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A preliminary study on the status of essential Cu, Fe and Zn in the leaflets of oil palm *(Elaeis guineensis)* collected from Lekir, Peninsular Malaysia

Research Article

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Abstract

The present study aimed to determine the status of essential Cu, Fe and Zn in the leaflets of oil palm (*Elaeis guineensis*) (age > 20 years), and to determine the ecological risk assessment of Cu and Zn in the habitat topsoils collected from four sampling sites (House area (HA); Forest; Factory; Roadside (RS)) from Lekir oil palm plantation, in 2014. By comparing to the nutrient guidelines by Fairhurst and Mutert (1999), for Cu levels in the OP leaves, HA and RS sites are categorised as 'Deficient'. The Factory site is categorized as between 'Optimum' to 'Excessive'. The Forest site is categorized as between 'Deficient' to 'Optimum'. For Zn levels in the OP leaves, both Factory and Forest sites are categorised as 'Optimum'. The HA site is categorized as between 'Optimum' to 'Excessive', and 'Excessive', while the RS site is categorized as between 'Optimum' to 'Excessive'. The Cu and Zn levels in the habitat topsoils is categorised as 'low potential ecological risk'. Hence, the present status of Cu and Zn levels in the leaves of OP from Lekir are inconsistent, ranging from 'Deficiency' to 'Excessive', depending on the location of the sampling sites. This seems to agree with the habitat topsoils that are considered 'low potential ecological risk' of Cu and Zn.

Keywords

Nutrient status; Oil palm leaves; Ecological risk assessment.

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Introduction

In the Oil Palm (OP) (*Elaeis guineensis*) plantation, nutrient deficiency is a major concern [1,2]. From the ecotoxicological point of view, the use of excessive fertilizers with trace elements Cu, Fe and Zn receive much ecological concern causing soil pollution due to the leach of the fertilizers into soils and waterways [3].

In the OP, Cu deficiency causes stunted new leaves to be produced, with leaflets reduced in size and with extensive tip necrosis [4] while Fe deficiency appears on newly emerging leaves as a uniform or interveinal chlorosis. In severe cases, new leaves may develop almost white in colour, with extensive leaf tip necrosis. Because Fe tends to accumulate in older leaves [5], symptomatic leaves may green up as they mature. Common symptoms of Zn deficiency are stunted plant growth; poor tillering; development of light green, yellowish, bleached spots and chlorotic bands [6].

The objective of this preliminary study is to determine the status of essential Cu, Fe and Zn in the leaflets of oil palm (*Elaeis guineensis*), and to determine the ecological risk assessment of Cu and Zn in the habitat topsoils collected from Lekir oil palm plantation, Peninsular Malaysia.

Materials and Methods

The study area, Lekir, SitiawanFelcra Berhad Plantation (Figure 1) is managed by FelcraBerhad Gugusan Lekir. The Lekir, SitiawanFelcraBerhad Plantation is located

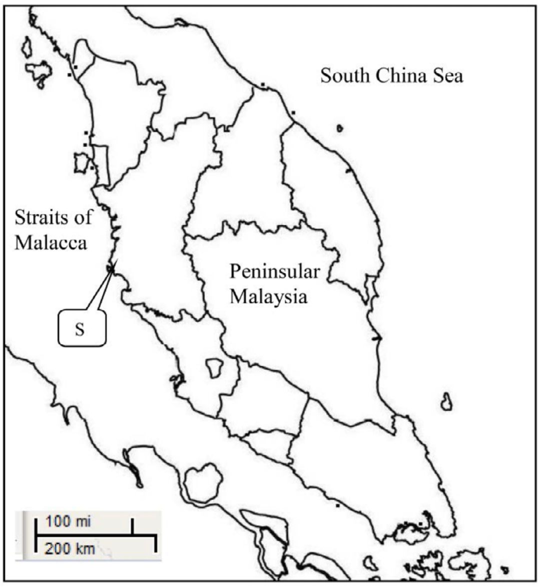

Figure 1: Map showing the sampling sites (S) at Lekir, SitiawanFelcraBerhad Plantation, Perak, Peninsular Malaysia.

inManjung, Perak. The samples of *E. guineensis* were taken from four sampling sites within the plantation namely near a Housing Area (HA), near to a Roadside (RS), near to a small fragmented Forest area (Forest) and an area near to an OP processing Factory (Factory).

