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Full Length Research Paper

Correlations between soil physicochemical properties and the incidence and severity of *Fusarium oxysporum* f. sp. *elaeidis* in oil palm plantations of Cameroon

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Oil palm (*Elaeis guineensis* Jacq.) is a key cash crop in Cameroon but is severely dreaded by vascular wilt disease caused by *Fusarium oxysporum* f. sp. *elaeidis* (FOE). This study evaluated how soil physicochemical properties influence the incidence and severity of FOE across four Cameroon Development Corporation (CDC) estates: Bota, Mondoni, Debundscha, and Idenau. Twelve bulked soil samples were collected, processed and analyzed for major soil physicochemical properties. Tolerant oil palm hybrid seeds were planted in soils collected from these estates and some in sterilized soil (control experiment) to evaluate incidence and severity. The R statistical package was used for analysis. Results showed that soils from Debundscha had the highest disease incidence (75%) and lowest in Mondoni (25%). In contrast, soils from Idenau had the highest disease severity index (12.02%) and lowest in Mondoni (4.55%). Correlation analysis revealed that total nitrogen was moderately and positively correlated with disease incidence. Whereas, organic carbon (OC), C/N ratio, sulfate (SO_4), and pH showed negative correlation. These findings highlight that soil fertility, particularly nutrient imbalances, significantly influence FOE development. Therefore, we suggest appropriate management of soil properties through balanced nutrient inputs and eco-friendly amendments to mitigate vascular wilt in oil palm.

Key words: Fusarium wilt, nutrient management, oil palm, plantation, soil fertility.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) of the Arecaceae originated from the tropical rain forest region of West Africa (Ntsomboh et al., 2015). The crop constitutes a major source of agricultural income for most countries (Food and Agriculture Organisation (FAO), 2021) and its production by multinational corporations provides employment for many. Most developing countries have oil palm as the most productive vegetable oil crop which contributes to their economic growth (Zimmer, 2010). This crop is the third most significant tree crop in Cameroon after cocoa and coffee. However, it is considered to be one of the leading cash crops in the

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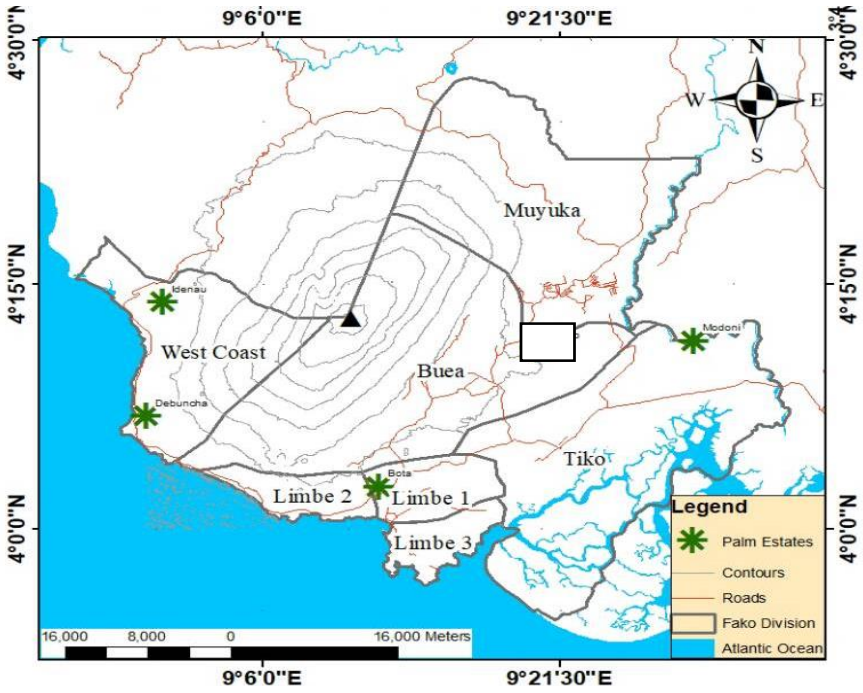


