



RESULTS OF A SURVEY ON THE USE OF MINERAL FERTILIZERS UNDER OIL PALM (ELEAISGUINEENSISJACQ.) IN CÔTE D'IVOIRE

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A B S T R A C T

In order to develop mineral fertilizer scales, adapted to different regions and new varieties of oil palm, a survey was conducted among 275 producers in the South-East, South-Center and South-West from Côte d'Ivoire. This semi-structured survey focused on the different types of mineral fertilizers, the doses applied and the producers' assessments of the use of these mineral fertilizers. According to the results of the survey, 10 different types of chemical fertilizers are applied under oil palm cultivation in Côte d'Ivoire. Among these types of fertilizer, KCl is the most used, with a rate of about 80% of use by producers surveyed in all regions. Border regions in neighboring countries, particularly the south-east, hold the record for the number of fertilizers used. Prolonged agricultural practices on the land have led to the need to restore them through the use of chemical fertilizers according to producers. Also, the wish of the oil palm producers surveyed is to use these chemical fertilizers. But given the high cost, lack of extension and low purchasing power of the rural population, fertilizers are not actually used. The few surveyed farmers, who have already used chemical fertilizers, have mostly obtained them through agroindustries.

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INTRODUCTION

In most African countries, agriculture is the most important activity and represents the lung of economic development. In Côte d'Ivoire, the agricultural sector accounts for about 22% of gross domestic product (GDP), more than 50% of export earnings and two-thirds of the population's sources of employment and income (Philibert, 2015). Agriculture is essentially based on the exploitation of industrial crops, including cocoa, oil palm, coffee, rubber and cashew nuts.

Palm oil, with an annual production of around 400 000 tons, ranks second among export products after cocoa (1 300 000 tons). Palm and palm kernel oils yield more than 500 billion CFA francs a year in Côte d'Ivoire and generate 10% of national revenues (Anonymous, 2013). These performances are the result of a major plantation development program undertaken since 1965. This program associated unit creation industrial plantations (industrial plantations) of several thousand hectares to multiple village plantations.

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In addition, high yielding varieties have been developed through research. Despite the high yield potential of new varieties, oil palm cultivation is still characterized by low productivity, linked to physical and socio-economic constraints that hinder production. One of these major constraints is unquestionably soil degradation, which has a direct impact on crop production.

Due to the importance of oil palm in the country's economy and the income security of rural families (Adjadi, 2008; APRM, 2009), there is a strong expansion of village plantations, with still low productivities, compared to industrial plantations. This extensive mode of exploitation, population growth and climate change in recent years have contributed to the intensification of land pressure, which has led to a considerable reduction in natural forest and fallow times (Gala et al., 2007). This situation predisposes the soils to erosion and leads to a degradation of their physicochemical properties (Sedogo, 1993; Bacyé, 1993), as well as the decline in crop yields.

To increase productivity and revolutionize the cultivation of oil palm in Côte d'Ivoire, it appears necessary to improve soil fertility by applying the best farming techniques and the

reasoned use of chemical fertilizers (Roose *et al.*, 2008). These mineral fertilizers, brought to the soil, will provide the plants with nutrient supplements necessary for their growth in order to improve, increase the yield and quality of crops (Zodomé, 2012).

But the use of mineral fertilizers must comply with safety rules. The right choice of the type of mineral fertilizer and its dose to apply would be one of the very important factors to consider. Excessive use of mineral fertilizers has serious consequences for human health, consumer health and the environment. The intensive use of mineral fertilizers can thus cause ecological catastrophes that can be fatal for humans (Daujat *et al.*, 2016).

The low level of education of producers means that they are unaware of the types and modes of use of fertilizers, which increases the risk of poisoning and reduces their effectiveness. In addition, they do not benefit from information enabling them to relate the fertilizers, their effectiveness, their damage, the type to be used, their dose and their spreading period. Information on packaging and their future is unknown to users. Findings were made in Senegal and Benin where recommendations on the correct use of fertilizers are not respected as well as the use of the appropriate type (Cissé *t al.*, 2003; Akogbeto *et al.*, 2005).