Samples of OP parts and their habitat topsoil were collected from the selected sampling sites, in 2014. The separated plant parts included seed, shell, fibre, Leaf Base (LB), Leaf Middle (LM), Leaf Tip (LT), frond, Frond Middle (FM), Frond Right (FR) and bark.

All freshly collected samples were placed into a plastic bag and tightly sealed to prevent contamination. The samples were brought back to the laboratory within one day. All collected OP parts were thoroughly washed with distilled water to remove dust and extraneous matter and get rid of air born pollutants. Samples were then cut down into smaller size and accordingly to their parts. Samples were then dried in over at 60°C for three days to remove all moisture. The dried samples were then ground and homogenized and stored in sealed plastic bags until further digestion.

Soil samples were collected at 6 m width from the OP tree and at 5-10 cm depths. The samples were stored in plastic bags and brought to laboratory. Soil samples were dried in oven at 60°C for 12 hours and were then grinded and homogenized. The soil samples were then sieved with a 75 µm mesh size sieve.

For plant samples, approximately 0.50 g (triplicates) was weighed and placed into digesting tube. The sample was digested with 10 ml of nitric acid (HNO_3). For soil samples, approximately 0.50 g (triplicates) was weighed and placed into digesting tube. The combination of concentrated nitric acid (69%) and perchloric acid (60%) in the ratio of 4:1 were added and heated onthe heating block digester.

For the first one hour, samples were digested on heating block at 40°C and the last three hours the temperature was raised up to 140°C to ensure all samples were fully digested. The samples were allowed to cool down and were later diluted by adding 40 ml of distilled water. Then all samples were filtered through Whatman No.1 filter paper into pillboxes. Procedural blank is prepared in order to check for sample accuracy.

Working standards of different concentrations of Cu, Fe and Zn were prepared from standard solutions. The

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concentrations of Cu, Fe and Zn were determined by using an air-acetylene flame atomic absorption spectrometer (AAS), Perkin Elmer model Analyst 800. The analytical procedure was verified by analysis of certified reference materials (CRMs) namelyNCS DC73319-Soil and MESS-3-Soil and their recoveries were acceptable between 57.9 and 94.2% (Table 1).

Table 1: Comparisons of Cu, Fe and Zn concentrations (µg/g dry weight) between certified reference materials (CRM) values and the measured values, and their recoveries.

Metals	Samples	CRM values	Measured value	Recovery Percentage (%)
Zn	NCS DC73319-Soil	680.00	394 ± 2.80	57.9 ± 41.2
	MESS-3-Soil	159 ± 8	156.23 ± 5.23	83.12 ± 1.56
Fe	NCS DC73319-Soil	NA	NA	NA
	MESS-3-Soil	4.34 ± 0.11	5.06 ± 3.45	88.12 ± 1.23
Cu	NCS DC73319-Soil	21.00	19.9 ± 0.24	90.4 ± 2.11
	MESS-3-Soil	33.9 ± 1.6	31.8 ± 0.94	94.2 ± 1.24

Data treatments

Two geochemical indexes were included in this study, namely the index of geoaccumulation (Igeo) and enrichment factor (EF). The Igeo was first proposed by Muller [7] as a quantitative measure of the degree of metal pollution in aquatic sediments:

$$Igeo = \log_2 (sample / 1.5 \times background)$$

In this equation, the sample is the concentration measured in the soil. The background reference values in this study are 30.0 and 80.0 mg/kg dry weight for Cu and Zn, respectively [8] while Fe follows 3.09% (Wedepohl 1995), while 1.5 is a correction factor due to lithogenic effluents.

The calculation of EF of the sediments in this study followed that defined Buat- Menerd and Chesselt [9]:

$$EF = (Me/Fe)_{sample} / (Me/Fe)_{background}$$

Where, (Me/Fe) sample is the metal to Fe ratio in the sediments while the background concentrations of metal and Fe were those reported as preindustrial levels in Hakanson [10]. The above equation can estimate the (EF) of Cu and Zn of the soil in the sampling sites using Fe as a normalizer for differences in sediment grain size and mineralogy [11].