Figure 1. Location of different oil palm estates of the Cameroon Development Cooperation.

rural economy in Cameroon. Oil palm uses high amounts of nutrients from the soil for optimum growth and development, which results in excessive removal of nutrients from the soil and leads to low soil fertility. Ofosu-Budu and Sarpong (2013) noted palm oil to be the largest natural source of Vitamin E, which is very important as well as rich in magnesium. Nkongho et al. (2014), emphasized inadequate demand-driven research especially in soil nutrient management is the major challenge to the local industry.

In Africa, a soil-borne fungus called *Fusarium oxysporum* f. sp. *elaeidis* (FOE) which is the causal agent of vascular wilt (Ntsomboh et al., 2012; 2015) mainly threatens oil palm cultivation. Vascular wilt occurs in two forms; a typical form, which leads to the death of the plant two to three months after the appearance of the first symptom, and a chronic form whereby the plant sustains the diseases and survives for a few years before its death (Cooper, 2011). The visible symptoms of vascular wilt on oil palm are a function of the age of the plant, the stage of infection, the susceptibility of the plant and the environment (Flood, 2006; Claudine et al., 2019). The internal symptoms are usually observed on pseudo-bulbs after dissection (de Franqueville and Diabaté, 2001).

The presence of vascular wilt in their host is determined by the number of pathogens in the soil, severity and their relationship with soil physicochemical properties, such as pH, organic matter and nutrient content (Orr and Nelson, 2018). Soil physicochemical properties play a central role in the occurrence and severity of soil-borne plant diseases. Factors such as soil pH, organic matter, and nutrient availability influence pathogen proliferation, plant vigor, and disease expression. Although FOE has been widely studied in terms of biology and pathogenicity, limited attention has been given to its relationship with specific soil properties in Cameroonian oil palm plantations. The occurrence of vascular wilt in crops is closely related to the amounts and invasion of soil pathogens and the physicochemical properties of soil. Exploring the nutrient content of pathogenic soil and their relationship with pathogens is therefore crucial for preventing and controlling soil-borne diseases (Orr and Nelson, 2018). This study therefore evaluates how individual soil physicochemical parameters correlate with FOE incidence and severity in four Cameroon Development Corporation (CDC) estates.

MATERIALS AND METHODS

Description of study area

The study was conducted out in four CDC estates: Bota, Mondoni, Debundscha and Idenau (Figure 1) and in the University of Buea; all located in Cameroon's humid forest zone. Each estate having different rainfall, temperature, and soil conditions (CDC, 2018).

Plant and soil materials

The plant materials used in this study were tolerant oil palm hybrid

Table 1. Disease severity scale.

Scale	Severity score		Interpretation
0	< 1	=	No infection
1	1 – 25	=	Low infection
2	26 – 50	=	Moderate infection
3	51 -75	=	High infection
4	>75	=	Very high infection

Bhat et al. (2020).

seeds obtained from the specialized Centre for Oil Palm Research of La Dibamba (CEREPAH) in Cameroon. The soil samples were collected around identified infected oil palm plants from the four estates *in situ*.

Seedling inoculation at the pre-nursery

A completely randomized block design was done at the pre-nursery. The pre-nursery was made up of tolerant hybrid seeds that were planted in polythene bags with soils collected around infected oil palm plants of CDC and the others in sterilized soil (which served as the control experiment). The soils collected in these study sites had been earlier characterized by Kinge et al. (2019).

