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# Assessing the variation in leaf nutrient concentrations of oil palm (*Elaeis guineensis*) germplasms

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ABSTRACT

Leaf samples were collected from 17$^{th}$ frond of 157 palms comprising 52 accessions of *teneras* and Cameroon, Guinea Biassau, Zambian and Tanzanian *duras* available in the field gene bank of ICAR-Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh, to assess the variation in leaf nutrient concentrations of oil palm (*Elaeis guineensis* Jacq.) germplasm. Collected leaf samples were processed and analysed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S) and boron (B) concentration. Leaf nutrient concentrations varied widely across the germplasm. Cameroon (0. 88%), Zambian (0. 91%) and Tanzanian (0. 98%) *duras* recorded higher leaf K concentration compared to Guinea Bissau *duras* and *teneras*. The *teneras* like 118×57, 134×57, 29×155, 139×155 and D×N (Deli× Nigeria) recorded higher leaf S concentration. Among the Zambian *duras*, ZS-1, ZS-3 and ZS-5 accessions recorded higher leaf K concentration, whereas ZS-2, ZS-3, ZS-6 and ZS-8 accessions had higher leaf Ca concentration. These findings could play a vital role in identification and development of nutrient efficient oil palm germplasm.

**Key words:** *Elaeis guineensis*, Genotypes, Genetic variability, Leaf nutrient concentration

Oil palm (*Elaeis guineensis* Jacq.) produces two types of oil, viz. crude palm oil from mesocarp of fruit and palm kernel oil from kernel of the seed. With adoption of better management practices, 4 to 6 tonnes of crude palm oil and 0.4 to 0.6 tonne of palm kernel oil are produced from ha of oil palm. Efforts are being made to enhance area under oil palm cultivation in India to mitigate vegetable oil demand of the country. An area of 1.93 million ha covering 19 states is having potential for oil palm cultivation in India (Rethinam *et al.* 2012), however at present, oil palm cultivation is being carried out in an area of 0. 331 million ha in 14 states.

Nutrient requirement of oil palm is relatively high and it needs balanced supply of nutrients for obtaining optimum nutrient concentration for better growth and production of fresh fruit bunches (FFB). For most of the crops including oil palm, relationship between leaf analysis value and plant productivity is generally evident and an assessment of fertilizer needs can be based on such analysis. According to Pushparajah and Chew (1979), besides other factors, maintaining optimum nutrient concentration in oil palm is of immense importance for obtaining higher productivity. Analysis of frond number 17 is established as diagnostic tool for assessing fertilizer requirements in oil palm (Goh *et al.* 2003). Nutrient anomalies like nitrogen (N)/potassium (K) imbalance, magnesium (Mg) and boron (B) deficiencies in oil palm plantations is one of the major limitations adversely affecting oil palm production in India (Rao *et al.* 2014, Kalidas *et al.* 2017).

The roles of biotic factors on oil palm nutrition are expected to become more prominent as we breed for true to type inbred hybrids with more uniform genetic make-up on a commercial scale. It is reported that oil palm planting materials differ significantly with respect to leaf nutrients concentrations (Lee *et al.* 2012) and some clonal palms and hybrids are responsive to low fertilizer inputs and still produce higher yields. Thus, the knowledge regarding leaf nutrient concentrations of different accessions would help in the identification and development of nutrient efficient varieties. Leaf nutrient concentrations of oil palm hybrids cultivated in farmers' plantations of different states of India have been reported by Behera *et al.* (2016a, 2017). However, information regarding leaf nutrient concentrations of different accessions of oil palm germplasm available in India is limited. Keeping in mind the above idea the present study was carried out to assess leaf nutrient concentration in oil palm germplasm present in field gene bank.

