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Original Research Article

Doses of magnesium sulphate in productivity of oil palm (Elaeis guineensis)

ABSTRACT

Objectives: The objective of this work was to evaluate the effect of doses of magnesium sulphate for increased productivity in the cultivation of oil palm.
Location and duration of study: The experiment was conducted in the Company Marborges, located in the municipality of Garrafão do Norte, State of Pará, Brazil. In the years 2014 to 2015.
Methodology: The experimental design was in randomized blocks, consisting of four doses of magnesium sulphate (500 g plant -1, 1000 g plant -1,1500 g plant -1 and 2000 g plant -1) plus the control treatment, with three replications. If collected soil samples prior to the application of magnesium sulphate at 20 and 40 cm depth in the projection of the canopy and planting rows for the characterization of fertility even in the experimental area. After the collection of soil, were carried out two applications manuals to haul every 6 months on the projection of the cup with MgSO4. The harvests of fresh fruit bunches were manually performed every fifteen days within a period of two years being evaluated the sum of the number of bunches of fresh fruits produced by treatment; bunch weight of fresh fruit (Kg) and productivity (t/ha/year). Performed analysis of variance year level of 5% probability and for variables whose F was significant regression analysis.
Results: The superficial application of magnesium sulphate in the projection of the copa promoted a significant increase in the level (P<0.05) probability of error, the dose of 1500 g plant-1 provided an increase of 12% for the variable number of bunches of fresh fruit. With respect to the variable weight of fresh fruit bunches were unable to calculate the best dose for the increase in weight was 1370 g plant-1. The dose of 1000 g plant-1 allowed an increase of 15 % by weight of bunches of fresh fruits in relation to witness. This behavior was also observed for the variable productivity, presenting significant effect (P<0.05) with respect to witness, suiting the quadratic equation.
Conclusion: This study showed that application of magnesium sulphate in the cultivation of oil palm in dose 1000 g plant -1 influenced the increase in the number of bunches of fresh fruit, as well as the weight and yield of plants.

Keywords: Amazon, fertilization, Palm Oil, Magnesium, oleaginous plant.

1. INTRODUCTION

The oil palm (*Elaeis guineensis*) has as its center of origin of the african continent, but has been cultivated in the Amazon region because of its climatic characteristics. According to Gomes Junior et al. [1] of the fruits of the palm oil are extracted from the palm oil and palm kernel oil, both with great potential for the food industry, cosmetics and more recently efficiency, which is arousing great interest cost by culture in the internal and external market. In this context it is emphasized the importance of the cultivation of this commodity agroindustrial sector, because it is considered the largest oilseed production of oil per area planted, reaching a productive potential ten times greater than the productivity of soybean, main raw material for the production of biodiesel in Brazil in the same planted area [2].

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A survey conducted by foong et al. [3] found in comparison with other major world oilseed crops such as rape girassol and soybeans, palm produces the highest yield of oil per hectare of land. In accordance with the Council of Malaysia Oil Palm [4], the oil palm requires only 0.26 ha / t, size less than that required for these crops. The palm oil represents about 30% of óleo vegetal produced around the world [3] .

Brazil has the largest area of agricultural suitability for the cultivation of Palma approximately 70 million hectares [5]. But, today, by only 0.5% of world production, with approximately 165,000 thousand hectares planted. In the year 2016 the Brazilian production amounted to 340 thousand tons of palm oil [6].

However one of the limiting factors for the cultivation of culture is low natural fertility of the soils of the region, since they present characteristics of acid reaction, with low values of pH and high levels of aluminum which limits directly the absorption of nutrients by the plant, being needed higher doses of fertilizers with the objective of ensuring the vegetative development of Palma and adequate productivity of clusters [7]. In addition, the continuous use of fertilizers with formulations of N-P-K (nitrogen, phosphorus and potassium), which does not contain Mg+2 in their formulations and not performing the practice of liming has aggravated problems of nutritional deficiency with magnesium in oil palm plantations in the region.