Disease incidence

Soil samples from each of the estates were collected and filled in individual pots. Twelve FOE susceptible oil palm seedlings each was planted in these soils; in individual pots. After two weeks of planting, some diseased symptoms were observed. The sampling for disease incidence was carried out at an interval of two weeks for 16 weeks. The disease incidence (DI) of vascular wilt disease was computed using Equation 1 (Chaube et al., 2015).

$$DI = \frac{\text{Number of infected oil palm plants}}{\text{Total number of oil palm plants assessed}} \times 100 \quad (1)$$

Disease severity

Plant sampling for disease severity was carried out for a period of sixteen weeks. The severity of the disease on the oil palm plants observed per soils of various estates was calculated and scored as described by Chaube et al. (2015) and defined as the ratio of the area of oil palm leaves infected over total area of oil palm leaves multiplied by 100. In each farm, ten plants were randomly assessed and mean scored for severity indices.

$$\text{Disease severity (\%)} = \frac{\text{Area of oil palm leaves infected}}{\text{Total number of oil palm leaves}} \times 100 \quad (2)$$

The disease severity measurement was based on a 5-point score (0 to 4 Scale) as shown on Table 1, according to Bhat et al. (2020).

Soil sampling

All four estates were selected for soil sampling. Twelve bulked soil samples were collected from each estate at a depth of 0–20 cm with a diagonal pattern using soil augur (Mabit and Maetroni, 2018). This was done around suspected diseased plants and was sampled within 48 h. The samples were placed in polythene bags, labeled and transported to the center for soil analysis, University of Dschang. All soil samples were then air-dried to constant weight to avoid microbial degradation. They were made lump-free and passed through a 2 mm sieve before analysis. The samples were then subjected to laboratory analysis for the major soil nutrients.

Soil physicochemical properties analysis

Standard analytical protocols were followed to analyze pH (International Institute of Tropical Agriculture (IITA), 1979), organic matter, organic carbon (Nelson and Sommers, 1982), total nitrogen (modified method described by Macro-Kjeldahl), available phosphorus, potassium, calcium, magnesium, sodium, sulfate, cation exchange capacity (CEC) Thomas (1982), and texture.

Data analysis

Analyses were conducted in R. Analysis of variance (ANOVA) tested differences among estates. Pearson correlation coefficients determined associations between soil parameters and FOE incidence and severity.

RESULTS

Soil nutrient stat e of oil palm plantations of CDC

The trend of results obtained from the soil nutrient analysis is as follows and presented in Table 2. Soils were acidic across estates (pH 5.5 to 6.3). Organic matter ranged from 2.6% in Idenau to 5.3% in Mondoni, with corresponding OC values. Nitrogen levels were uniformly low (<0.15%). Available phosphorus was deficient in most sites, except Idenau. Cation exchange capacity values were moderate.

Disease Incidence

Based on the results on Figure 2, it is seen that soils from Debundscha and Idenau showed high disease incidence (75 and 58.33% respectively). The lowest percentage disease incidence came from soils collected from Mondoni (25%).

Disease severity

From Figure 3, it is observed that oil palm plants, planted in the soil from Idenau showed the highest percentage severity (12.02%) and the least being the soils from Mondoni (4.55%). The mean (severity score) of the plants planted in soils from each estate is presented in Table 3.

Table 2. Statistical results of the soil physicochemical properties of CDC oil palm estates.

Parameter	Bota	Debundscha	Idenau	Mondoni
pH (H_2O)	5.6	5.5	6.3	6.0
Organic Matter (%)	3.5	3.6	2.6	5.3
Organic Carbon (%)	2.0	2.1	1.5	3.0
Total N (%)	0.12	0.10	0.10	0.10
C/N ratio	16.1	12.9	7.6	40.8
Available P (mg/kg)	9.3	8.7	33.7	6.4
Calcium (cmol/kg)	4.0	2.6	3.6	3.2
Magnesium (cmol/kg)	2.0	1.0	2.0	1.4
Potassium (cmol/kg)	1.3	1.5	1.9	1.6
CEC (cmol/kg)	16.7	17.0	15.7	18.0

Source: Authors' data.