The problem of the use of chemical fertilizers in Côte d'Ivoire is very complex. The majority of farmers do not master the methods of fertilizer use and especially do not know how to adapt fertilizers to crops, a situation aggravated by polycultures. It is not uncommon to find farmers using the coffee fertilizer for oil palm cultivation, and vice versa. Respecting prescribed doses also poses a real problem for producers. This leads to a double loss for the farmer, because the insufficient doses do not allow a significant increase of the production, and at the same time, the producer loses the money.

During this study, the different users of mineral fertilizers, under oil palm cultivation, namely the producers, were questioned. The general objective of this work is to show the diversities of the types of mineral fertilizers and the variability of the doses applied under oil palm cultivation in Côte d'Ivoire. In this study, we will examine producers' perceptions of the following issues: (a) the importance of different types of mineral fertilizers used under oil palm cultivation, (b) the effectiveness of these different types of mineral fertilizers; (c) the increase in yield from mineral fertilizers for oil palm and (d) the correct technique of applying fertilizers.

MATERIAL AND METHODS

Sampling

The target population is that of oil palm producers in the Southeast, South-Central and South-West regions of Côte d'Ivoire. These three (3) regions are the largest producing areas of the country's oil palm. Administrative regions were selected following the results of a preliminary survey that established the typology of populations based on the weight of the oil palm in the area. These are Maféré, Aboisso and Ehania in the Southeast, Divo, Boubo and Sikensi in the South Center and Iboké, Tabou and Sassandra in the Southwest. These regions are often characterized by land pressure in the image of other regions of Côte d'Ivoire (Charpentier *et al.*, 1999). The survey

lasted approximately one year from November 2010 to December 2011.

To carry out this survey among the oil palm producers, the reasoned choice method led to working preferentially with the members of the producers' cooperatives. They were made using specific forms and including closed questions and semi-structured interviews. This survey was carried out in both village and industrial settings, that is, oil palm agro-industries.

Survey methods

The data were collected by the individual survey method (Sinarinzi and Nisabw, 1999). It has been supplemented in some cases by focus group discussions. This approach helps to understand the knowledge, attitudes, practices, and perceptions of the target groups about the questions asked (Dawson *et al.*, 1995). The survey was conducted on the basis of semi-structured interviews using questionnaires designed for this purpose. The questionnaires were sent to the operations manager or his representative. Some responses were verified by direct observation on the farm. The main results sought are:

- the percentage of oil palm producers who know about chemical fertilizers,
- the percentage of oil palm producers using chemical fertilizers,
- the different types of chemical fertilizers encountered in Ivorian palm groves,
- the doses of mineral fertilizers applied by oil palm producers,
- oil palm producers' assessments of the different types of chemical fertilizers.

For the study, the number of oil palm producers surveyed by region is shown in Table I.

Table I Distribution of the number of producers surveyed by region

Regions	Number of producers surveyed
Southeast	138
South center	67
Southwest	70
Total	275

Data analysis

The data collected were analyzed in Excel and their processing was performed according to the variables noted in the field. The statistical parameters (means and percentages) were calculated and used for the construction of the distribution tables and histograms for each parameter analyzed.

RESULTS

Different types of fertilizer used in Ivorian palm groves

Figure 1 shows the results of the different types of mineral fertilizers used in Ivorian palm groves. The study allowed us to show that in the palm groves of Côte d'Ivoire, 10 different types of mineral fertilizers are used by the producers. It shows that with 80.29%, potassium chloride (KCl) is the mineral fertilizer most used by oil palm producers. KCl is by far the most important mineral fertilizer, in terms of user and quantity, in palm groves in Côte d'Ivoire. Ternary fertilizer, nitrogen-phosphorus-potassium (NPK), with 44.52%, is the second most frequently encountered mineral fertilizer in palm groves.

Kieserite, Dolomite, Tricalcium Phosphate, Boron Oxide and Maturion are the least frequent mineral fertilizers among producers, with a utilization rate of 0.36%. Urea, Kalichlorid and Hydropalm are used respectively by 5.47%, 13.86% and 1.09% of oil palm producers surveyed in the 3 major producing regions.

