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Influence of Rainfall and Water Deficit in the Efficiency of Potassium Fertilizer on the Productivity of Oil Palm (*Elaeis Guineensis* Jacq.), Grown in Southeastern Côte d'Ivoire

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ABSTRACT: In Côte d'Ivoire, palm oil occupies a preponderant position in agricultural production, in the economy, as well as consumer fats. Yield remains low, even with improved plant material being popularized whose productivity is estimated at more than 25 tons/ha/year. Trials have been set up in La Mé and Ehania (South-east Côte d'Ivoire), to help improve oil palm productivity, through a comparative study of the efficiency of potassium fertilization applied according to the locality. The experiments were conducted in Fisher blocks, including 5 treatments and 4 repetitions. The treatments included 5 doses of potassium fertilizer (T1, T2, T3, T4, T5) corresponding, respectively, to 1; 1.5; 2; 2.5; 3 kg KCl/tree/year. The results showed that the rainfall recorded in the locality of Ehania was significantly higher than that of La Mé. The average annual rainfall was 2000 mm of water in Ehania against, approximately, 1700 mm of water in La Mé. The yield and its components (weight of the bunch and number of bunches) were gradually improved according to the locality of cultivation by the different doses of fertilizer applied. This improvement was significantly higher on the Ehania plantation compared to that of La Mé. This improvement was approximately 30% and 27% compared to the standard dose of 1 kg KCl/tree/year, respectively, in Ehania and La Mé. It appears that the locality intervenes in the efficiency of potassium fertilizers, in the improvement of yield and its components. Rainfall appears, as, a main factor of productivity observed on the plot of the oil palm. Strict compliance with the choices of suitable areas, combined with reasoned potassium fertilization, will allow a better expression of the production potential of new oil palm plant material, currently being popularized.

KEYWORDS: Côte d'Ivoire, Oil Palm, Potassium Fertilizer, South-East, Technical Itineraries

INTRODUCTION

Today, estimated at more than 831 million, Africa's population is expected to reach 3.8 billion by 2100. These demographic changes are superimposed on profound environmental changes, due to climate change, which in a region where extensive agriculture is dominant, negatively impact agricultural production [1] [2] [3]. In this context of food insecurity risks, it is essential to increase agricultural production to meet the challenges of development and reduce the vulnerability of populations.

Like most developing countries, the Ivorian economy is, essentially, based on agriculture, in particular, on the exploitation of industrial crops (cocoa, oil palm, coffee, rubber, etc.). Palm oil, with an estimated annual production of more than 400,000 tons, occupies since 2007, the 2nd place of export products after cocoa (1,300,000 tons). Côte d'Ivoire ranks first among palm oil exporters and second among regime-producing countries at the African level [4]. These performances are the result of a major plantation creation program, undertaken since 1961. In total, more than 14 million hectares are devoted to oil palm plantations in the intertropical zone [4]. These farms developed in the Ivorian forest south, on soils whose natural fertility was complete, and in appropriate rainfall conditions.

Despite this relative natural fertility of soils under forest clearing, the studies of [5], [6] and [7] showed that soils in southern Côte d'Ivoire, dominated by Ferralsols, developed on tertiary sediments, have certain physico-chemical characteristics. These soils are acidic, and have a low cation exchange capacity; they are, in particular, low in potassium. This is due to the low retention power of kaolinite, the main constituent of the clay fraction. As a result, potassium deficiency is the main mineral deficiency observed on these types of soils, in the first generation. Thus, in soils in tropical climates, potassium is the first of the factors limiting yields in bunches.

The optimal use of potassium fertilizers would be one of the most effective ways to increase olive production. The fertilizer formulas used under Ivorian palm groves have changed very little over time, to better adapt to new pedoclimatic conditions, and cover the mineral needs of new oil palm plant material being popularized. In current crop systems, the fertilization operation still recommends an intake of 1 kg of KCl per tree per year, in all oil palm production areas of Côte d'Ivoire. It is necessary to develop an adequate scale of doses of potassium fertilizer for better oil palm productivity.

As a result, the objective of increasing production is constrained by two constraints: the scarcity of land traditionally fertile for oil palm and the less favourable climatic conditions than in the past, namely the decrease in rainfall.

Oil palm production is linked to the result of a number of factors: climate, soil fertility, genetic potential of seeds and cultivation techniques. Among these factors, water supply appears to be the most important factor of production. Oil palm is a heliophilic plant with continuous growth and production, with special climatic requirements. The optimum production is achieved with an annual rainfall of 1800 mm and a monthly average of 150 mm [8] [9]. In oil palm, annual production is affected by climatic parameters and, in particular, by water stress [10] [9]. Oil palm is a well-developed cash crop in the forest area of southern Côte d'Ivoire [11]. In these areas, water is the main determining factor of the environment acting on the production of oil palm.

It is with a view to the development of a scale of potassium manure, adapted to the cultivation of oil palm, in relation to rainfall that this study was initiated. The general objective is to contribute to the development of a scale of potassium manure adapted to the new oil palm plant material being popularized, by evaluating the influence of rainfall on the effectiveness of potassium fertilizer.

MATERIALS AND METHODS

Characteristics of study environments

The studies were conducted in the open field on two different localities in the South-east of Côte d'Ivoire. These are the localities of La Mé and Ehania.

The experiments were conducted on two plots distributed in the two localities, namely: the CNRA plot of La Mé and that of PALMCI of Ehania.

The town of La Mé is located in the South-east of Côte d'Ivoire, 24 km east of Abidjan. Its geographical coordinates are 05°26' north latitude and 03°50' west longitude. The climate is humid subtropical with marked seasons. The annual rainfall, abundant, very irregular. The monthly distribution reveals a bimodal rainfall cycle consisting of four seasons with two rainy seasons alternating with two dry seasons. The soils, derived from tertiary sands, are Ferralsols, highly desaturated, deep and sandy on the surface.

The locality of Ehania is located in the South-east of Côte d'Ivoire, about 40 km from Aboisso. Its geographical coordinates are 05°28' north latitude and 03°12' west longitude. The climate is humid tropical of altitude marked by four distinct seasons. The soils are predominantly sandy-clay with coarse sands. These soils are Ferralsols, highly desaturated and reworked.