For the determination of potential ecological risk (Hakanson 1980), the following formulas were used:

$$CF = Cs / Cn$$

Where:

CF= contamination factor of metals (*i*)

Cs = the examined metal (*i*) in the samples.

Cn= the background value.

In this study, the evaluation of ecological risk for a given metal were made by adopting the potential risk of individual metal (ER) and potential ecological risk index (PERI) which were first proposed by Hakanson (1980). The formulas for the two calculations are as the following:

$$ER = Tr \times CF$$

Where ER is the potential risk of individual metal; Tr is the toxic-response factor (5 and 1 for Cu and Zn, respectively) based on Hakanson (1980) while Fe Tr is not available and therefore the Fe ER is not calculated. The values of background values follow those previously mentioned.

Results and Discussion

Distributions of concentrations of Cu, Fe and Zn in the different parts of *E. guineensis* collected from four sampling sites in Perak, Peninsular Malaysia are presented in (Table 2).

According to the Cu guideline in leaves of oil palm of > 6 years) after planting suggested by Fairhurst and Mutert [12], the three Cu concentrations (mg/kg) are ‘Deficiency (<3.0)’, ‘Optimum (5.00-8.00)’, and ‘Excessive (>15.0)’. In the present study, the Cu levels in the three parts of leaves (base, middle and tip) ranged from 0.20 to 2.90 mg/kg in both HA and RS. Therefore, these two sites are categorised as ‘Deficiency (<3.0)’. The Factory site, ranging from 8.10 to 10.4 mg/kg, is categorized as between ‘Optimum’ to ‘Excessive’. The Forest site, ranging from 3.00 to 3.20 mg/kg is categorized as between ‘Deficiency’ to ‘Optimum’.

According to the Zn guideline in leaves of oil palm of > 6 years after planting suggested by Fairhurst and Mutert [12], the three Zn concentrations (mg/kg) are ‘Deficiency (<10.0)’, ‘Optimum (12.0-18.0)’, and ‘Excessive (>80.0)’. In the present study, the Zn levels in the three parts of leaves (base, middle and tip) ranged from 12.3 to 20.0 mg/kg in both Factory and Forest sites. Therefore, these two sites are categorised as ‘Optimum (12.0-18.0)’. The HA site, ranging from 57.3 to 159 mg/kg, is categorized as between ‘Optimum’ to ‘Excessive’, and ‘Excessive’. The

Table 2: Distributions of concentrations (mg/kg dry weight) of Cu, Fe and Zn in the different parts of *Elaeis guineensis* collected from four sampling sites in

	Leaf (Base)	Leaf (Middle)	Leaf (Tip)	Frond (Left)	Frond (Middle)	Frond (Right)	Seed	Shell	Fibre	Bark	Soil
Cu											
HA	2.70	1.60	0.20	1.60	2.40	2.00	13.3	5.00	1.40	2.20	12.5
Fact	8.10	9.50	10.4	2.80	2.30	2.40	16.4	12.1	12.6	3.90	10.7
Forest	3.00	3.20	3.00	0.70	0.60	0.60	14.3	8.3	8.90	1.70	2.90
RS	2.90	2.90	2.90	5.60	6.10	6.50	16.6	8.8	13.6	2.30	4.40
Zn											
HA	159	57.3	71.4	20.6	25.2	17.3	28.4	2.9	10.7	13.1	48.1
Fact	13.7	20.0	20.6	12.1	5.50	6.80	23.7	4. 3	5.80	9.00	27.3
Forest	12.3	13.5	13.7	3.50	5.10	4.10	23.4	4.40	4.20	13.0	10.5
RS	23.3	25.2	22.6	2.90	10.0	9.60	6.90	28.0	26.7	15.9	18.1
Fe											
HA	78.5	74.5	77.6	4.70	26.3	67.6	11.8	8.30	19.2	134	4544
Fact	220	263	306	38.0	17.8	34.9	31.4	36.5	29.0	66.6	3528
Forest	119	103	102	20.1	26.1	26.2	29.8	30.5	36.1	71.9	2586
RS	184	179	183	84.9	76.1	81.8	59.2	74.3	80.1	120	3098

Note: HA= near housing area; RS= near roadside; Fact= near a palm oil processing factory.