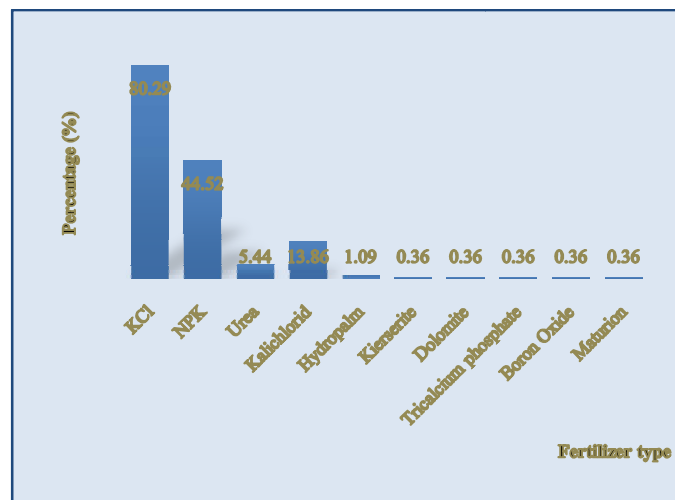


Figure 1 Evolution of the different types of mineral fertilizers encountered in Ivorian palm groves according to their percentage of use

Doses of mineral manures applied by oil palm producers

The study showed that in Ivorian palm groves, there is a variability of doses applied for the different types of mineral fertilizers used (Table II). These applied doses vary from 20 g / plant to 4000 g / plant. For KCl, the most applied rate by producers is 1 kg / plant, with a 61.3% utilization rate. Of the 220 people using this mineral fertilizer, 135 producers apply this dose. At the NPK level, of the 122 producers using this fertilizer, 50 people, or 40.98%, apply the 300 g / tree dose. Kieserite, Boron oxide, Tricalcium Phosphate, Dolomite and Maturion are the least used fertilizers of the producers, with respective ones of 1500, 25, 1000, 1750 and 30 g / tree.

Table II Summary of the different doses of mineral fertilizers applied in Ivorian palm groves

Doses (g/plant)	KCL		NPK		Urea		Kalichlorid		Hydropalm		Maturion		Kieserite		BoronOxide		TricalciumPhosphate		Dolomite	
	PAD	%	PAD	%	PAD	%	PAD	%	PAD	%	PAD	%	PAD	%	PAD	%	PAD	%	PAD	%
20	-	-	-	-	1	6.66	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-
30	-	-	1	0.81	-	-	35	92.1	1	33.5	1	100	-	-	-	-	-	-	-	
35	-	-	1	0.81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
50	-	-	2	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
60	-	-	-	-	-	-	1	2.63	-	-	-	-	-	-	-	-	-	-	-	
100	1	0.45	-	-	1	6.66	-	-	-	-	-	-	-	-	-	-	-	-	-	
150	-	-	1	0.81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
200	1	0.45	3	2.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
300	1	0.45	50	40.98	2	13.3	-	-	-	-	-	-	-	-	-	-	-	-	-	
500	20	9.09	29	23.77	4	26.6	1	2.63	-	-	-	-	-	-	-	-	-	-	-	
600	-	-	2	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
700	-	-	1	0.81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1000	135	61.3	29	23.77	6	40.0	-	-	-	-	-	-	-	-	-	-	1	100	-	
1500	15	6.81	1	0.81	1	6.66	1	2.63	-	-	-	1	100	-	-	-	-	-	-	
1750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
2000	39	13.1	2	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	
2500	1	0.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3000	6	2.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
4000	-	-	-	-	-	-	-	-	2	66.5	-	-	-	-	-	-	-	-	-	
Total	220	100	122	100	15	100	38	100	3	100	1	100	1	100	1	100	1	100	1	100

PAD: Person apply the dose
%: Percentage

Producer appreciation for the use of mineral fertilizers under palm groves

The survey also focused on the appreciation of oil palm producers on the efficiency of mineral fertilizers for plant development and productivity. Table III presents the results obtained. This table shows that out of 275 producers surveyed, 199 people, or 72.36%, found the efficiency of fertilizers good. For producers, who found the average fertilizer use, are 59, a percentage of 21.45%. For 10.90% producers interviewed, the use of mineral fertilizers in palm groves is not necessary. They found that mineral fertilizers have a low effect on the productivity of their plants. The results in Table 3 also show that out of 275 respondents, only 20 producers, let be 7.27%, did not have an opinion on the use of mineral fertilizers in palm groves.

