations of Southern India

By Teki Nagendra Rao and Nasim Ali

Information on response to S application in oil palm is limited, and there is a need to understand the importance of S nutrition in oil palm based on the crop's high removal rate plus the large potential for the loss of applied S.

Sulfur is recognized as one of the most limiting nutrients after N, P, and K in Indian agriculture. Low soil S concentrations and corresponding crop responses to S fertilization are commonly reported in India (Tandon, 2011). However, S nutrition in oil palm is less explored even though S uptake by oil palm and S removal through fresh fruit bunch (FFB) harvest are both considerable (Gerendás et al., 2015). Additionally, nutrient loss caused by high rainfall/irrigation events typical of the growing environment in southern India promotes significant leaching of S in sulfate form, especially in coarse-textured soils.

India's commercial oil palm production began in the 1960s and today the southern state of Andhra Pradesh is the largest center for oil palm cultivation in the country. Farmers in the state have achieved sustained success with oil palm under public-private partnerships involving government and commercial agencies. A survey was organized during 2013-14 to determine the nutritional status of this region's oil palm plantations. Leaf samples were collected from 177 mature oil palm plantations at Chintalapudi, Kamavarapukota, Dwaraka Tirumala, and Unguturu mandals of West Godavari district in Andhra Pradesh.

Composite samples were collected from each oil palm garden using the central point of the rachis of frond #17, and analysed for leaf N and S. The analyses revealed that N concentration ranged from 1.61 to 3.92% (average of 2.60%), and the average N concentration in all four mandals was within the published optimum range of 2.4 to 2.8% (**Table 1**). Similarly, the leaf S concentration ranged from 0.04 to 0.18% (average of 0.10%), indicating that values across all the surveyed plantations were below the published critical level of 0.20% (**Figure 1**).

Gerendás et al. (2015) reported a N:S ratio of 15:1 as optimum for oil palm grown in Indonesia. However, leaf analyses data in the current study showed N:S ratios ranging from 15 to 80 with a mean of 29, suggesting significant imbalance between these two nutrients (**Figure 2**). Leaf N:S ratio and leaf S concentration were significantly and inversely related to each other (**Figure 3**), highlighting the importance of S fertilization for narrowing down the prevailing N:S ratio.

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; S = sulfur; Ca = calcium; KCl = potassium chloride; 1 US$ = 64 Indian Rupees (Rs.).

Marking the palms for sulfur experiment.

Table 1. Leaf nitrogen concentration (%) of oil palm plantations in four mandals of West Godavari district, Andhra Pradesh.

Leaf N concentration	Chintalapudi	Kamavarapukota	Dwaraka Tirumala	Unguturu
Mean	2.58	2.76	2.57	2.50
Std. Dev.	0.39	0.50	0.28	0.25

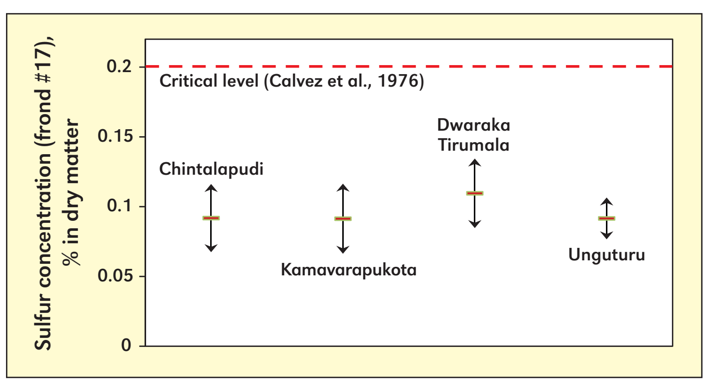


Figure 1. Average S concentration for samples of frond #17 (dry weight basis) in four mandals of West Godavari district, Andhra Pradesh (arrows indicate standard deviation).

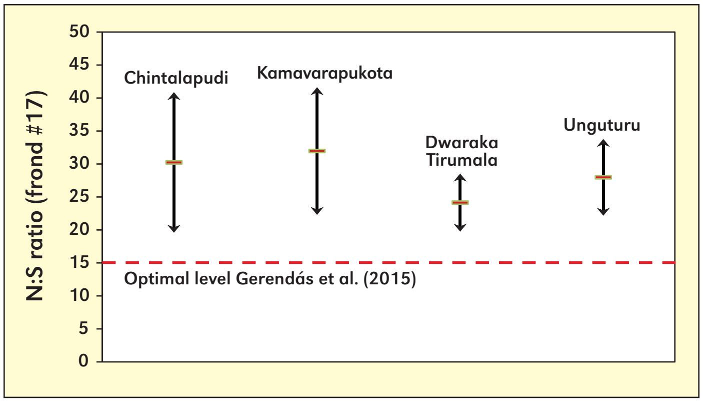


Figure 2. Average N:S ratio for samples of frond #17 (dry weight basis) collected across four mandals of West Godavari, Andhra Pradesh (arrows indicate standard deviation).