RS site, ranging from 22.6 to 25.2 mg/kg, is categorized as between 'Optimum' to 'Excessive'.

Unfortunately, there is no Fe guideline in leaves of oil palm of 1-6 years (or > 6 years) after planting suggested by Fairhurst and Mutert [12]. Therefore, the comparison with any Fe guidelines is not possible.

The Cu levels in the topsoils from the four sites ranged from 2.90 to 12.5 mg/kg, are lower than Cu levels of the normal range (30 mg/kg) in soils [13] and toxic soils (60-125 mg/kg) for plants [14,15]. The Zn levels in the topsoils from the four sites ranged from 10.5 to 48.1 mg/kg, are lower than Zn levels of the normal range (90 mg/kg) in soils and toxic soils (70-400 mg/kg) for plants. The Fe levels in the topsoils from the four sites ranged from 2586 to 4544 mg/kg, and they are lower than the background level of Fe (30,900 mg/kg) of the (Wedepohl 1995). Therefore, the levels of Cu, Fe and Zn in the habitat topsoils are not polluted at all and can be considered lower than the background levels. This agrees with the status of Cu and Zn in the OP leaves, which are in deficiency in some sampling sites.

The values of EF, Igeo, CF and ER are presented in (Table 3.) All EF values for Cu (0.0001 to 0.0003) and Zn (0.0002 to 0.0004) of all four sites fall into the contamination categories viz. i) EF<2, depletion of mineral enrichment, according to Sutherland [16]. All Igeo values for Cu (-3.96 to -1.85) and Zn (-3.51 to -1.32) of all four sites fall into the classification for the Igeo '< 0 practically unpolluted', according to Muller [7]. All ER values for Cu (0.48 to 2.08) and Zn (0.13 to 0.60) of all four sites fall into the classification for 'low potential ecological risk' (ER<40), according to Hakanson [10]. Therefore, there is no ecological risk of Cu and Zn based on the above assessments. Again, the major environmental concern is that those levels of Cu, Fe and Zn are in deficiency rather than the creation of ecological risk of these metals.

Table 3: Enrichment factor (EF) and index of geoaccumulation (Igeo) of heavy metals, values of the contamination factor (CF), and potential risk of individual metal (ER) of all sampling sites in the habitat topsoils of oil palm.

	Cu				Zn			
	EF	Igeo	CF	ER	EF	Igeo	CF	ER
HA	0.0003	-1.85	0.417	2.08	0.0004	-1.32	0.601	0.60
Fact	0.0003	-2.07	0.357	1.78	0.0003	-2.14	0.341	0.34
Forest	0.0001	-3.96	0.097	0.48	0.0002	-3.51	0.131	0.13
RS	0.0001	-3.35	0.147	0.73	0.0002	-2.73	0.226	0.23

Conclusions

For the status of essential Cu and Zn in the leaflets of oil palm, by comparing to the nutrient guidelines by Fairhurst and Mutert [12], for Cu levels in the OP leaves, two sites are categorised as 'Deficient'. The Factory site is categorized as between 'Optimum' to 'Excessive' while the Forest site is categorized as between 'Deficient' to 'Optimum'. For Zn levels in the OP leaves, two sites are categorised as 'Optimum'. The HA site is categorized as between 'Optimum' to 'Excessive', and 'Excessive', while the RS site is categorized as between 'Optimum' to 'Excessive'. For the ecological risk assessment of Cu and Zn in the habitat topsoils collected from four sampling sites, the Cu and Zn levels are categorised as 'low potential ecological risk'. Hence, the present status of Cu and Zn levels in the leaves of OP from Lekir is inconsistent, ranging from 'Deficiency' to 'Excessive', depending on the location of the sampling sites. This seems to agree with the habitat topsoils that are considered 'low potential ecological risk' of Cu and Zn.

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