Plant material

The plant material consists of hybrids (*Tenera*) of oil palm obtained by growth between *Dur*a (female parent) and *Pisifera* (male parent). The *Dura* type is characterized by fruits with a thin pulp and a thick shell while the *Pisifera* type is characterized by a high abortion rate of the fruit and a very thin shell. The hybrid, called *Tenera*, belongs to the C1001F category. It is characterized by fruits with thick pulp and medium shell, high yield and resistance to *Fusarium* wilt so recommended for replanting.

Mineral manure

The fertilization of the oil palms was ensured by the simple fertilizer represented by potassium chloride (KCl), dosed at 60% K_2O, in the form of granules.

Methods

On each plot, the statistical device adopted is in totally randomized Fisher blocks with 5 treatments and 4 repetitions. The treatments that have been applied are T1: 1 kg of KCl/tree/year corresponds to the popularized control, T2: 1.5 kg of KCl/tree/year, T3: 2 kg of KCl/tree/year, T4: 2.5 kg of KCl/a/year and T5: 3 kg KCl/tree/year. These five treatments were applied annually during the period 2011 to 2014. An entire plot consists of 20 (4 x 5) elementary micro-plots, each with 49 trees spread over 7 lines of 7 trees. Of the

49 trees, 25 trees are useful, on which measurements have been made and the other 24 are bordering. The entire plot consists of 980 trees. The mineral manure test installed on the dominant soil unit (on tray) is on a 5-year-old replanting palm grove. The fertilizer was applied at the end of the rainy season (mid-July) in the circle of 2 meters radius around each tree.

Measured parameters

All the agro-industrial complexes of PALMCI and the research station of the CNRA of La Mé have rain gauges, which have made it possible to collect data on rainfall and total numbers of rainy days. Ten-year series of data have made it possible to monitor the evolution of rainfall in the South-East (La Mé and Ehania) of Côte d'Ivoire. These rainfall data were used for the calculation of annual water deficits (DH) by the simplified water balance method [12].

The water balance (BH) is expressed from the following formula:

$$BH = P + R - E$$

where

BH: Water balance (mm);

P: Rainfall (mm);

R: Initial water reserve of the soil from one period to the next (limited to a maximum of 200 mm, due to the sandy texture of the soil) [10];

E: Simplified assessment of adult oil palm evapotranspiration, which takes the value of 120 mm per month when the number of rainy days is greater than 10, and 150 mm per month, if this number is less than 10 [10].

When the water balance is negative, there is a water deficit (DH). The water deficit (DH) is expressed according to the following formula:

$$DH = - BH$$

The determination of the yield represented by the tonnage of bunches (TR) and its components, consisting of the number of bunches (NR), the weights of bunches (PR) and the average weight of bunch (PMR) was made on the basis of individual harvests. The number of bunches was obtained by counting all bunches harvested per tree. The weight of bunches was determined by weighing all bunches harvested per tree. The average weight was determined from the following relationship:

PMR = PR / NR, where

PMR: Average bunch weight per tree (kg)

PR: Weight of bunches per tree (kg)

NR: Total number of bunches per tree

The yield or tonnage of bunches (TR/ha/year) was obtained from the following relationship:

TR/ha/year = NR * PMR * D, where

TR/ha/year: Tonnage of bunches per hectare per year (tons),

NR/tree/year: Number of bunches per tree per year,

PMR/tree: Average bunch weight (kg) per tree,

D: Planting density with a standard of 143 plants/ha.

Statistical analyses

The results obtained were statistically analyzed using GenStat Release software version 10.1. The graphs were produced using Microsoft Office Excel, version 2007 (Microsft Software, 2007). The Newman-keuls test made it possible to rank the means using an analysis of variance (ANOVA) at the threshold of 1% and 5%. The means of the variables were separated at probability threshold $P < 0.05$ (significant) or $P < 0.01$ (highly significant).

RESULTS

Evolution of rainfall and water deficit in the localities of the study

Rainfall data recorded in both localities show great interannual variability (**Figure 1**). The variations in rainfall at the La Mé and Ehania stations are characterized by alternating wet (high rainfall), moderately wet (close to average) and dry (low rainfall) years. Over the 11 years of data, rainfall has indicated, as a whole, a more decreasing trend in La Mé than in Ehania.

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The annual rainfall in La Mé fluctuated from 1300 to 2000 mm of water over the observation period, with an average of 1700 mm of water per year. It is a moderately watered region. The annual rainfall of the Ehania area has varied over the last decade from 1700 to 3000 mm of water. The annual average recorded in this region was about 2000 mm of water per year. This locality has been heavily watered. The Ehania region (**Figure 1**) was distinguished by average annual rainfall significantly higher than that of La Mé. The total numbers of rainy days per year recorded at the two study sites are shown in **Figure 2**. Over the period 2002 to 2012, the number of annual rainy days remained very high at both sites (Ehania and La Mé). In La Mé, the average annual number of rainy days varied from 140 to 170 days, over the observation period. On the other hand, in Ehania, the number has fluctuated from 120 to 230 rainy days per year.

The evolution of the water deficit (DH) explains the degradation of the climate in a locality. Over the 11 years of observation, the DH was greater than 200 mm of water in the two localities (La Mé and Ehania). The annual water deficit (**Figure 3**) remained greater in La Mé, with values often exceeding 400 mm of water. The DH obtained at La Mé varied from 95 to 477 mm of water. As for Ehania, the annual DH fluctuated from 0 to 333 mm of water, with an average of about 200 mm of water.

On analysis of **Figure 3**, the DH recorded in La Mé remained always higher than that obtained in Ehania. The information recorded in Ehania and La Mé since 2002 shows that, overall, rainfall has been down, while the DH has been slightly up.

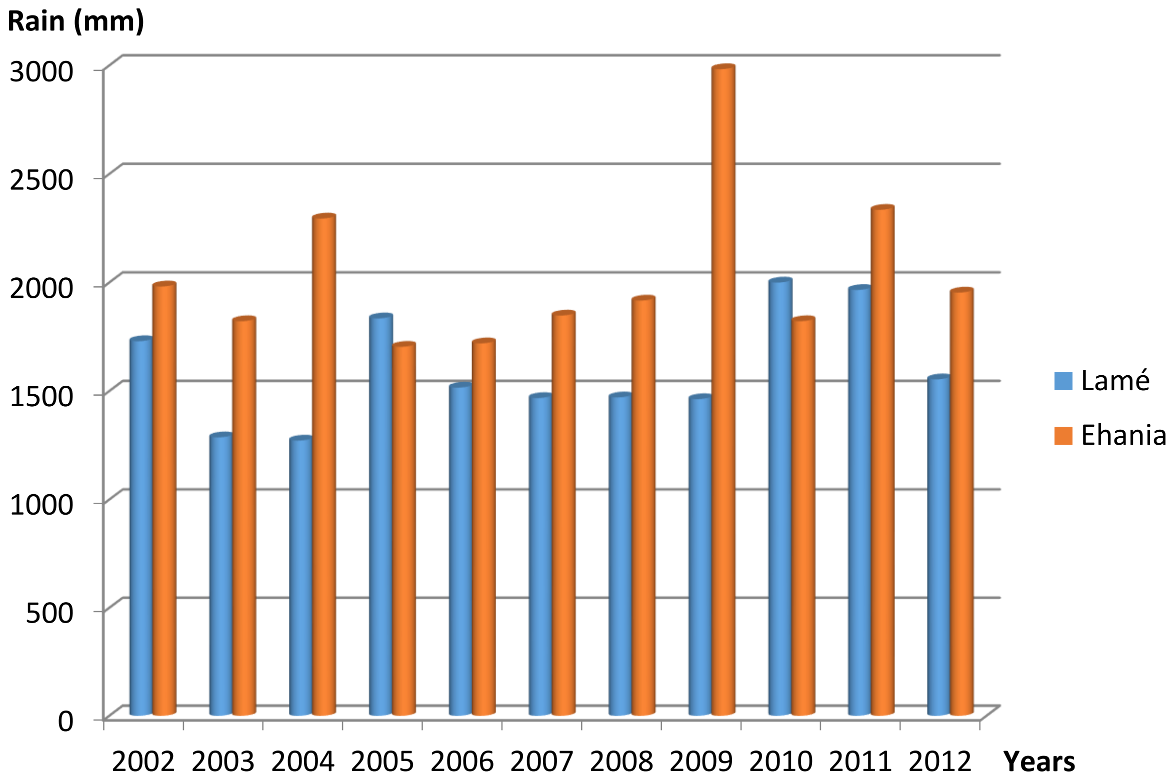

Figure 1: Evolution of annual rainfall on the two meteorological stations during the period 2002 to 2012

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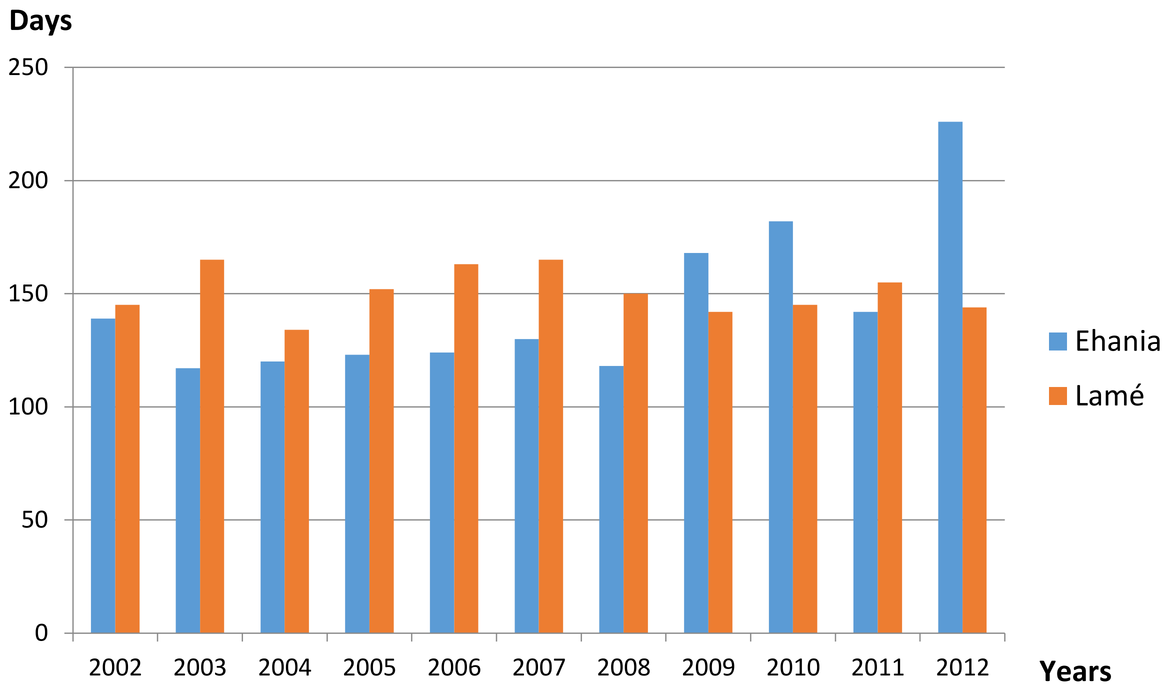

Figure 2: Evolution of the total number of rainy days on the two weather stations during the period 2002 to 2012

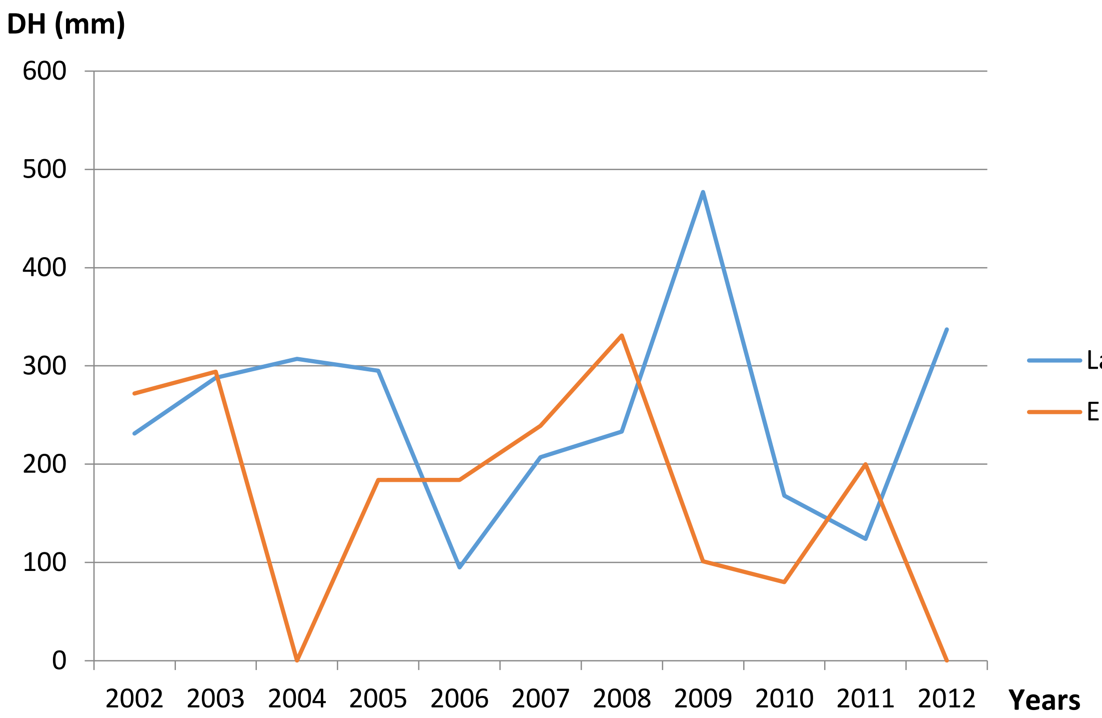

Figure 3: Evolution of the annual water deficit on the two meteorological items during the period 2002 to 2012

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Effects of different doses of potassium fertilizer on yield and its components

The components of the yield as a whole consist of the number of bunches per tree per year (NR/tree/year), the weight of bunches per tree per year (PR/tree/year), the average weight of bunch per tree per year (PMR/tree/year). The yield of oil palm is represented by the tonnage of bunches per hectare per year (TR/ha/year). The effects of different doses of potassium fertilizer on these variables were studied in both localities and on a single type of plantation. The results of the analysis of variance for the effects of treatments and locations on performance components are presented in **Table 1.** The results of the analysis reveal that the treatments, localities and their interactions have a highly significant influence (from $p < 0.05$ to $p < 0.001$) on the components of yield. Their variability is therefore due both to the doses of fertilizer provided and to the localities.

Table I: Table after analysis of variance with three factors considering treatments, localities and types of planting on the characteristics of production

Variation of spring	df	F value		
		NR	PTR	PMR
Treatments	4	1.90	8.58***	16.3***
Localities	1	30.6***	544.8***	3956***
Treatments*Localities	4	2.81**	11.02***	19.6***

NR: Number of bunches; PTR: Total weight of bunches; PMR: Average weight of bunch; df: degree of freedom
*: < 0.05; **: < 0.01; ***: < 0.001

Case of the plantation of La Mé

The averages of the number of bunches (NR/tree/year), the weight of bunches (PR/tree/year) and the average weight of bunch (PRM/tree/year) are presented in **Table 2**. The analysis of variance reveals that there is no significant difference ($p > 0.05$) between the NR means obtained with the different doses applied over the three campaigns. The NR/tree/year, which was increasing in the first two campaigns, began to decrease from the third campaign. The application of potassium fertilizer did not have a significant influence on the production of bunches on this plantation of La Mé.

For PMR, the analysis of variance reveals that there is no significant difference ($p > 0.05$) in the first campaign between the averages of the different doses applied. During this campaign, the PMR varied between 6.6 and 6.9 kg depending on the dose. However, in the second and third campaigns, the analysis of variance revealed that there are significant differences ($p < 0.05$) between the means obtained with the different doses applied. Classification according to the Newman-Keuls test resulted in three distinct groups during these two campaigns. This is the dose of T1 treatment, which had the lowest effect, statistically different from those of the doses of T2 and T3 treatments, forming the second group. The third group is formed by the doses of T4 and T5 treatments. Trees fertilized with the highest doses of treatments (T3, T4 and T5) gave a high PMR, in contrast to what was observed with those of the lowest doses (T1 and T2). These results showed that potassium fertilizer significantly improved PMR and PR on this plot of La Mé (**Table 2**).

The average tonnage of bunches or yield (TR/ha/year) for the three seasons ranged from 18.8 tons/ha/year (T1) to 22.1 tons/ha/year (T3). The analysis of variance reveals that there are significant differences ($p < 0.05$) between the means obtained with the different doses applied (**Table 3**). Classification according to the Newman-Keuls test resulted in two distinct groups. The first group is formed by the doses of the treatments (1 and 2) whose effects are statistically different from those of the doses of the other three treatments (3, 4 and 5). The yield was improved by the application of potassium fertilizer.

Table 2: Effects of different doses of KCl on yield components on La Mé planting during the three marketing years

Treatments	Campaigns								
	2011 - 2012			2012 - 2013			2013 - 2014		
	NR	PR (kg)	PMR (kg)	NR	PR (kg)	PMR (kg)	NR	PR (kg)	PMR (kg)
T1	16 a	107 a	6.6 a	17 a	143 a	8.4 a	15 a	144 a	9.6 a
T2	15 a	99 a	6.6 a	17 a	151 a	8.9 a	16 a	157 a	9.8 a

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T3	16 a	107 a	6.7 a	18 a	160 ab	8.9 a	17 a	182 b	10.7 b
T4	16 a	107 a	6.7 a	18 a	171 b	9.5 b	16 a	178 b	11.1 b
T5	16 a	110 a	6.9 a	18 a	175 b	9.7 b	16 a	178 b	11.1 b
CV	5.4	11.2	10.0	9.1	10.0	9.4	14.1	12.5	9.6
P	0.296	0.504	0.751	0.503	0.013	0.025	0.982	0.010	0.002

The means followed by the same letter in the same column are not statistically different at the threshold of 0.05 by the Newman and Keuls test.
PR: Weight of bunches per tree per year (kg/tree/year); NR: Number of bunches per tree per year; PMR: Average bunches weight (kg), T1 : 1 ; T2 : 1,5 ; T3 : 2 ; T4 : 2,5 ; T5 : 3 (dose of KCl in kg/tree/year

Table 3: Effects of the different doses of KCl on the average yield of the three seasons and its components on the La Mé plantation

Traitements	**Yield and its components**		
	NR/ha/year	**TR (tons/ha/year)**	**PMR (kg)**
T1	2288 a	18.8 a	8.2 a
T2	2289 a	19.3 a	8.4 a
T3	2431 a	22.1 b	9.1 b
T4	2383 a	21.4 b	9.1 b
T5	2382 a	21.3 b	9.0 b
CV	6.4	6.7	8.7
P	0.793	0.023	0.015

Means followed by the same letter in the same column are not statistically different at the 0.05 by Newman Keuls test
TR: Tonnage of bunch (TR/ha/year); NR/ha/year: Number of bunch per hectare per year on the basis of 143 trees per hectare; PMR: Average of bunch weight (kg), T1 : 1 ; T2 : 1,5 ; T3 : 2 ; T4 : 2,5 ; T5 : 3 (dose of KCl in kg/tree/year)

Case of Ehania plantation

The effects of the different doses on NR/tree/year, PMR/tree/year and PR/tree/year, obtained during the three campaigns, are presented in **Table 4**. The analysis of variance reveals that there is no significant difference ($p > 0.05$) between the NR means, obtained with the different doses applied during the three campaigns. The contribution of KCl did not have a significant effect on the production of bunches.

For PRM (**Table 4**), it ranged from 7.3 kg (T2) to 7.6 kg (T4 and T5) in the 2011–2012 season, by 9.4 kg (T1) to 11.5 kg (T5) during the 2012 – 2013 marketing year and from 10.4 kg (T1) to 12.8 kg (T5) depending on the doses applied. The analysis of variance revealed that there is no significant difference ($p > 0.05$) between the means obtained with the different treatments during the first campaign. However, during the second and third campaign significant differences ($p < 0.05$) were observed between the means of the different applied doses.

The effects of the different treatments on the average yield of the three campaigns are presented in Table 5. The averages varied between 21.2 (T1) and 25.6 TR/ha/year (T4) depending on the doses provided. The analysis of variance reveals that there is a significant difference ($p < 0.05$) between the means obtained. The highest yields were obtained with the doses of T2, T3, T4 and T5 treatments. Their effects constituted the second homogeneous group and the first group was formed by the doses of T1 treatments according to the classification according to the Newman-Keuls test. It appears from the above that the potassium fertilizer applied significantly improved the average weight of the diet and the yield during these three seasons.

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Table 4: Effects of different doses of KCl on the components of Ehania's planting yield during the three campaigns

Treatments	Campaigns								
	2011 - 2012			2012 - 2013			2013 - 2014		
	NR	PR (kg)	PMR (kg)	NR	PR (kg)	PMR (kg)	NR	PR (kg)	PMR (kg)
T1	16 a	120 a	7.5 a	18 a	169 a	9.4a	15 a	156 a	10.4 a
T2	16 a	119 a	7.3 a	18 a	193 a	10.7 b	16 a	194 ab	11.5 b
T3	16 a	120 a	7.5 a	19 a	207 ab	10.9b	17 a	200 b	11.8 bc
T4	17 a	129 a	7.6 a	19 a	209 b	11.0 c	17 a	213 c	12.5 c
T5	16 a	122 a	7.6 a	18 a	207 b	11.5c	18 a	230 c	12.8 c
CV	9.1	10.9	2.7	11.3	11.2	2.9	12.3	12.8	3.2
P	0.784	0.260	0.444	0.159	0.001	0.001	0.088	0.003	0.001

Means followed by the same letter in the same column are not statistically different at the 0.05 by Newman Keuls test
PR: Bunche's weight per tree per year (kg/tree/year); NR: Number of bunches per tree per year; PMR: Average of bunch weight (kg)
T1 : 1 ; T2 : 1,5 ; T3 : 2 ; T4 : 2,5 ; T5 : 3 (dose of KCl in kg/tree/year)

Table 5: Effects of different doses of KCl on the average yield of three seasons and its components on the Ehania plantation

Treatments	Yield and its components		
	NR/ha/year	TR (tons/ha/year)	PMR (kg)
T1	2336 a	*21.2 a*	9.1 a
T2	2383 a	*24.8 b*	10.4 b
T3	2415 a	*25.6 b*	10.6 b
T4	2420 a	*25.2 b*	10.5 b
T5	2352 a	24.7 b	10.5 b
CV	7.5	8.7	2.4
P	0.131	0.015	< 0.001

Means followed by the same letter in the same column are not statistically different at the 0.05 by Newman Keuls test
TR: Tonnage of bunch (TR/ha/year); NR/ha/year: Number of bunch per hectare per year on the basis of 143 trees per hectare; PMR: Average of bunch weight (kg)
T1 : 1 ; T2 : 1,5 ; T3 : 2 ; T4 : 2,5 ; T5 : 3 (dose of KCl in kg/tree/year)

Presentation of the number of bunches (NR/tree/year) on the four plots of the study

Figure 4 shows the comparative evolution of the NR/tree/year according to the different treatments on all the plots studied. In the analysis of this figure, we observe the constitution of two distinct groups. The first group is formed by the averages recorded on the Ehania plantation, which produced a higher NR regardless of the treatment used. The second group consists of the averages obtained on the plantation of La Mé. The averages obtained in Ehania were significantly higher than those recorded in La Mé. The number of diets produced by Ehania's plantation varied between 17 (T1) and 18 bunches/tree/year (T5). On the La Mé plantation, the number of bunches ranged from 16 (T1) to 17 bunches/tree/year (T3, T4, T5). Depending on the locality, the Ehania plantation produced a significantly higher NR compared to the plot of La Mé. The locality has had an influence on the efficiency of potassium fertilizer in improving oil palm productivity.

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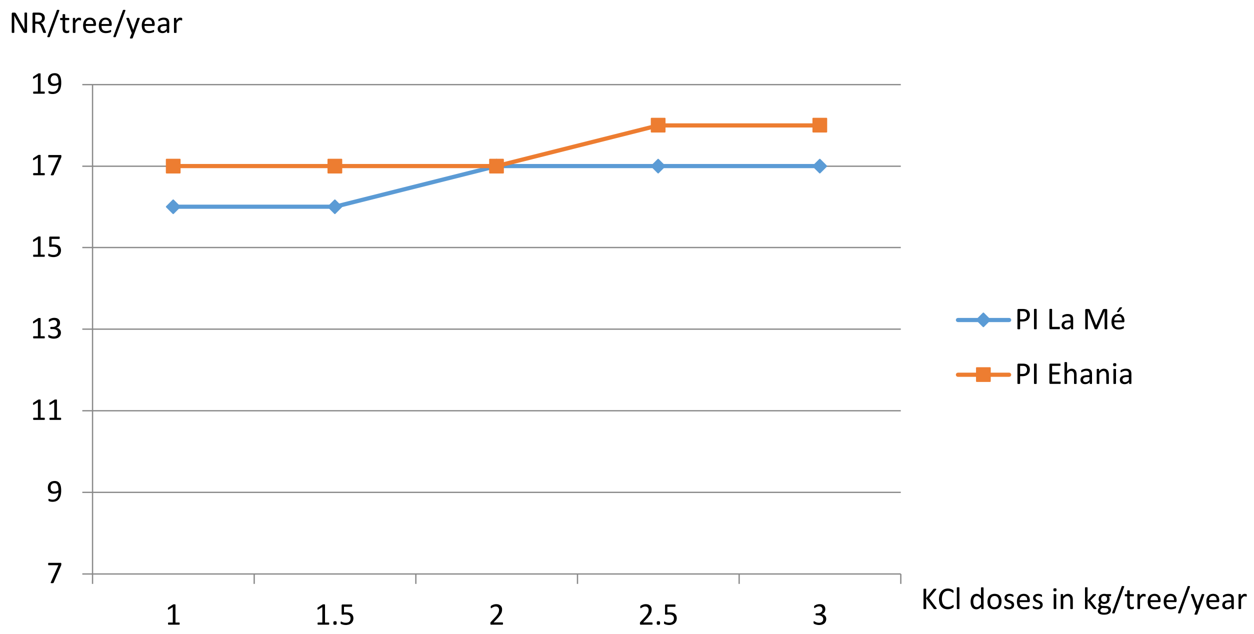

Figure 2: Comparative evolution of the effect of different doses of KCl on the number of bunches per tree per year (NR/tree/year) on all plots of the study

Presentation of the average bunch weight (PMR) on the four plots of the study

The comparative evolution of the PRM according to the different treatments applied to all the plots is presented in **Figure 5.** It emerges from this figure from the constitution of two very distinct groups. The first is the averages recorded on Ehania's plantation, which produced bunches with significantly higher PMR, with a maximum of 10.6 kg/bunch (T5). The planting of La Mé, with a maximum of 9.1 kg/bunch (T5), forms the second element. The averages recorded on La Mé plantation were significantly the lowest, compared to those produced by the Ehania plantation. The potassium fertilizer allowed a better improvement of the PMR on the Ehania plantation compared to that of La Mé. Depending on the locality, the Ehania plantation produced diets with a significantly higher PMR compared to that of La Mé.

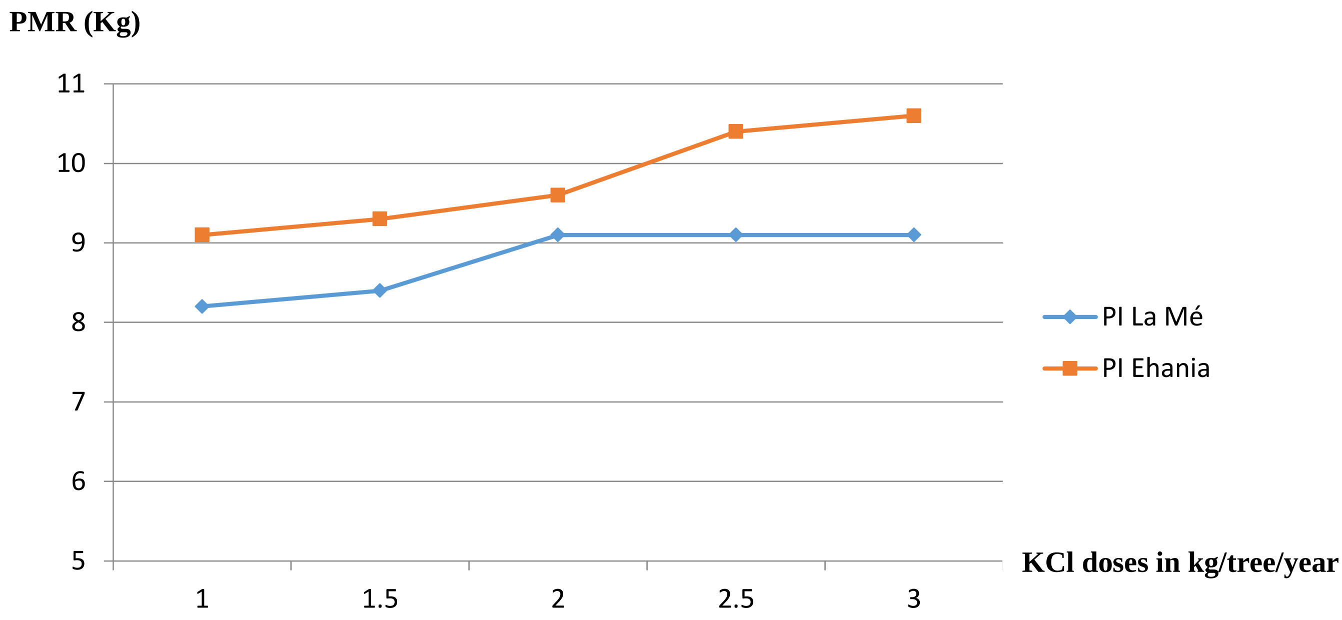

Figure 5: Comparative evolution of the effects of different doses of KCl on the mean bunch weight (PMR) on all plots of the study

DISCUSSION

In recent years, rainfall has been declining, which has led to an increase in DH in southeastern Côte d'Ivoire. This observation, confirmed by our studies, has already been mentioned by authors, such as [13] and [14]**.** The decrease in rainfall and the increase in DH are due to the combined action of man and nature [14]. The abusive exploitation of forests in the wetland, combined with natural phenomena, has contributed to a significant reduction in rainfall. Seasonal bushfires, uncontrolled deforestation without sufficient reforestation and extensive slash-and-burn agriculture in southern Côte d'Ivoire contribute to the decline in rainfall [15].

According to **[16]**, the decrease in rainfall can be explained by climate deregulation, linked to the unfavourable influence of certain environmental factors on the migration mechanism of the intertropical front (FIT). The different positions of the FIT determine the climate in West Africa, in particular, in La Mé and Ehania. The highest rainfall recorded in the locality of Ehania is explained by the proximity of the sea and the presence of a dense evergreen forest. The numbers of clearly high rainy days, recorded in both localities, explain the heavy rainfall obtained in La Mé and Ehania. The rains, being well distributed throughout the year, thus favor a continuous production of oil palm throughout the year in the South-East of Côte d'Ivoire.

In our experiments, we obtained a yield improvement of more than 27%, with an intake of 2 kg of KCl/tree/year (T3) compared to the dose of 1 kg of KCl/tree/year (T1) on the La Mé plantation. For the Ehania plot, the yield improvement was 30%, with the intake of 1.5 kg KCl/tree/year compared to the standard dose (T1). These results show that there is a better response of oil palm to potassium-based fertilization on Ferralsols the localities of La Mé and Ehania.

The different doses of KCl applied gradually improved the yield of the oil palm, through a consequent increase in the average weight of the diet (PMR). This efficiency of potassium manure on yield confirms previous results obtained in Cameroon by [17]; in Côte d'Ivoire by [18] and [19]; in Southeast Asia by [20] and in Oceania by [21]. Potassium, by its specific action as an activator of the transport of assimilates from the leaves to the storage organs, makes it possible to induce a good yield through a significant increase in PMR [19]. Potassium plays an active role in reproductive metabolism and water stress resistance processes [22]. The increase in PRM would be related to the large number of fruits on the diet [19]. Good potassium nutrition activates growth, increases the reserves of the stem organs, and improves fruit set and grow-out. The improvement of PRM through fertilizer input only became significant after two campaigns. These results are consistent with those of [23] who showed that the yield in kilos of diets differs only from at least 20 months after fertilizer intake. The increase in yield after the addition of potassium fertilizer during the second and third marketing years is explained by the fact that potassium manure occurs during the active growth phase of the inflorescence, which lasts 23 to 20 months before the harvest of bunch [24].

The high potassium requirements of oil palm are combined with the mineral poverty of the tropical soils of our cultivation sites. To this end, fertilization must have the effect of compensating for exports and increasing the potassium content of the soil to a level such that the absorption capacity is sufficient to cover the needs of the tree. According to [25]**,** the amount of potassium absorbed by the plant depends on the species grown, the potassium available in the soil, and environmental conditions.

Our results also showed that the effects of different doses of KCl in improving yield components are related to the locality in which the plantation is located. Yields on Ehania's plantations were significantly higher than those at La Mé. Oil palm production has been strongly influenced by the pedoclimatic factors of the locality.

Rainfall appears, as, the main climatic parameter for a better productivity of the oil palm. The optimal annual need is estimated at about 1800 mm of rain, well distributed throughout the year [10]**.** [26] showed that the rainfall deficit has a negative effect on the oil palm production process. Three critical periods of its production are particularly sensitive to a lack of water [26] [27].

A lack of water occurring during the period from floral initiation to sexualization, that is, 42-36 months before the harvest of diets, leads to a higher rate of male inflorescences, to the detriment of female inflorescences. When water deficiency occurs during the period before the emission of the leaf bearing the inflorescence, 24-20 months before harvest, the risk of abortion of this floral draft becomes high. A lack of water that occurs during the phase of increase of the female inflorescence, also increases the risk of abortion, and significantly reduces the size and weight of diets. This period is between 15 and 6 months before the harvest of the future diet. According to [28], DH is a factor in yield, since a 100 mm increase in the annual deficit, within the deficit range of 0 to 500 mm, causes a variation in yield of 2.1 tons of revs, i.e. 10% of the potential production with zero water deficit.

For [29], water stress is, apart from any other edaphic factor, responsible for the low productivity of crops, in particular, oil palm. The rainfall of Ehania is significantly higher compared to that of La Mé. This factor is mainly responsible for the higher productivity observed on the Ehania plot compared to that of La Mé, so hard the effectiveness of the different doses fertilizers applied. In **1977,**

[30] argued that the yields of the new popularized material could reach 25 TR/ha/year, but, exceptionally, 30 tons, if the rainfall is abundant and well distributed to ensure a permanent water supply. Rainfall therefore appears to be the most important ecological factor in ensuring abundant and regular fruiting of oil palm. Thus, the production recorded on the plantations of La Mé, less watered, rarely exceeds 22 TR/ha/year, while in Ehania, it frequently reaches 25 TR/ha/year, with reasoned mineral fertilization.

CONCLUSION

Rainfall and water deficit in South-eastern Côte d'Ivoire are discriminating factors in the long-term cultivation of oil palm. With an average of 2000 mm of water per year, the locality of Ehania appears, therefore, more watered than that of La Mé, whose average rainfall is 1700 mm of water. However, in both localities, rainfall and DH are favorable for the cultivation of oil palm, and the choice of the South-East zone represents, currently, an interesting solution for improving the productivity of this speculation in Côte d'Ivoire.

Regarding the yield and its components, potassium-based fertilization (KCl) improves the total production and the average weight of the diets, on the two plantations of the two localities. Potassium fertilization is an excellent way to improve productivity and thus meet the growing demand for fats in the world, especially that of populations in intertropical areas. This improvement was approximately 30% and 27% compared to the standard dose of 1 kg KCl/tree/year, respectively, at Ehania and La Mé. It appears that the locality intervenes in the efficiency of potassium fertilizers, in the improvement of yield and its components. Rainfall appears to be the main factor, responsible for the higher productivity observed on the Ehania plot compared to that of La Mé.