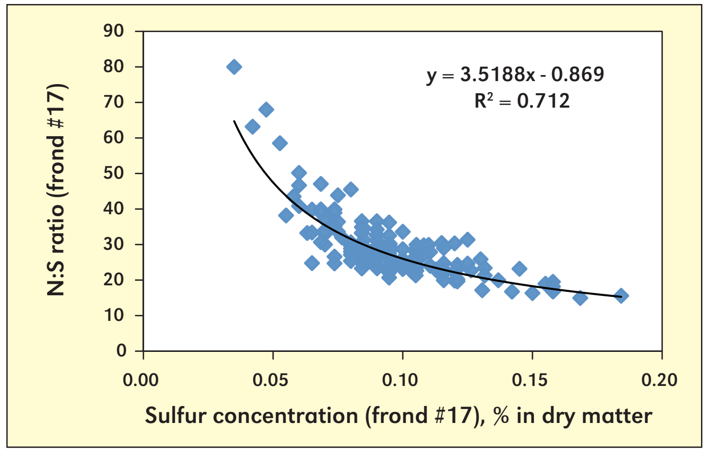


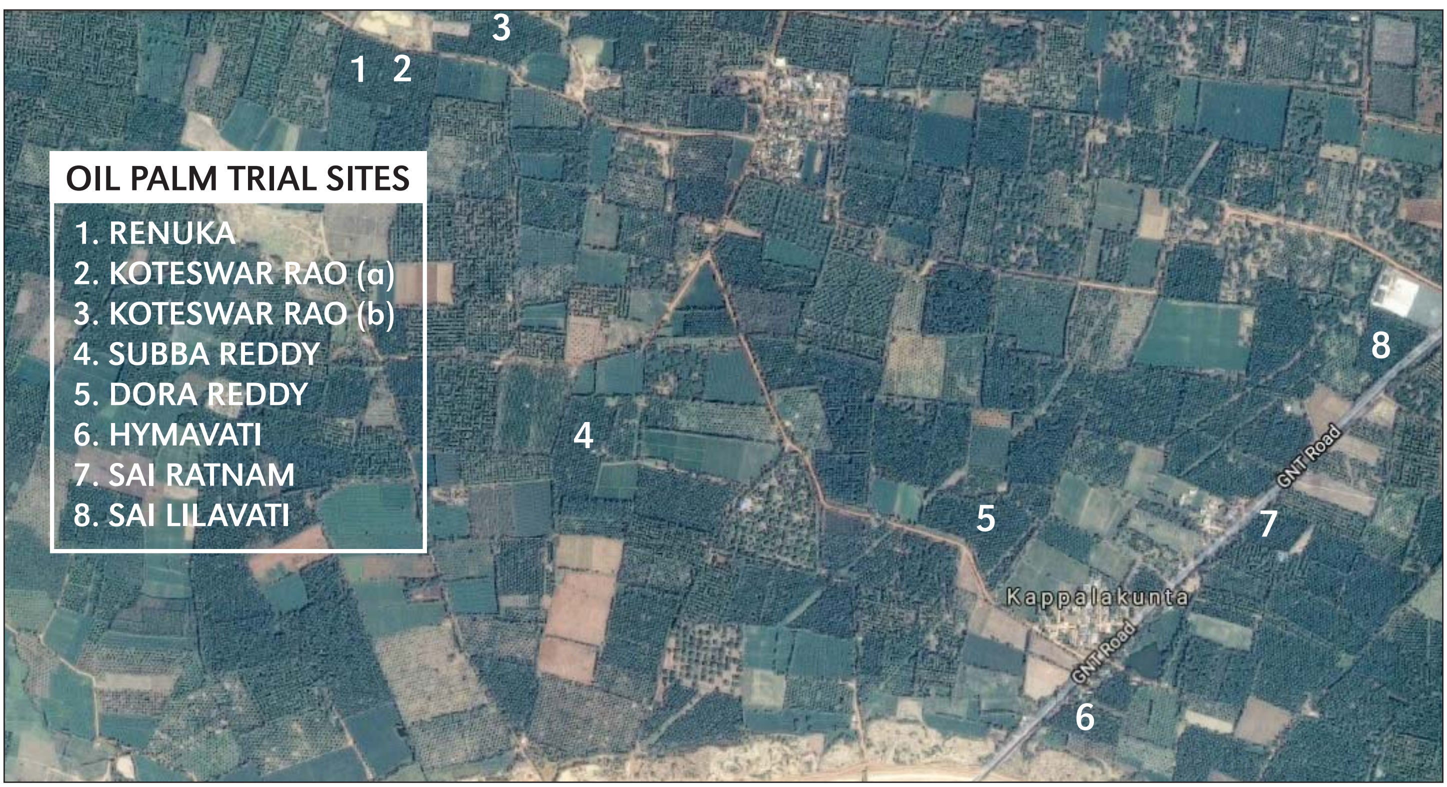
Figure 3. Relationship between N:S ratio and S concentration in samples collected across four mandals of Andhra Pradesh.