In accordance with cakmak And Iazici [8] the deficiency magnesiana worrying factor is considered to have a predominant role as central atom of the chlorophyll molecule, in addition, the Mg is directly involved in the reactions of carboxylation of photosynthesis, i.e., as a coenzyme in CO2 fixation, basic reaction for the synthesis of other constituents of the plant as starch, protein, fats and vitamins. By this fact, the Mg deficiency in plants severely limits the CO2 fixation [9]. Much has been discussed, and research has shown that the drains organs such as roots in growth also are severely affected by the deficiency of Mg [10].

The palm has a high requirement of Mg to be necessary for the conversion of sunlight into carbohydrates and its mobilization for the bunches of fruit and conseguente conversion into oil. Admit that an efficient fornecimeno Mg in a wide variety of deficient soils can ensure an adequate root development and by consequence, improve the uptake of water and nutrients and improve their productive efficiency [11]. Thus, the objective of this work was to evaluate the effect of doses of magnesium sulphate on the number of fresh fruit bunches, weight and yield of palm oil.

2. MATERIAL AND METHODS

The experiment was conducted in the municipality of Garrafão do Norte, State of Pará, Brazil, west between the coordinates of latitude 1° 55' 59" S and longitude 47° 2' 59" W at an altitude of 56 meters [12]. According to the classification of Köppen, the climate of the region is tropical of altitude (AMI), the local soil characteristic of an alic Yellow Latosols [13]. The site chosen for the implementation of the experiment was in an area of commercial plantations belonging to company Marborges (01° 57' 42" S and 47°00'53" W) with plants already in productive age (3 years of age) cultivar BRS C 2501, type Tenera.

2.2 Product used

The fertilizer used in the experiment was magnesium sulfate (kieserite granular) with chemical formulation ($MgSO_4$-H_2O) originated in the deposits of salt from Germany, purchased from company K+S KALI Brasileira. According to Carvalho et al. 2011 [14] the KIESERITE granular form, is an excellent product with 25% of Mg and 20 % of S are soluble

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in water, with excellent properties of spread because of their characteristic shape and hardness of the granules.

2.3 Delhineamento, experimental treatments and variables studied

The experiment was mounted in field conditions in area of cultivation of three years of age. In an area of approximately 2.6 ha^{-1}. The plants were spaced by 7.8 m between rows and between plants per 9 m, in the form of a equilateral triangle, and planting density of 143 plants/ha^{-1}.

The treatments were composed by the control (without application of $MgSO_4$) and 4 doses of magnesium sulphate soil, described in Table 1.

Table 1- description of the treatments employed in the area of palm oil.

Treatment	MgSO4 (g $plant^{-1}$)	Mg (g $plant^{-1}$)	S (g $plant^{-1}$)
1	0	0	0
2	500	125	100
3	1000	250	200
4	1500	325	300
5	2000	500	400

*Magnesium sulphate ($MgSO_4$, H_2O - 25% Mg and 20% S).
Source: Authors.

The treatments were applied parceladamente being the first application on 22 June and the second on 22 July 2014. The applications were carried out in order to haul manual, evenly distributing the fertilizer under the projection of the canopy of palm oil. Thirty days prior to the installation of the experiment, soil sampling was done to analyze the layers 0-20 and 20-40 cm) for the determination of the chemical and physical attributes (Table 2). These collections at random in line with the projection of planting (COPA) and in the middle of the Interrows. Procedures for the withdrawal of soil samples were carried out in accordance with cloves et al. [15] and the samples sent to the laboratory for analysis of soil.

Table 2 - Granulometric and chemical characteristics of samples of soils (Yellow Latosol (Oxisol) at 0-20 and 20-40 cm depths before the installation of the experiment.

Layer	PH	P	Ca^{2}+	Mg^{2}+	K+	Al $^{3+}$	H + Al	CTC	V	M
Cm	$CaCl_2$	Mg/dm-^{3}	Cmolc dm $^{-3}$						%	
							Cup projection[1]			
00 -20	3.7	1	0.2	0.1	0.07	0.6	3.4	3.8	10	62
20 -40	3.8	1	0.2	0.1	0.05	0.4	3.8	4.2	8	53
							Interline [2]			
00 -20	3.8	2	0.2	0.1	0.07	0.3	3.4	3.8	10	45
20 -40	3.9	1	0.2	0.1	0.07	0.5	3.8	4.2	9	57

Projection of the copa: Collect held in the middle of the area of projection of the canopy [1]; Collect held in the middle of rows of crops [2].
Data source for research.

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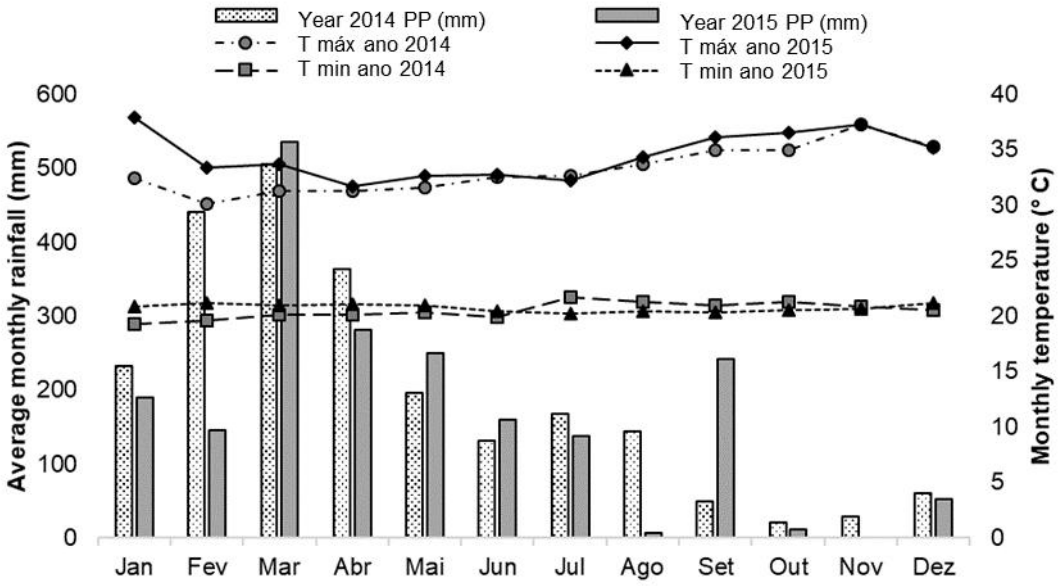
During the conduct of the experiment, the cultural and phytosanitary treatment were made by the Company in accordance with the necessity of culture, having been performed the fertilization recommendation for all evaluated treatments: MAP (12-54-00) 500 g plant^{-1} (188 Kg); potassium chloride (KCl) 700 g plant^{-1} (263 Kg); boric acid (10% (B)100 g plant^{-1} (38 Kg).With the objective of evaluating the annual income, harvests were carried out manually, every fifteen days, being evaluated the sum of the number of bunches of fresh fruits produced by treatment; bunch weight of fresh fruit CFF (Kg) and productivity (t/ha/year).

During the period of the completion of the experiment were collected in the company Marborges climatic data. The maximum and minimum temperatures were measured with the aid of a Digital Termohigrômetro and rainfall, with the aid of the Tank Class A. The data obtained were made available by the company and are presented in Figure 3

Figure 1- monthly temperature and precipitation monthly, during the years of 2014 and 2015 in DEMIJOHNS of north-PA, Brazil.



Source: Marborges, 2014.

2.2 STATISTICAL ANALYSIS

The results were submitted to analysis of variance, and when F was significant, we carried out regression, at 5% of probability to evaluate the effect of doses of magnesium sulphate in productivity of oil palm. The analyzes were performed using the statistical program Assistat [16].

3 RESULTS AND DISCUSSION

We can observe that the municipality of DEMIJOHNS of America presents little variation in temperature of the air, while that in terms of rainfall, there is a variability in the rainy period with periods of high rainfall and others with little rainfall. For the period assessed, it could be inferred that there was no limitation with respect to temperature for the culture, since the

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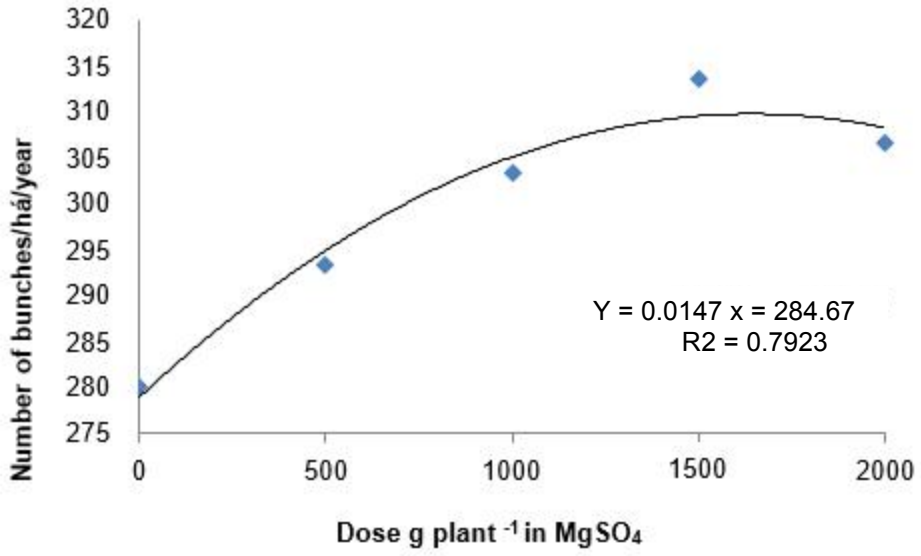
minimum value found was not less than 20 °C and 37 °C. With regard to rainfall, it was observed that in the year 2014 the months of June, August, September, October, November and December had less than 150 mm rainfall per month. However, the annual sum for the same year was 2,341 mm, being in the range adequate for the crop. With respect to the year 2015 this rainfall variation was even greater for the second half of 1997, except for the month of September, the annual sum was equivalent to 2,003 mm.

It appeared as the analysis of soil, before application of MgSO4, taking as a basis the standards for interpretation of results offered by Carvalho et al. [14] ed in the state of Pará, Brazil was possible to observe that in general the soil where it was deployed the experiment showed , characterized by acidic pH values below 5.0, i.e., soils with high acidity in both depths evaluated, besides presenting nutritional content of nitrogen, phosphorus, potassium and magnesium mainly far below the ideal in soil exchangeable phase (<0.2 cmolc/dm-3). Another characteristic of the utmost importance in plant nutrition is the base saturation (V%) which must be in the range of 45% for the cultivation of oil palm and the cation exchange capacity of the soil (CTC), which to the area of the experiment were far below the desired for culture.

3.1 Income productive harvest year 2015

The improvement in the chemical characteristics of the soil in the experimental area harvest year 2015, with the superficial application of MgSO4, promoted a significant increase (*P<0.05*) for the number of bunches of fresh fruits per plant in relation to witness, the addition of fertilizers thermophosphate contributed to the income of the number of bunches in the cultivation of oil palm, in this study, it was observed a correlation coefficient of 0.79, adjusting the linear equation, it is possible to determine the optimal dose for this variable. Furthermore, it was observed an increase in the number of bunches of fresh fruit produced by the plant for all doses of MgSO4, but the dosage of 1500 g plant $^{-1}$ allowed an increase of 12 % in the harvest year of 2015 in relation to witness (Figure 2).

Figure 2. The number of bunches of fresh fruit in function of the superficial application of doses of magnesium sulphate in the cultivation of oil palm.