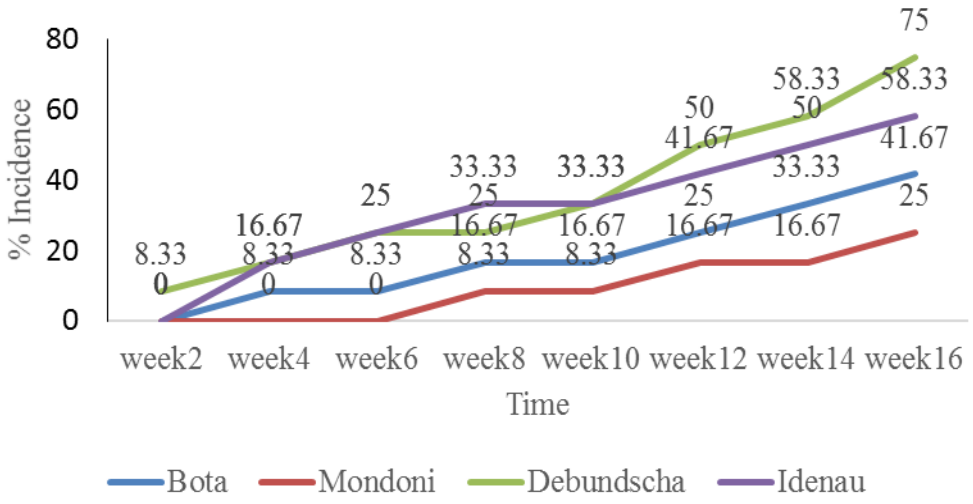


Figure 2. Percentage incidence of FOE from Soils of different estates.

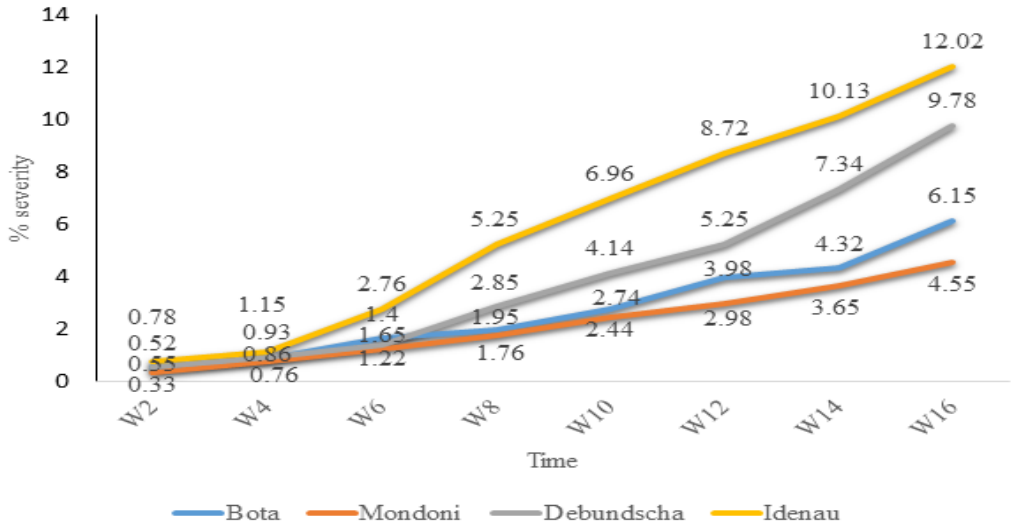


Figure 3. Disease severity of FOE from soils of estates.

Table 3. Mean disease severity score of CDC oil palm estates.

Estate	Mean (severity score)	Scale	Interpretation
Bota	19.15	02	Low infection
Mondoni	13.62	02	Low infection
Debundscha	26.51	03	Moderate infection
Idenau	43.08	03	Moderate infection

Source: Authors' data.

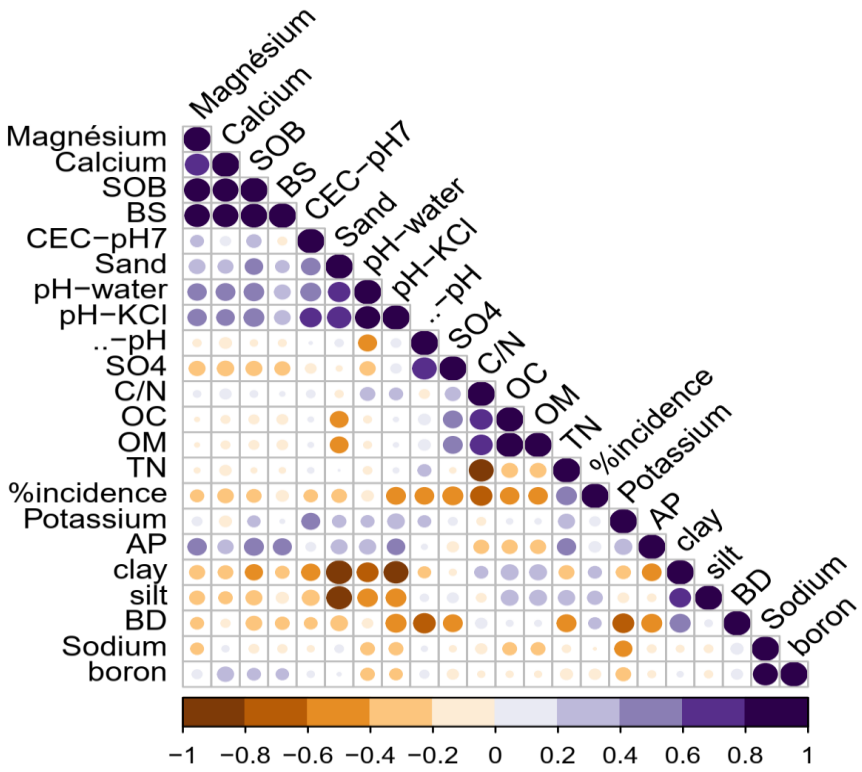


Figure 4. Correlation between soil physicochemical parameters and disease incidence in CDC oil palm estates.

Idenau had the highest disease severity (43.08%) as opposed to Mondoni which had the least severity (13.62%). However, all the four estates were known to have moderate infection (Debundscha and Idenau) and low infection (Bota and Mondoni).

Correlation between disease incidence and soil physicochemical properties

The correlation index (Figure 4) had the following positive correlation with disease incidence: Total nitrogen ($r > 0.5$). The negative correlations with disease incidence were OM, OC, C/N ratio, SO_4, and pH. Severity correlations were weak, suggesting additional factors beyond soil conditions determine disease progression. The results indicate a moderately strong positive correlation between disease incidence and total nitrogen, suggesting that as nitrogen levels increase, disease incidence also tends to increase. Total nitrogen has a moderately strong positive correlation with disease incidence. Thus, as TN increases, disease incidence increases and vice versa. Meanwhile, Organic matter (OM), OC, C/N, SO_4, pH and pH-KCl have a moderately strong negative correlation with disease incidence.

DISCUSSION

The relative proportions of sand, silt and clay in a particular type of soil determine its soil class, textural class, textural grade, and texture. Soil productivity and

sustainability depend on soil texture, which has a direct influence on crop productivity. The properties of soil texture are dynamic. This means there are changes depending on weathering rate and the initial mineralogy of the parent material or the deposition of material from streams, runoff, and erosion (Minasny and McBratney, 2007). Soil texture influences soil quality indices. There was not much difference among the soils in the four estates. In addition, the presence of more clay particles especially in humid form, contributes to soil colloids having charges, which can hold cations (Syafrimen and Yulnafatmawita, 2018).

Nitrogen and disease incidence

The positive correlation between total nitrogen and FOE incidence underscores the dual role of nitrogen in oil palm health and disease. Nitrogen is critical for vegetative growth, yet excess or imbalanced application may stimulate conditions that favour pathogen proliferation. High N can promote lush, succulent growth that is more vulnerable to pathogen attack and may also disrupt the soil microbial balance, reducing the population of beneficial antagonists. Apart from the application of inorganic fertilizers on all the estates, (some of them being nitrogenous based fertilizer), Mondoni has an edge over them all. They make use of organic resources such as manure from cow dung, which is key to increasing the N content of the soil (Zhou et al., 2019).

Organic Matter, Carbon, and Soil Fertility

OM, OC and the C/N ratio emerged as protective factors against FOE. The OC recorded for soil samples from Mondoni was 3.0% meanwhile that of Idenau was 1.5%, thereby falling below the OC critical threshold for oil palm trees (Goh, 2004). Their negative correlations with disease incidence suggest that higher organic inputs enhance soil suppressiveness. Organic matter supports beneficial microbial populations that compete with FOE or induce systemic resistance in plants. For example, Mondoni soils, enriched by cattle manure and mulched palm fronds, had the highest OM (5.3%) and recorded the lowest disease incidence (25%). Conversely, Idenau, with the lowest OM (2.6%) and OC (1.5%), showed both higher incidence and severity. This contrast demonstrates how organic-based soil management can mitigate disease risk. Johnston (1986) and Nguemezi et al. (2020) stated that organic matter helps in availability of plant nutrient, improve the soil structure, water infiltration and retention, feeds soil micro-flora and fauna, and the retention and cycling of applied fertilizer. According to Goh et al. (1999) and Apori et al. (2020) available P content less than 25mg kg^{-1} is below the phosphorus threshold for oil palm trees.

Soil pH and sulfate

Although oil palm can tolerate acidic soils, the observed negative correlation between pH and disease incidence indicates that slightly higher pH levels within the acidic range may reduce FOE proliferation. Extremely low pH can limit nutrient availability and alter microbial community conditions that may benefit pathogens. Sulfate was negatively associated with incidence, possibly due to its role in enhancing plant defense mechanisms such as the synthesis of sulfur-containing compounds involved in pathogen resistance. This result corroborates with that of Apori et al. (2020) that had acidic soils too.

Disease incidence versus severity

While soil properties were clearly linked to incidence, correlations with severity were less consistent. This suggests that although soil factors set the stage for infection, disease progression and symptom expression depend more heavily on plant genotype, age, and environmental stressors. For instance, Idenau soils showed both high incidence and the highest severity, but Debundscha, despite its high incidence (75%), had lower severity than Idenau (9.78% vs. 12.02%).

This indicates that factors beyond soil chemistry such as microclimate or varietal resistance may shape disease severity.

Management implications

The findings highlight the importance of balanced nutrient management as a disease mitigation strategy. Reducing reliance on nitrogen-heavy fertilizers while supplementing soils with organic amendments such as compost and manure could help suppress FOE. Addressing phosphorus deficiencies (observed in Bota, Debundscha, and Mondoni) and maintaining moderate pH levels through liming where appropriate could further enhance soil health. Integrated nutrient management that combines organic and inorganic inputs appears critical for reducing wilt incidence and improving oil palm productivity in Cameroon.

Conclusion

This study demonstrates that soil physicochemical properties significantly influence the incidence and, to a lesser extent, the severity of FOE in oil palm plantations. Total nitrogen showed a positive association with disease incidence, while organic matter, organic carbon, C/N ratio, sulfate, and pH were negatively correlated. These relationships highlight the potential of soil fertility

management as a strategy to mitigate vascular wilt. Adoption of balanced nutrient management, organic inputs, and soil conservation practices is recommended to enhance oil palm resilience against FOE in Cameroon. Future work should investigate interactive effects between soil properties, host genotype, and environmental conditions to develop comprehensive disease management strategies.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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