Farmers growing oil palm generally apply single superphosphate (SSP) as a source of P, which contains S in gypsum ($CaSO_4 \cdot 2H_2O$) form. However, it is not known whether such a sparingly soluble form of S is an appropriate source for oil palm grown in nearly neutral, coarse-textured soils. It is generally assumed that SSP indirectly supplies adequate S for the crop. However, our assessment of S status of oil palm plantations showed values below the critical level across the region. Either palms are low in S because of inadequate application rates or a lack of S availability due to an inappropriate source. A field study was organized during 2014 and 2015 to further investigate the response of oil palm to S fertilization in the region.

Sulfur Response Study

Mature oil palm plantations of 6 to 8 years in age were chosen at eight locations in the Kappalakunta area of Dwaraka Tirumala Mandal. The sites represented the sandy to loamy soil texture common to the region. Initial leaf and soil samples had S concentrations below critical values (averages across sites: 0.13% for leaves and 6.1 mg/kg for soil). Palms were irrigated through micro-sprinkler systems, a common practice followed in most plantations of the region.

The study consisted of three treatments: 1) farmer practice (FP), 2) FP + Gypsum, and 3) FP + elemental S (ES). Farmer practice was considered a control, blanket management practice that included N-P_2O_5-K_2O application of 1,200-600-1,200 g/palm/yr using urea, SSP, and KCl. This combination is a general recommendation for the region (Narasimha Rao et al., 2014). SSP contributed 400 g S/palm/yr. The FP + Gypsum treatment applied an additional 400 g S/palm/yr through the gypsum source (without increasing P dose). Since gypsum is also a S source being used by some farmers, this treatment was incorporated in the study. The FP + ES treatment added 400



Map showing multi location trial sites (farmer plantations) at Kappalakunta (Dwaraka Tirumal Mandal) where the experiment was organized during 2014 and 2015.

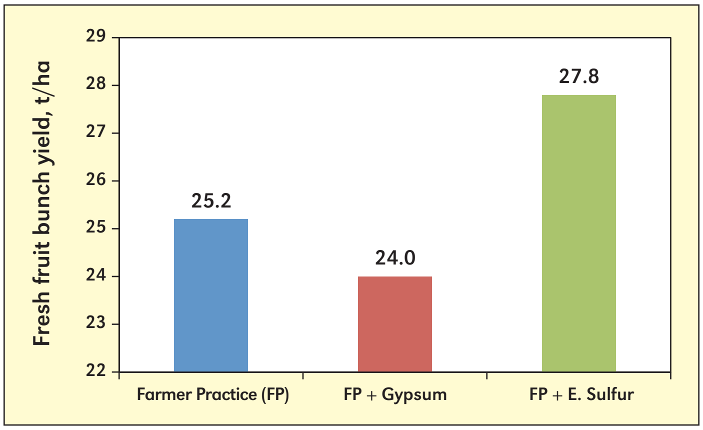


Figure 4. Average oil palm FFB yield response to additional S application over farmer practice at eight locations. Critical Difference = 2.03 (p = 0.05).

g S/palm/yr through a granular bentonite clay-based form of elemental S. Sulfur uptake and removal of S by oil palm were taken into consideration while deciding the rates of applied S.