Producer appreciation for the use of each type of mineral fertilizer under palm grove

Table IV presents the results of the producers' assessment of the use of different types of mineral fertilizers for oil palm cultivation in Côte d'Ivoire. With regard to KCl, which is the most applied mineral fertilizer, the table shows that the low, average and good ratings have respective percentages of 11.9, 21.2 and 64.6%. Only 4 people did not have an opinion on the use of KCl under palm plantation. As for ternary fertilizer, that is to say the NPK, 88.9% of the users considered good its application under palm and only 0.9% find weak its effects. Fertilizers least used in eleaiculture, namelyHydropalm, Kieserite, Dolomite, Tricalcium Phosphate, Boron Oxide and Maturion are appreciated by the few users who judge their application good. Kalichlorid, which is a potash fertilizer is considered good by 69.2% of users and average by 16.5% of users.

Table III Summary of producer appreciation for fertilizer use

Appreciation	Number of users	Percentage of efficiency
Low	30	10.90
Average	59	21.45
Good	199	72.36
Very good	2	0.72
Not determined	20	7.27
Total	275	100

Different types of fertilizer applied per region under oil palm cultivation

The survey also examined the use of different types of mineral fertilizers in the three producing regions, the results of which are shown in Table V. In the Southeast region, out of the 138 producers surveyed, 116 people either 84.05% use KCl. Fertilizer types such as NPK, urea and Kalichlorid use the respective percentages of 50.00, 5.05 and 13.04%. In this region, KCl and NPK are the most used mineral fertilizers. Kierserite, Dolomite, Tricalcium Phosphate, Boron Oxide and Maturion are used in this region of the Southeast, with a proportion of 0.7%, or 1 producer out of 138 interviewed.

With regard to south-central Côte d'Ivoire, the most applied fertilizers are still KCl and NPK, with respective proportions of 68.6 and 55.2% of users. Of the 67 producers interviewed in this region, no one has ever used fertilizer types such as Kierserite, Dolomite, Tricalcium Phosphate, Boron Oxide and Maturion.

As for the south-west region of the country, KCl, with a 91.4% utilization rate, remains the most popular mineral fertilizer used by producers. Of the 70 oil palm producers surveyed, 64 apply this fertilizer on their plantations. NPK and Kalichlorid are frequently used in the region, with respective proportions of 28.5 and 24.2% of the 70 producers surveyed.

In South-West Côte d'Ivoire, respondents never used the other 7 mineral fertilizers found in other regions. It is therefore Urea, Kierserite, Dolomite, Tricalcium Phosphate, Boron Oxide and Maturion.

DISCUSSION

In the surveyed areas of south-east, south-central and south-west Côte d'Ivoire, oil palm appears as one of the main cash crops. The continuous exploitation of the lands with the only way of restoring fertility, the natural fallow, causes sharp declines of its yield. To compensate for such losses, it is necessary to add fertilizers. And chemical fertilizers can in this case play a key role (Bationo and Somda, 1994). But lack of knowledge of the role and timing of fertilizer application and the high cost of fertilizer inhibit their adoption and use (Randrianarisoa and Minten, 2003).

The use of mineral fertilizers to improve productivity obeys certain rules for choosing the type of fertilizer for optimization. Unfortunately, our results have shown that such rules are not respected in the areas of our study. The different types of fertilizer listed during the survey, for the improvement of oil palm production, have been the subject of several studies (Ollagnier and Ochs, 1981, Pacheco *et al.*, 1985). It appears that the majority of fertilizers used under oil palm cultivation are not suitable. The use of Urea and Kierserite, a nursery and young crop fertilizer (or proven deficiency correction), for use as a production fertilizer is one example. Similarly, maturion, boron oxide and dolomite are fertilizers whose use in palm grove for productivity is not yet proven. This inadequate fertilizer choice can be explained by the ignorance of the users but also by the free marketing of these products (Kanda *et al.*, 2009). One of the consequences noted during this study is that the majority of listed fertilizers are not licensed.

Table IV Summary of producer assessments for the use of different types of mineral fertilizers

Fertilizer type	Appreciation of users							
	Low		Average		Good		Not dtermined	
	Number of users	Percentage of users	Number of users	Percentage of users	Number of users	Percentage of users	Number of users	Percentage of users
KCL	27	11.9	48	21.2	146	64.6	04	2.3
NPK	01	0.9	09	7.1	112	88.9	01	0.9
Urea	0	0	01	6.3	13	81.3	02	12.4
Kalichlorid	03	8.1	06	16.5	25	69.2	02	5.3
Hydropalm	0	0	0	0	02	100	0	0
Kierserite	0	0	0	0	01	100	0	0
Dolomite	0	0	0	0	01	100	0	0
Tricalcium phosphate	0	0	0	0	01	100	0	0
BoronOxide	0	0	0	0	01	100	0	0
Maturion	0	0	0	0	01	100	0	0

Table V Summary of different types of fertilizer used in palm groves by region of production

Fertilizer types	Southeast			South center			Southwest		
	Producers surveyed	Users of the type of fertilizer	Percentage of use (%)	Producers surveyed	Users of the type of fertilizer	Percentage of use (%)	Producers surveyed	Users of the type of fertilizer	Percentage of use (%)
KCl	138	116	84.05	67	46	68.6	70	64	91.4
NPK	138	69	50.00	67	37	55.2	70	20	28.5
Urea	138	7	5.05	67	9	13.4	70	0	0
Kalichlorid	138	18	13.04	67	2	2.9	70	17	24.2
Hydropalm	138	0	0	67	2	2.9	70	0	0
Kierserite	138	1	0.7	67	0	0	70	0	0
Dolomite	138	1	0.7	67	0	0	70	0	0
Tricalcium phosphate	138	1	0.7	67	0	0	70	0	0
BoronOxide	138	1	0.7	67	0	0	70	0	0
Maturion	138	1	0.7	67	0	0	70	0	0

The non-registration of these commonly encountered fertilizers could be linked initially to the multiple fertilizer supply circuits. Indeed, some products used come mainly from countries bordering Côte d'Ivoire.

In addition, the sale of fertilizers is operated mostly in an informal circuit, thus escaping the control of the competent authorities. Thus, in line with what is observed in several countries of the West African sub region, the majority of traders are unaware of the existence of fertilizer registration institutions (Kanda *et al.*, 2009; Cissé *et al.*, 2003). The lack of control in the marketing and use of chemical fertilizers then results in various manipulations and repackaging of the formulations, all of which has a negative impact on the quality of these mineral fertilizers.

Another problem highlighted by the results of our study is the misuse of fertilizers resulting in non-compliance with the recommended doses and conditions of use, the mismatch between the stage of development and the type of fertilizer and poor management of spraying periods. This set of bad practices is detrimental to the environment, human health and producer shortfalls (Williamson *et al.*, 2008; Kanda *et al.*, 2009).

KCl has been the most widely used mineral fertilizer in production areas. As soon as oil palm comes into production, potassium appears to be the most important nutrient in oil palm production (Ochs *et al.*, 1991; Rafflegeau, 2008). The goal of a high yield in number and weight of the diet cannot be achieved without an adequate supply of this nutrient. On all continents, it has long been known that it is important to monitor the potassium nutrition of palm groves in production to achieve maximum yield (Ochs 1965; Ruer 1966; Anon 1968; Bachy 1969; Pacheco *et al.*, 1985; Hornus *et al.*, 1987 and Anon, 1992).

Among the different types of fertilizer used by all producers, KCl, 60% potassium, therefore appears to be the richest in potassium. This explains the producers' interest in KCl. According to some authors, this fertilizer, via potassium, is directly involved in many functions within cellular metabolism (Clarkson and Hanson 1980, Maathuis and Sanders 1993, Walker *et al.* The efficiency of potassium nutrition on oil palm yield has already been confirmed by previous results, obtained in Cameroon by Rafflegeau (2008); in Côte d'Ivoire by Ballo *et al.* (1994), Caliman *et al.* (1994), Ballo (2009); in Southeast Asia Jamaluddin and Zulkifli (2005), Othman *et al.* (2005) and in Oceania by Breure (1982).

However, at a young age, regardless of the locality, nitrogen fertilizer is the mainstay of fertilization to ensure good vegetative growth of oil palms and early production (Rafflegeau, 2008). Phosphatic, potassium and magnesium fertilizers are generally essential for the good development of young oil palms. This would explain the presence of nitrogen and phosphate types in the list of fertilizers used by producers. Doses ranged from 25 g to over 4000 g / tree, depending on the types of fertilizer and by region of production. For some authors, fertilizer doses must be modulated according to the previous crop, soil type, climate and plant material used (Caliman *et al.*, 1994 and Wey *et al.*, 2002). For others, among the factors involved in the modulation of fertilizer doses, the physical and chemical characteristics of soils play the most important role (Olivin 1968; Ng 1968; Barral *et al.*, 2004). However, generally in Côte d'Ivoire, the dose of 1000 g of KCl

/ tree / year is that which is currently popularized in all production areas. But the lack of information and training on good fertilizer use practices is a major problem. The low education rate severely limits fertilizer knowledge, especially on the modes of application and types to be used.

Despite this low level of education of producers, more than 82% of respondents approve the use of mineral fertilizers in palm groves. But, the variety of types, doses and the appreciation of fertilizers (Vall *et al.*, 2012) shows that producers do not follow the recommendations. For the standard recommendations for fertilizer use do not seem to be adapted to the diversity of the regions, the types of soil cultivated and the practices of the producers.

The assessments and the types of fertilizer applied varied according to the major production areas of the oil palm. Fertilizer use was significantly higher in the South-East and South-West regions, compared to south-central Côte d'Ivoire. The Southeast region borders Ghana and the Southwest region shares a border with Liberia. Indeed, the greatest number of fertilizers used come from neighboring countries, in particular from Ghana. The so-called new types of fertilizer (Kalichlorid and Maturion) have been widely used in the Southeast region. These products come mainly from the Republic of Ghana, which has been easier for producers in the Southeast region to access.

An increase in the use of chemical fertilizers remains one of the solutions to improve the low agricultural productivity in Côte d'Ivoire. Improving access to and use of chemical fertilizers is therefore an important point in agricultural production policy. However, the inappropriate use of fertilizers can seriously damage the environment (mainly water, air and soil, but also indirectly to natural environments such as forests, wetlands, dry grasslands).

The results obtained in this study should challenge the Ivorian state, in particular, and the whole West African sub region in general, because we think like Idrissiet *al.* (2010) that the adverse effects of fertilizers are a reflection of dysfunction in a country or region, reflecting regulatory and economic deficiencies and a low level of education of the population. They also highlight the need for rigorous enforcement of existing regulations, as well as increased training and awareness of stakeholders in producer communities.

CONCLUSION

Surveys carried out in the three regions, namely South-East, South-Central and South-West Côte d'Ivoire, provided an opinion on the issue of the use of chemical fertilizers in cultivation of oil palm.

In general, poorly educated farmers practice risk-based mineral fertilization, based on empirical behavior, in the use of fertilizers and the management of adverse effects from such use, as well as the profitability of fertilizers. The variety of types and doses of fertilizers is explained by the lack of training of producers.

The application of fertilizers requires a lot of precautions, but above all, a mastery of good practices in this area. However, the lack of information on the non-respect of constraints to authorization, and especially the absence of an obligation to register fertilizers in Côte d'Ivoire are the real causes of the drifts in the use of these products in the large areas of culture.

The use of chemical fertilizers, the high cost of fertilizers, the predominant poverty of the rural world, the water stress sometimes accentuated are, among other things, factors which lead producers to use small quantities of fertilizer in oil palm cultivation.

The attitude of users varies from one region to another. In border regions with neighboring countries, producers have easy access to fertilizer while those more distant are more difficult to access.

In the light of these observations, the sector needs to be taken over in order to strengthen oil palm productivity improvement programs in Côte d'Ivoire. For this, the development and dissemination in national languages, the benefits of mineral fertilizers to make it more accessible to the populations concerned, a code of good practice is required.

Following the action of some actions of the state, through the National Agency for Support to Rural Development (ANADER), mineral fertilization in oil palm cultivation is starting to take off in the study areas. At the level of the research, it will be necessary to deepen the work going in the direction of the determination of the doses of economically profitable fertilizers according on the one hand, the agro-ecological zones and, on the other hand, in the respect financial conditions of farmers who receive neither subsidies nor credits.

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