REFERENCES

1. Wheeler, T. and von Braun, J. Climate change impacts on global food security, Science, 341 (6145), 2013, pp. 508 - 513.
2. Challinor, A.J., Watson, J., Lobell, D.B., Howden, S.M., Smith, D.R., Chhetri, N. A meta-analysis of crop yield under climate change and adaptation. Nature Climate Change, 5(4), 2014, 287 - 291.
3. Leroux, L. Suivi et Caractérisation des Dynamiques de la Production Agricole en Afrique de l’Ouest par Télédétection à Moyenne Résolution Spatiale, 2005, 12p.
4. Anonyme. L'huile de palme, l'autre poumon économique de la Côte d'Ivoire - Afrik.com : l'actualité de l'Afrique noire et du Maghreb - Le quotidien panafricain, 2012, 1 - 20.
5. De Taffin, G. and Ochs, R. La fumure potassique du palmier à huile au Dahomey. Oléagineux, 28, (6), 1973, 269 - 273.
6. Ollagnier, M., Daniel, C., Fallavier, P. et Ochs, R. Influence du climat et du sol sur le niveau critique du potassium dans le diagnostic foliaire du palmier à huile. Oléagineux, 42, 1987, P. 425 – 449.
7. Ochs, R., Olivin J., Quencez, P. et Hornus, P. Réponse à la fumure potassique sur les sols acides sableux formés sur les sédiments tertiaires. Oléagineux, 46, n° 1, 1991, P. 1 – 11.
8. Fondio, L. Étude de l’impact des conditions pédoclimatiques et de l’âge sur la production en régimes du palmier à huile : cas du bas - cavally (EAI de Blidouba et de Néka) et du sud - est (EAI d’Ehania) de la Côte D’Ivoire. Mémoire de fin d’étude agronomique ENSA. Yamoussoukro, 1992, 84 p.
9. Quencez, P. La culture du palmier à huile en Afrique intertropicale : Les conditions du milieu physique. OCL, 3, (2), 1996, 116 - 118.
10. Yao, N.R., Orsot-dessi, D.S., Ballo, K. et Fondio, L. Déclin de la pluviosité en Côte d’Ivoire : impact éventuel sur la production du palmier à huile. Sécheresse, 6, 1995, pp. 265 – 271.
11. Tailliez, B. Importance des fumures équilibrées sur jeune palmeraie au Nord de Sumatra. Oléagineux, 37, (6), 1982, 271 - 281.
12. Dufour, O., Frère, J. L., Caliman, J. P. et Hornus P. Présentation d’une méthode simplifiée de prévision de la production d’une plantation de palmiers à huile à partir de la climatologie. Oléagineux, 43, (7), 1988, 271 - 282.
13. Buisson, A. Tendances climatiques pour l’évaluation de la pluviométrie durant la saison des pluies de l’Afrique sub-saharienne. Veille climatique satellitaire, 24, 1989, 43 - 51.
14. Yao, N. R. Les changements climatiques en Côte D’Ivoire : tentative d’explication et esquisse de solutions. Séminaire national sur l’agroclimatologie et la bioclimatologie. Abidjan, Côte D’Ivoire, 1989, 4 - 6.

15. Tanina, D. S., Nagnin, S., Yéi, M. S. O., Théophile, L., Gbombélé, S., Kouassi, E. A. et Biémi, J. La variabilité climatique et son impact sur les ressources en eau dans le degré carré de Grand-Lahou (Sud-Ouest de la Côte d'Ivoire), *Physio-Géo* [En ligne], Volume 5, mis en ligne le 20 février 2011, Consulté le 19 avril 2013. URL: http://physio-geo.revues.org/1581; DOI: 10.4000/physio-geo, 2011, 1581 p.
16. Péné, B. et Assa, A.D. Variations interannuelles de la pluviométrie et de l'alimentation hydrique de la canne à sucre en Côte d'Ivoire. Sécheresse, n°1, vol. 14, 2003, 43 - 52.
17. Rafflegeau, S. Dynamique d'implantation et conduite technique des plantations villageoises de palmier à huile au Cameroun : facteurs limitant et raisons des pratiques. Thèse à l'Institut des Sciences et Industries du Vivant et de l'Environnement (Agro Paris Tech), 2008, 148p.
18. Caliman, J. P., Daniel, C. et Tailliez, B. La nutrition minérale du palmier à huile, 1994, pp. 21 - 29.
19. Ballo, K. Incidences de la fertilisation à base de potassium sur les composantes du rendement du palmier à huile et sur les caractéristiques d'un sol : cas des ferralsols du sud de la Côte d'Ivoire. Thèse de doctorat de l'Université de Cocody, UFR de Sciences de la Terre et des Ressources Minières, 2009, 140 p.
20. Othaman, H., Tarmizi, A. M. and Dolmat, M. T. Effects of various sources of potassium fertilizer application on oil palm planted in peat in Sarawak. In proceeding of PIPOC, 2005, 864 - 875.
21. Breure, C. J. Factor's affecting yield and growth of oil palm *Tenera* in west New Britain. Oléagineux, 37, (5), 1982, 213 - 223.
22. Pettigrew, W. T. and Meredith, W. Dry matter production, nutrient uptake, and growth of cotton as affected by potassium fertilization. Journal Plant Nutrition, 20, 1997, 531-548.
23. Ollagnier, M. et Ochs, R. Gestion de la nutrition minérale des plantations industrielles de palmier à huile. Economies des engrais, Oéagineux, 36, n° 8 - 9, 1981, 409 - 421.
24. Bredas, J. et Scuvie, L. Aperçu des influences climatiques sur les cycles de production du palmier à huile, Oléagineux, 15^{e} année, n° 4, 1960, 211 - 222.
25. Pettigrew, W. T. Potassium influences on yield and quality production for maize, wheat, soybean and cotton. Physiology Plant, 133, 2008, 670 - 681.
26. Houssou, M. Amélioration du palmier à huile en zone peu humide. Résultats récents obtenus au Bénin. Thèse Doct. Ing, Université PARIS-SUD ORSAY, 1985, 119 p.
27. Frère, J. L. Relation climat - production d'une palmeraie en Côte D'Ivoire, Université Nationale d'Abidjan, mémoire de thèse, 1986, 23 - 30.
28. Caliman, J. P. Dégradation des propriétés physiques conditionnant la fertilité des sols sous culture du palmier à huile en Côte d'Ivoire, essai de correction. Science Sol, 1992, 44-63.
29. Chaudhary, R. C., Nanda, J. S. et Tran, D. V. Guide d'identification des contraintes de terrain à la reproduction du riz. Commission international du riz, FAO, Rome, 2003, 79 p.
30. Ochs, R. et Ollagnier, M. Effet des engrais sur la composition des liquides produits par des oléagineux tropicaux pérennes et sur le rendement. *Oléagineux,* 32, (10), 1977, 409 - 426.

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