Thus, the study considered increasing the dose of S application either through the gypsum source or the new bentonite S source. Of the two S sources, gypsum is a sparingly soluble S source with Ca as an associating cation whereas bentonite S is slow release in nature with no associating cation and sulfate is released only after oxidation. The entire S dose was divided into two equal splits (200 g S/palm at each application) and applied at an interval of three months from the beginning of each year to ensure better solubilization and absorption by the oil palm. Applied S was placed at the basin encircling the trunk at a distance of nearly one meter.

In each plantation, 30 palms distributed in three rows were selected for each treatment, and nutrients as per FP, FP + Gypsum, and FP + ES were applied to the three treatments. The middle row of 10 palms were tagged and observations were recorded only from the tagged palms to avoid a border affect. Thus at each location, 90 palms were chosen for the study (0.63 ha) and response to right source of S application was determined. FFBs were collected from each site at 10 day harvest intervals, weighed, and yields were recorded for two consecutive years (2014 and 2015).

The average yield of FFB, averaged over sites and years, across the oil palm plantations of the study region was 25.2, 24.0, and 27.8 t/ha/yr under FP, FP + gypsum, and FP + ES, respectively (**Figure 4**). The FFB yield in FP + ES was significantly higher compared to FP and FP + Gypsum. The results suggested that application of bentonite S along with FP improved the yield of FFB significantly by 2.6 t/ha/yr over FP. Application of FP, with additional application of 400 g S/palm sourced through gypsum had no profound effect on oil palm productivity as far as S nutrient source is concerned. The study also indicated that additional application of S at 400 g/palm through bentonite S resulted in an additional net return of Rs. 13,946/ha (US$218) with an improved incremental benefit:cost ratio of 4.7, respectively (data not shown). Hence, in order to obtain yield response to S application, oil palm growing farmers may choose bentonite S instead of gypsum as an appropriate S source applied at 400 g S/palm/yr.

Sulfur fertilizer application in a circle around the palm trunk (right place) as per prescribed method, each hectare is planted with 143 palms at nine meter distance triangular planting.

Summary

Leaf S concentrations in the oil palm plantations across four mandals of West Godavari district in Andhra Pradesh were below the referenced critical level of 0.20% S and had N:S ratios beyond 20:1, indicating the need for improved S nutrition. A multi-location field study conducted during 2014 and 2015 showed oil palm response to S fertilization. Application of 400 g S/palm/yr (in addition to FP) through bentonite S (bentonite clay based elemental S pastilles) was considered as an appropriate source of S to improve the FFB yield of oil palm. This may be applied in two splits at an interval of three months during early months of each year placed at the basin encircling the trunk at a distance of approximately one meter. Thus, practicing principles of 4R Nutrient Stewardship coupled with the inferences drawn from leaf tissue analyses shall form the basis of S nutrition for improved productivity of oil palm plantations in Andhra Pradesh. BC

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TAKE IT TO THE FIELD

Applications of a bentonite clay-based elemental S can provide an effective S supply for improving FFB yields of irrigated oil palm plantations grown on coarse-textured, S-limited soils.

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Annual IPNI Photo Contest: Now a Forum to Share Crop Diagnostics and 4R Accomplishments

A strip tillage implement designed to place phosphorus during the fall into winter wheat stubble **(example of 4R Nutrient Stewardship – Right Place)**. IPNI Image taken in Ontario, Canada.

Vibrant expression of phosphorus deficiency in corn **(First Prize winner in 2016)**. Taken near Limington, Maine, USA by Jim Valent, State College, Pennsylvania, USA.

Starting this year, the International Plant Nutrition Institute's annual photo contest expanded its format to include (1) our regular competition for finding the clearest examples of crop nutrient deficiency and (2) a new 4R Nutrient Stewardship category designed to collect images that demonstrate the best use of crop nutrients with in-the-field examples of 4R Nutrient Stewardship—applying the Right Source at the Right Rate, Right Time, and Right Place.

The entries have been coming in steadily but we'd like to see more!

Submit your best photos in any of these four categories until December 5, 2017. Our winners will be announced early in 2018.

For additional information, please contact Gavin Sulewski, IPNI Editor, at gsulewski@ipni.net. You can also view past winners of the photo contest at http://www.ipni.net/photocontest/history BC

Photo Contest Categories

1. 4R Nutrient Stewardship - New!

2. Primary Nutrient Deficiencies
- nitrogen (N), phosphorus (P), and potassium (K)

3. Secondary Nutrient Deficiencies
- sulfur (S), calcium (Ca), and magnesium (Mg)

4. Micro Nutrient Deficiencies
- boron (B), copper (Cu), chloride (Cl-), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn).