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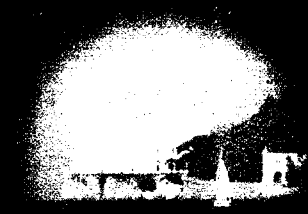

preprint

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Abstract

The potassium is the main nutrient element which plays a significant role on oil palm tree (Elaeis guineensis (jacq)) production and its resistance to the dry season. One can observe 30% decrease of the production in case of potassium deficiency. The potassium nutrition control of an oil palm tree field is a very important activity and leads to the fertilisation policy.

The Laser Induced Fluorescence (L.I.F.) is a fast and simple method compared to the classical one, "Diagnostic Foliaire", usually used in agronomy. We used the L.I.F. method to detect the oil palm tree stress caused by potassium deficiency, analysing the fluorescence spectrum of the chlorophyll a. We proved that the intensity ratio of the fluorescence spectrum R = F690/F73S is superior to 0.5 when the tree is under stress and its value is around 0.4 in case of intact tree.

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1. Introduction

In the last decade, several spectroscopic methods have been considered for the characterisation of physiological state of plants. Among them, the use of a fluorescence signal emitted by plants has been the object of intense research activity. Measurement of red (chlorophyll a) fluorescence has become a useful investigation tool in photosynthesis research plant physiology [1,2,3,4,5].

The aim of this work is to investigate the way to detect stress caused by potassium deficiency on oil palm tree. Palm oil is the second source of oil in the world and also the main financial resource for several developing countries. Several research activities have proved that potassium is the main nutrient element which is essential in oil palm tree production and its resistance to the dry season. One observe can 30% decrease of production, in Ivory Coast, in the case of potassium deficiency [6,7,8,9,10].

We show using the L.I.F. technique, which is more fast and simple than the classical one "Diagnostic Foliaire" that when the stress on oil palm tree is caused by potassium deficiency, the rate of fluorescence curves intensities differ from the intact tree. We also give essential parameters for an accurate diagnostic using the L.I.F. technique.

2. Material and Method

Plant material

The oil palm trees are LM2TxDA10D type growth since 1974 at Lame Agricultural Research Institute in south Ivory Coast. The are two groups of fields. One field was fertilised with KCl and 60% of K_2O as 345 kg of KCl/ha/year (group K3).

The other group K0 was growth without potassium fertilisation.

For the experiment, we have selected four trees of each group and analysed 10 leaflets of leaves of rank 1,9,14 and 17.

Method

1- The classical method, called "Diagnostic Foliaire" [11], consists of :

- collect and transport the leaves samples from the fields;
- dry the sample;
- send the sample to specialise laboratories for chemical dosimeter measurement.

The concentration of potassium of samples are compared to a reference concentration (0.9% /dry material) for the conclusion of potassium deficiency.

This technique passes through many processes such as collecting, drying and analysing leaves. The laboratory analysis is usually made in developed countries and it takes a minimum of 6 months to have the results.

2- The Laser Induced Fluorescence technique scheme is shown in figure 1. The excitation source is a HeNe laser of 10 mW power emitting at a wavelength of 632 nm. The photomultiplier is a XP1011 type from RTC, with a frontal window of 35 mm of useful diameter. The monochromator is a Higler Watt, with a holographic grating of 600 lines/mm. We used a 632nm cut of filter and a XY recorder for the spectrum plot.
For the measurements, we have taken 10 leaflets of each leaf. The average of the 10 fluorescence spectra gives us the spectral response of the leaf. The fluorescence spectra are fitted [12] with the program "Origin 3.5".

3. Results

Figure2 and figure3 show the kind of spectrum we have obtained, where Xc,Wy and Ai are the position, the width and the area of relative contribution of fluorescence curves centred at 690nm and 735nm. R is the intensities ratio of the curves.
Table1a and table1b respectively present the fluorescence spectrum parameters of the tree A2515K0 with stress caused by potassium deficiency and tree A2022K3 without stress. According to the ratio R, we observe that the values of leaves of rank 6 and 14 are homogeneous compared to leaves of rank 1 and 17. This was confirm by Ballo K. [6] who proved that a very young leaf (at the top of the tree) does not have the same value of concentration in potassium as other leaves because it takes the potassium of the oldest leaves to grow. In the case of the leaf of rank 17, it presents a visual default due to its age and it is not useful for the L.I.F. technique.
We conclude that to use the L.I.F. technique, it would be better to use leaves of rank 9 or 14. For our specific case we have used leaves of rank 9.
Table2 and table3 present the results for the group K0 and K3 of the trees we have analysed. We observed that all the trees with stress caused by potassium deficiency have their spectrum intensity ratio R >0.5. The K3 group of intact trees have R around 0.4.

4. Conclusion

Extreme deficiency in potassium is not manifested by visible plant change but in Laser Induced Fluorescence intensities at specific wavelength. We prove in the case of stress caused by potassium deficiency that ratio R >0.5 and for intact trees have R around 0.4. We have also shown that to use the L.I.F. method it is better to analyse leaves of rank 9 and 14.

The Laser Induced Fluorescence technique could replace the classical method "Diagnostic Foliaire" because of its simplicity and rapidity.

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Table1a : L.I.F. fitted spectrums parameters for oil palm tree called A2515K0 leaves, with stress caused by potassium deficiency. λ_{690}, λ_{735}, W_{690} and W_{735} are the position and the width of the relative contribution of fluorescence curves centred at 690nm and 735nm. R is the intensities ratio of the curves.

A2515K0	leaf of rank 1	leaf of rank 9	leaf of rank 14	leaf of rank 17
λ_{690} (nm)	693.006	693.389	693.211	693.775
λ_{735} (nm)	737.934	740.748	738.657	739.209
W_{690} (nm)	27.492	27.121	26.152	22.909
W_{735} (nm)	46.295	45.389	45.469	45.311
R = F690/F735	0.55	0.62	0.62	0.58

Table1b : L.I.F. fitted spectrums parameters for oil palm intact tree called A1923K3 leaves. λ_{690}, λ_{735}, W_{690} and W_{735} are the position and the width of the relative contribution of fluorescence curves centred at 690nm and 735nm. R is the intensities ratio of the curves.

A2515K3	leaf of rank 1	leaf of rank 9	leaf of rank 14	leaf of rank 17
λ_{690} (nm)	686.406	688.538	688.283	688.433
λ_{735} (nm)	735.395	735.245	734.235	736.856
W_{690} (nm)	25.167	25.087	23.387	25.134
W_{735} (nm)	50.988	43.961	43.905	43.701
R = F690/F735	0.50	0.43	0.42	0.48

Table2 : L.I.F. fitted spectrums parameters for oil palm tree of group K0, leaves rank 9, stress caused by potassium deficiency. λ_{690}, λ_{735}, W_{690} and W_{735} are the position and the width of the relative contribution of fluorescence curves centred at 690nm and 735nm. R is the intensities ratio of the curves.

K0 group	A2615	A2616	A2614	A2514
λ_{690} (nm)	687.46 (0.47)	687.90 (0.55)	686.04 (0.80)	693.39 (0.91)
λ_{735} (nm)	733.23 (0.41)	735.88 (0.31)	734.45 (0.69)	740.75 (0.34)
W_{690} (nm)	26.31 (1.13)	26.45 (0.90)	24.58 (2.31)	27.12 (0.78)
W_{735} (nm)	45.16 (1.05)	42.82 (0.86)	52.59 (1.37)	45.39 (0.94)
R = F690/F735	**0.55**	**0.55**	**0.65**	**0.62**

Table3 : L.I.F. fitted spectrums parameters for intact oil palm tree of group K3, leaves rank 9. λ_{690}, λ_{735}, W_{690} and W_{735} are the position and the width of the relative contribution of fluorescence curves centred at 690nm and 735nm. R is the intensities ratio of the curves.

K3 group	A2022	A1923	A1922	A2024
λ_{690} (nm)	690.63 (0.64)	688.54 (0.51)	688.05 (0.49)	688.27 (0.41)
λ_{735} (nm)	738.73 (0.35)	735.25 (0.31)	734.68 (0.33)	735.48 (0.22)
W_{690} (nm)	25.25 (1.29)	25.09 (0.92)	25.48 (1.13)	24.22 (0.74)
W_{735} (nm)	43.33 (1.06)	43.96 (0.86)	44.91 (10.89)	43.14 (0.63)
R = F690/F735	**0.42**	**0.43**	**0.44**	**0.40**

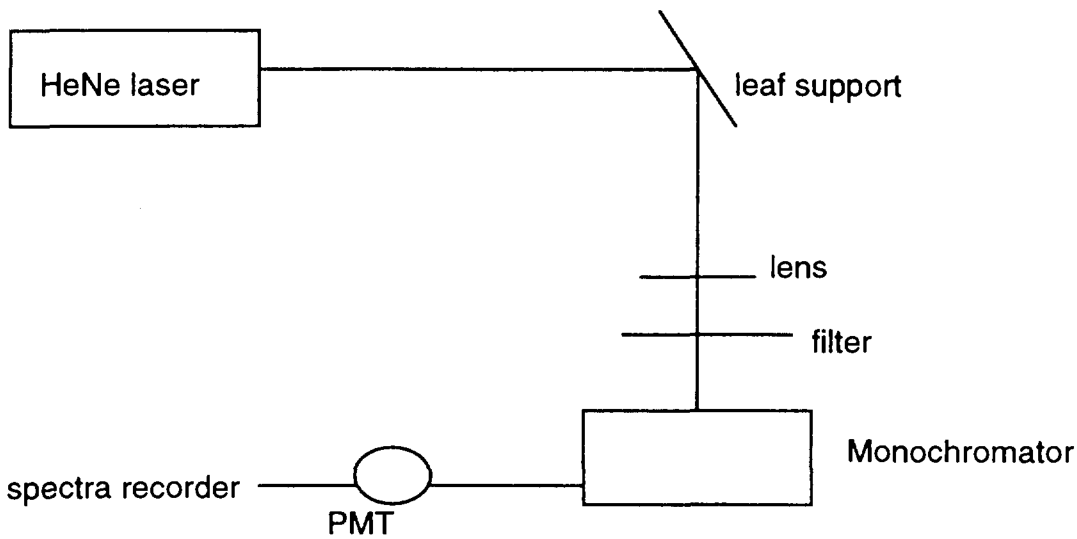

Figure 1 : Scheme of laser -induced fluorescence experiment.

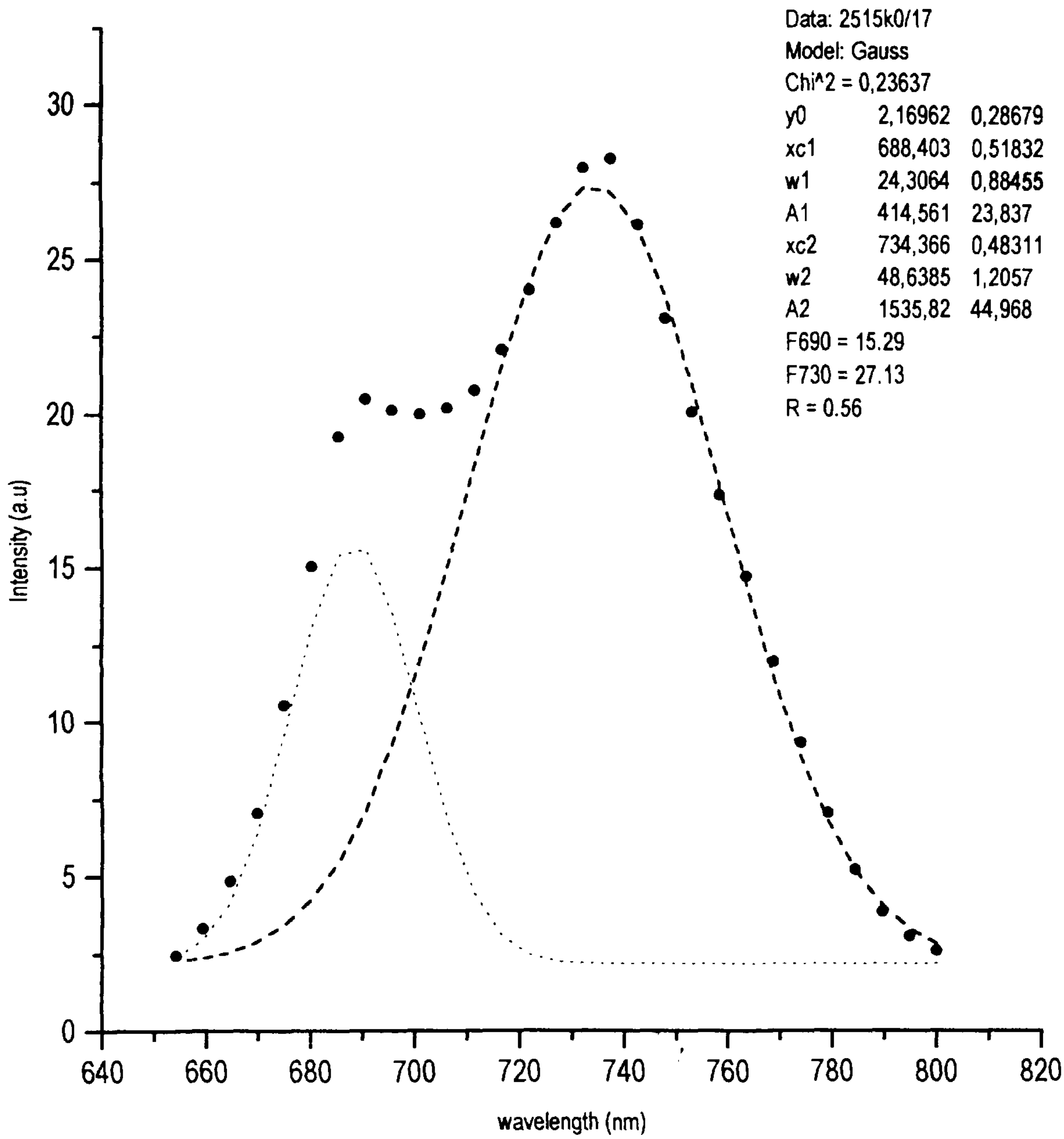

Figure 2 : Fitted spectrum of leaf of rank 17 from tree A2515k0
under tress caused by potassium deficiency.

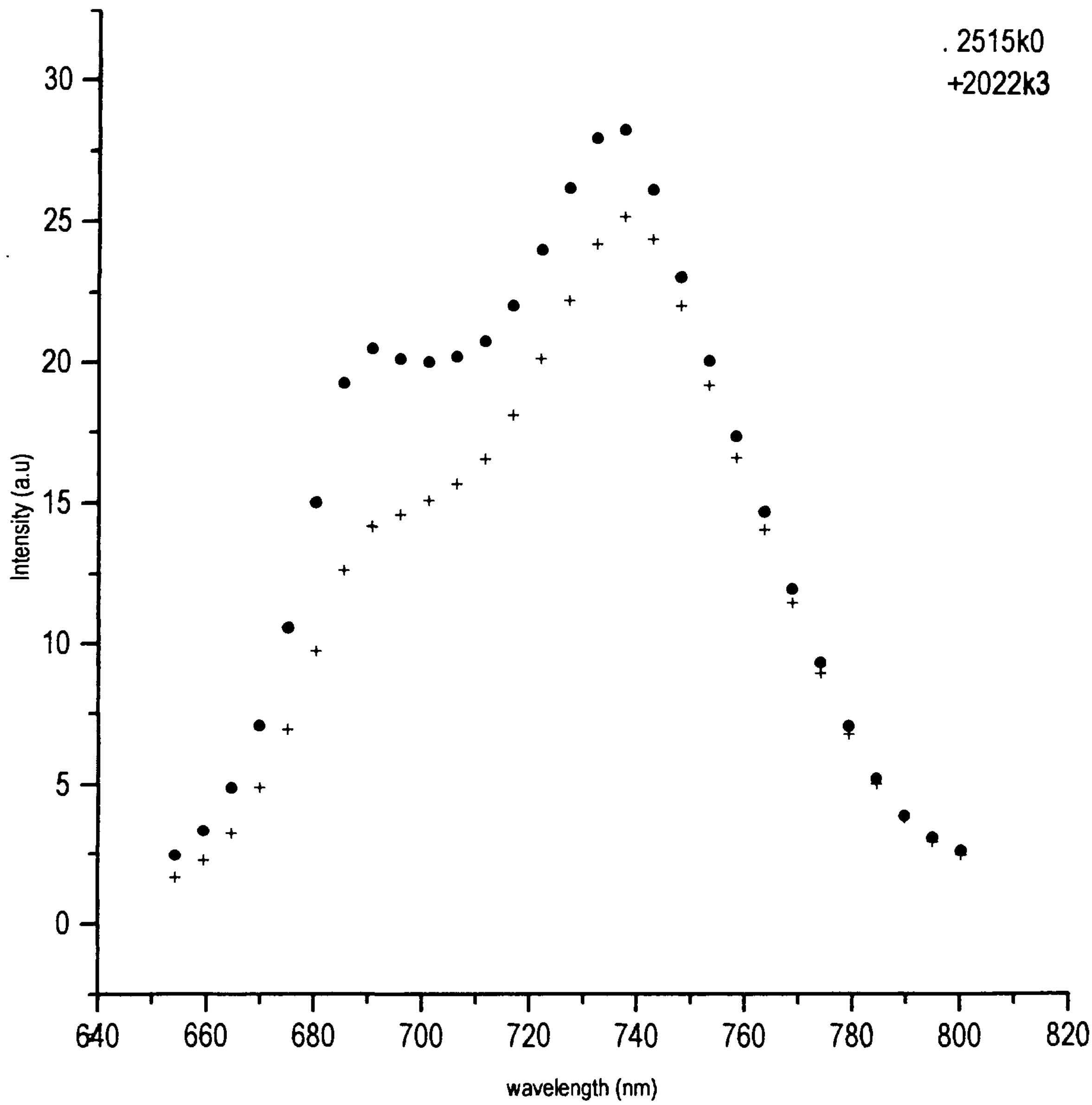

Figure 3 : Fluorescence spectra of leaves of rank 17 of oil palm tree
under potassium deficiency A2515k0 and intact tree A2023k3.