## MATERIALS AND METHODS

The experimental material included 52 genotypes (a total of 157 palms) of 10-18 years age and comprising 19 hybrids (*tenera*) and 14, 8, 6 and 5 Cameroon, Guinea Biassau, Zambian and Tanzanian *duras* respectively. The study was conducted in 2016 at Research Farm of ICAR-

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IIOPR, Pedavegi, Andhra Pradesh which is located at 16°43'N and 81°09'E with average sea level of 13.40 m having average annual rainfall of 800 to 1200 mm (about 90% of rainfall is received during June-September). Mean highest (39°C) and lowest (23°C) temperature prevailed in the month of May and December, respectively. Mean highest (90%) and lowest (60%) relative humidity are obtained in the month of July-August and February, respectively. Soil of the study site is red sandy loam in nature. Oil palm germplasms were planted in 9 m × 9 m × 9 m spacing and grown as an irrigated crop. Recommended doses of fertilizers were applied in four equal splits during the year and standard crop husbandry practices were followed.

A total of 157 leaf samples were collected from 52 accessions by identifying 17$^{th}$ leaf by following standard procedures (Behera and Suresh 2013). Collected samples were processed by three stage washing followed by removal of excess water and air and oven drying. The dried leaf samples were powdered by using stainless steel mill and stored in polythene bottles for analysis. Leaf samples were analyzed for N, P, K, Ca, Mg, S and B concentration. The samples (except for N) were analyzed by taking 1 g material and digesting in nitric acid-perchloric acid mixture (9:4) following standard procedures (Jackson 1973). Nitrogen was estimated by micro-Kjeldahl method. Phosphorus, K and S were estimated by vanadomolybdate, flame photometer and turbidity methods, respectively. Ca and Mg concentrations were estimated by atomic absorption spectrophotometry (Jones *et al.* 1991). Boron was estimated through azomethine-H method (Gaines and Mitchell 1979).

Descriptive statistics revealing minimum, maximum, mean, standard deviation (SD), coefficient of variation (CV), skewness and kurtosis for leaf nutrient concentration were obtained. Unblock design analysis of variance (ANOVA) was used to analyze the data using SAS 9. 2 software pack (SAS 2011).

## RESULTS AND DISCUSSION

The concentration of N, P and K in the leaf samples of studied oil palm germplasms varied from 1.64 to 4.14, 0.10 to 0.27 and 0.47 to 1.20% respectively. Whereas, Ca, Mg, S and B concentration ranged from 0. 97 to 2.49, 0.29 to 1.15, 0.09 to 0.37% and 25.6 to 141 mg/kg, respectively. The mean values of leaf nutrient concentration followed the order N > Ca > K > Mg > S > P > B. The CV values ranged from 17.1 (for N) to 38.4% (for B). Our results are in line with the observations made by Lee *et al.* (2011) in different planting materials of Malaysia. The wide variation of leaf nutrient concentration across the germplasms is ascribed to varied genetic make-up of the population. Skewness values of leaf nutrients varied from -0.13 (for K) to 1.12 (for N) revealing their normal distribution. This is in agreement with the findings of Behera *et al.* (2016d) who reported skewness values of -0.46 to 3.22 for leaf nutrients of oil palm plantations in different states of India.

The mean values of N, P, Ca, Mg, S and B concentrations

Table 1 Mean (±SD) leaf nutrient concentrations of teneras

| Hybrids | N (%) | P (%) | K (%) | Ca (%) | Mg (%) | S (%) | B (mg/kg) |
|---|---|---|---|---|---|---|---|
| 53×57 | 2.45±0.08 | 0.18±0.04 | 0.66±0.13 | 1.73±0.26 | 0.64±0.05 | 0.21±0.03bcde | 64.7±28.5 |
| 118×57 | 2.90±0.53 | 0.16±0.01 | 0.69±0.17 | 1.62±0.62 | 0.50±0.24 | 0.26±0.04a | 43.7±13.3 |
| 119×57 | 2.26±0.06 | 0.18±0.03 | 0.65±0.20 | 1.46±0.19 | 0.72±0.09 | 0.19±0.02cdefg | 66.0±20.2 |
| 134×57 | 3.10±0.23 | 0.18±0.04 | 0.57±0.08 | 1.65±0.44 | 0.76±0.12 | 0.23±0.02abc | 76.5±31.1 |
| 135×57 | 2.28±0.21 | 0.20±0.05 | 0.74±0.18 | 1.56±0.26 | 0.68±0.28 | 0.17±0.01efg | 71.5±26.6 |
| 155×57 | 2.55±0.45 | 0.18±0.03 | 0.91±0.17 | 1.50±0.32 | 0.59±0.32 | 0.17±0.05efg | 62.4±26.7 |
| 165×57 | 2.44±0.42 | 0.18±0.02 | 0.73±0.21 | 1.65±0.12 | 0.60±0.10 | 0.17±0.03fg | 58.4±23.3 |
| 29×155 | 2.64±0.24 | 0.16±0.00 | 0.56±0.01 | 1.62±0.36 | 0.78±0.22 | 0.22±0.01abcdef | 114±37.5 |
| 44×155 | 2.18±0.09 | 0.17±0.02 | 0.84±0.07 | 1.57±0.21 | 0.67±0.02 | 0.20±0.02bcdefg | 51.3±4.37 |
| 97×155 | 2.19±0.17 | 0.17±0.02 | 0.80±0.16 | 1.59±0.10 | 0.48±0.17 | 0.22±0.01abcd | 69.2±38.4 |
| 135×155 | 2.38±0.07 | 0.17±0.02 | 0.58±0.07 | 1.55±0.11 | 0.72±0.08 | 0.20±0.02bcdefg | 42.0±15.7 |
| 139×155 | 2.45±0.31 | 0.16±0.03 | 0.66±0.24 | 1.63±0.28 | 0.84±0.28 | 0.23±0.03ab | 101±13.0 |
| 146×155 | 2.46±0.71 | 0.19±0.03 | 0.87±0.32 | 1.26±0.09 | 0.67±0.32 | 0.17±0.00g | 54.4±11.0 |
| 30×90 | 2.08±0.13 | 0.18±0.02 | 0.75±0.23 | 1.62±0.20 | 0.46±0.15 | 0.19±0.02cdefg | 65.4±23.1 |
| 47×90 | 2.21±0.26 | 0.17±0.02 | 0.74±0.20 | 1.36±0.12 | 0.82±0.03 | 0.18±0.01defg | 46.4±9.22 |
| 56×90 | 2.34±0.45 | 0.19±0.05 | 0.60±0.14 | 1.53±0.27 | 0.68±0.30 | 0.19±0.05cdefg | 46.7±20.8 |
| 113×90 | 2.39±0.03 | 0.14±0.01 | 0.60±0.11 | 1.66±0.24 | 0.74±0.11 | 0.21±0.02bcdefg | 69.9±36.7 |
| D×N | 2.55±0.28 | 0.17±0.02 | 0.81±0.19 | 1.52±0.25 | 0.66±0.03 | 0.23±0.03abc | 62.4±12.5 |
| D×G | 2.90±0.83 | 0.18±0.00 | 0.83±0.13 | 1.27±0.25 | 0.46±0.09 | 0.17±0.01efg | 68.2±40.6 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | 0. 045 | NS |

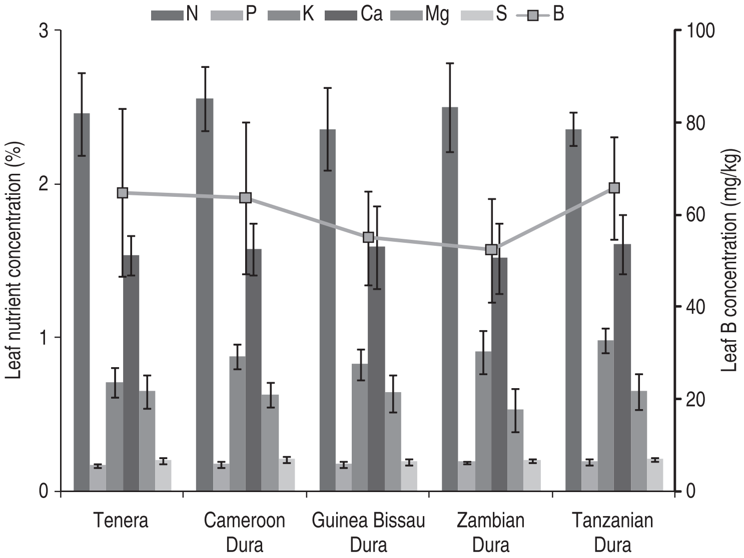


Fig 1 Comparison of leaf nutrient concentrations among germplasm.

(except K) of *teneras*, Cameroon, Guinea Bissau, Zambian and Tanzanian *duras* were statistically at par (Fig 1). However, germplasm varied significantly with respect to K concentration. The mean concentration of leaf K in Cameroon (0.88%), Zambian (0.91%) and Tanzanian (0.98%) *duras* were statistically at par. The mean value of K concentration in Guinea Bissau was found to be 0.83%. However, *teneras* had the lowest K (0.71%) concentration among the germplasm. In contrast to our findings, Lee *et al.* (2011) reported significant variation in leaf N, P, K, Ca, Mg, S, Cl and B concentration in Yangambi-Y103, NIFOR-N144, La Me-L110, AVROS-A122, Yangambi-DQ8 and Yangambi-SC3 planting materials planted in Pahang, Malaysia. The mean values of leaf nutrients (except S) concentration of 19 *teneras* were statistically at par (Table 1). However, the values varied from 2.08 to 3.10, 0.14 to 0.20, 0.56 to 0.84, 1.26 to 1.73, 0.46 to 0.84% and 43.7 to 114 mg/kg for N, P, K, Ca, Mg and B respectively. The concentration of leaf S in 19 *teneras* varied significantly and it ranged from 0.17 to 0.26%. The *teneras* like 118×57, 134×57, 29×155, 139×155 and D×N had higher leaf S concentration. Behera *et al.* (2016) reported the mean values of leaf N, P, K, Ca, Mg, S and B in the range of 2.21 to 2.49, 0.10 to 0.44, 0.56 to 0.78, 1.40 to 1.78, 0.48 to 0.65, 0.91 to 1.19% and 8.48 to 20.7 mg/kg respectively, in *teneras* planted in oil palm plantations of farmers' field in Karnataka, Gujarat, Goa and Mizoram states of India.

The mean values of leaf nutrient concentrations of Cameroon and Guinea Bissau accessions did not vary significantly (Table 2,3). However, the mean concentration of N, P and K varied from 2.31 to 3.00, 0.15 to 0.22 and 0.72 to 0.99% respectively, for accessions of Cameroon *duras* and from 1.94 to 2.78, 0.15 to 0.21 and 0.68 to 1.00% respectively for accessions of Guinea Bissau *duras*. The mean concentration of Ca, Mg, S and B ranged from 1.34 to 1.95, 0.49 to 0.80, 0.17 to 0.26% and 30.9 to 94.2 mg/kg respectively, for Cameroon accessions and from 1.25 to 1.98, 0.48 to 0.77, 0.16 to 0.22% and 43.2 to 70.8 mg/kg respectively, for Guinea Bissau accessions. The values of leaf N, P, K, Ca, Mg, S and B in Zambian accessions varied from 2.08 to 2.90, 0.17 to 0.21, 0.68 to 1.01, 1.20 to 1.78, 0.36 to 0.73, 0.18 to 0.23% and 41.4 to 70.0 mg/kg respectively (Table 4). However, these accessions varied significantly with respect to leaf K and Ca concentration.

Table 2 Mean (±SD) leaf nutrient concentrations of Cameroon dura accessions

| Accession | N (%) | P (%) | K (%) | Ca (%) | Mg (%) | S (%) | B (mg/kg) |
|---|---|---|---|---|---|---|---|
| CA-3 | 2.46±0.71 | 0.20±0.01 | 0.91±0.14 | 1.74±0.23 | 0.69±0.12 | 0.19±0.03 | 94.2±37.2 |
| CA-4 | 2.80±0.59 | 0.18±0.03 | 0.99±0.11 | 1.37±0.43 | 0.49±0.26 | 0.19±0.05 | 58.6±2.94 |
| CA-5 | 2.74±0.42 | 0.15±0.07 | 0.88±0.38 | 1.45±0.07 | 0.74±0.10 | 0.23±0.05 | 30.9±6.54 |
| CA-6 | 2.52±0.62 | 0.22±0.02 | 0.92±0.13 | 1.34±0.20 | 0.74±0.08 | 0.21±0.01 | 60.4±25.2 |
| CA-7 | 2.37±0.25 | 0.20±0.02 | 0.87±0.10 | 1.67±0.15 | 0.60±0.18 | 0.22±0.05 | 53.0±37.0 |
| CA-8 | 2.34±0.06 | 0.18±0.04 | 0.78±0.24 | 1.34±0.16 | 0.62±0.15 | 0.24±0.01 | 73.9±23.2 |
| CA-9 | 2.77±0.11 | 0.21±0.01 | 0.76±0.04 | 1.60±0.01 | 0.80±0.19 | 0.20±0.00 | 74.5±20.3 |
| CA-10 | 2.67±0.63 | 0.18±0.01 | 0.89±0.02 | 1.95±0.29 | 0.64±0.35 | 0.23±0.05 | 50.3±6.54 |
| CA-11 | 3.00±0.42 | 0.19±0.03 | 0.92±0.13 | 1.53±0.07 | 0.59±0.29 | 0.17±0.01 | 62.2±36.4 |
| CA-12 | 2.31±0.41 | 0.17±0.02 | 0.97±0.07 | 1.67±0.22 | 0.55±0.15 | 0.18±0.08 | 68.4±18.6 |
| CA-15 | 2.46±0.04 | 0.18±0.02 | 0.72±0.13 | 1.50±0.08 | 0.58±0.17 | 0.26±0.05 | 84.2±38.8 |
| CA-16 | 2.35±0.07 | 0.16±0.02 | 0.91±0.17 | 1.70±0.09 | 0.64±0.41 | 0.25±0.04 | 42.9±6.19 |
| CA-17 | 2.61±0.57 | 0.19±0.03 | 0.99±0.18 | 1.66±0.09 | 0.60±0.27 | 0.20±0.04 | 68.6±9.89 |
| CA-18 | 2.43±0.15 | 0.17±0.01 | 0.81±0.11 | 1.61±0.38 | 0.55±0.10 | 0.20±0.06 | 69.7±25.0 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS | NS |

Table 3 Mean (±SD) leaf nutrient concentrations of Guinea Bissau dura accessions

| Accession | N (%) | P (%) | K (%) | Ca (%) | Mg (%) | S (%) | B (mg/kg) |
|---|---|---|---|---|---|---|---|
| GB-5/301 | 2.32±0.06 | 0.21±0.03 | 0.89±0.12 | 1.36±0.32 | 0.77±0.17 | 0.22±0.12 | 50.3±30.1 |
| GB-5/310 | 2.21±0.60 | 0.15±0.00 | 0.78±0.19 | 1.26±0.36 | 0.48±0.08 | 0.16±0.02 | 43.2±21.9 |
| GB-10/306 | 1.94±0.26 | 0.17±0.03 | 0.68±0.21 | 1.80±0.09 | 0.70±0.35 | 0.18±0.03 | 67.5±17.9 |
| GB-21/310 | 2.68±0.09 | 0.19±0.04 | 0.85±0.14 | 1.68±0.05 | 0.49±0.12 | 0.20±0.04 | 47.0±8.48 |
| GB-22/311 | 2.78±0.97 | 0.15±0.01 | 0.72±0.16 | 1.64±0.52 | 0.54±0.10 | 0.18±0.04 | 70.8±29.5 |
| GB-23/312 | 2.39±0.07 | 0.20±0.05 | 0.90±0.04 | 1.79±0.66 | 0.66±0.05 | 0.19±0.01 | 60.0±13.5 |
| GB-29/318 | 2.36±0.37 | 0.19±0.01 | 1.00±0.03 | 1.25±0.16 | 0.76±0.18 | 0.19±0.01 | 55.8±11.2 |
| GB-32/321 | 2.17±0.02 | 0.20±0.02 | 0.84±0.04 | 1.98±0.39 | 0.71±0.05 | 0.21±0.01 | 46.1±18.1 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS | NS |

Table 4 Mean (±SD) leaf nutrient concentrations of Zambian dura accessions

| Accession | N (%) | P (%) | K (%) | Ca (%) | Mg (%) | S (%) | B (mg/kg) |
|---|---|---|---|---|---|---|---|
| ZS-1 | 2.50±0.41 | 0.21±0.03 | 1.09±0.05a | 1.35±0.28bc | 0.73±0.23 | 0.21±0.04 | 61.4±21.5 |
| ZS-2 | 2.90±0.77 | 0.19±0.03 | 0.85±0.15bc | 1.78±0.17a | 0.67±0.15 | 0.21±0.03 | 52.4±17.9 |
| ZS-3 | 2.72±0.59 | 0.19±0.03 | 0.94±0.07ab | 1.56±0.07ab | 0.45±0.05 | 0.20±0.01 | 41.4±7.26 |
| ZS-5 | 2.34±0.19 | 0.18±0.06 | 1.01±0.12ab | 1.20±0.08c | 0.52±0.14 | 0.23±0.07 | 70.0±11.3 |
| ZS-6 | 2.08±0.19 | 0.17±0.06 | 0.68±0.03c | 1.76±0.23a | 0.36±0.07 | 0.20±0.04 | 42.7±18.1 |
| ZS-8 | 2.45±0.30 | 0.17±0.01 | 0.89±0.17bc | 1.51±0.22ab | 0.48±0.18 | 0.18±0.06 | 46.6±5.35 |
| CD (P = 0.05) | NS | NS | 0.195 | 0.316 | NS | NS | NS |

Table 5 Mean (±SD) leaf nutrient concentrations of Tanzanian dura accessions

| Accession | N (%) | P (%) | K (%) | Ca (%) | Mg (%) | S (%) | B (mg/kg) |
|---|---|---|---|---|---|---|---|
| TS-4 | 2.38±0.46 | 0.18±0.02 | 0.92±0.24 | 1.67±0.54 | 0.54±0.18 | 0.21±0.07 | 60.9±20.4 |
| TS-5 | 2.26±0.02 | 0.23±0.03 | 1.07±0.07 | 1.50±0.01 | 0.86±0.03 | 0.20±0.01 | 71.6±13.5 |
| TS-9 | 2.31±0.30 | 0.19±0.03 | 0.89±0.21 | 1.44±0.25 | 0.59±0.10 | 0.21±0.04 | 64.8±19.5 |
| TS-10 | 2.32±0.51 | 0.18±0.03 | 1.06±0.15 | 1.53±0.08 | 0.65±0.04 | 0.21±0.00 | 51.5±0.44 |
| TS-11 | 2.53±0.14 | 0.18±0.01 | 0.95±0.13 | 1.91±0.37 | 0.64±0.21 | 0.22±0.04 | 81.0±33.7 |
| CD (P = 0.05) | NS | NS | NS | NS | NS | NS | NS |

Higher leaf K concentration was obtained in ZS-1, ZS-3 and ZS-5 accessions. Whereas, the higher values of leaf Ca were recorded in ZS-2, ZS-3, ZS-6 and ZS-8 accessions. The mean concentration of N, P, K, Ca, Mg, S and B in leaves of Tanzanian accessions varied from 2.26 to 2.53, 0.18 to 0.23, 0.89 to 1.07, 1.44 to 1.91, 0.54 to 0.86, 0.20 to 0.22% and 51.5 to 81.0 mg/kg respectively (Table 5). But the values of leaf nutrients among the accessions were on par with each other.

Though the leaf nutrient concentration across the germplasm varied widely, the leaf K concentration varied significantly among the germplasm revealing higher K concentration in Cameroon, Zambian and Tanzanian *duras*. Hence, there is a need for further characterization of these *duras* for comprehensive understanding of higher K accumulation in them. The *teneras* and accessions of Zambian *duras* varied significantly with respect to leaf S and K and Ca concentration respectively, though they maintained other nutrients at similar levels. The reasons for this observation are not understood and further investigation is needed in this regard. Higher S accumulating *teneras* and higher K and Ca accumulating accessions of Zambian *duras* also needs to be further studied and considered during development of nutrient efficient germplasms in future.

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