Source: research data.

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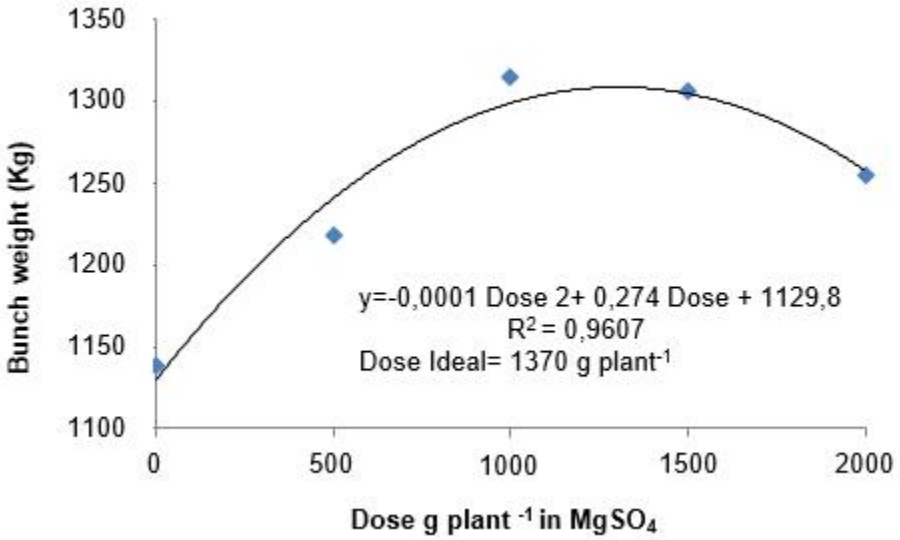
The regression analysis, performed with the doses (0, 500, 1000, 1500 and 2000 g plant $^{-1}$) of magnesium sulphate enabled a quadratic adjustment for the variable weight of bunch of fresh fruit for the cultivation of oil palm (Figure 3). By means of the parameters of the equation shown in figure 3 it was possible to calculate the maximum dose by the method of the derived from the first equation for the variable weight of bunch of fresh fruit. The ideal dose was 1370 g plant $^{-1}$ $MgSO_4$ (342 g plant $^{-1}$ Mg and 274 g plant $^{-1}$ S), for the conditions observed in this experiment, the ideal dose remained in the range of 1000 to 1500 g plant $^{-1.}$ These doses provided 250 to 325 g plant $^{-1}$ Mg and 200 to 300 g plant $^{-1}$ of S, therefore catering for the cultivation of oil palm. With respect to the increment for the weight variable bunch of fresh fruit, it was observed that the dose of 1000 g plant $^{-1}$ allowed an increase of 15 % for the variable weight of bunches of fresh fruits produced by Palm.

Figure 3 - Weight of bunch of fresh fruit in function of the superficial application of doses of magnesium sulphate in the cultivation of oil palm.



Source: research data.

The use of magnesium sulphate also provided increment in other cultures among which we can mention the maize [17], potatoes and sugar beet [18]. According to Wang et al. [19] evaluating areas of coffee production in Africa observed increases in production of arabica coffee in relation to the increase in the Mg content in the soil, and consequent increase in the production of coffee to provide greater dose of magnesium plants.

The application of magnesium sulphate granulated was positive in productivity of oil palm, presenting statistically significant (*P<0.05*), with a high correlation coefficient of 0.96, which allows us to affirm that the yield obtained in the oil palm harvest year 2015, was influenced by the supply of Mg and S in the soil and consequently in the plant. The model was adjusted by the quadratic regression was, since it was observed a linear increase of absorption by the plant until the dose of 1000 g plant $^{-1}$ MgSO4 (equivalent to 250 g plant $^{-1}$ Mg and 200 g plant $^{-1}$ of S), but the journey this dose, there was a decrease of absorption of the plant with the application of higher quantities, possibly due to the occurrence of interactions of Mg and S with other nutrients in the soil solution and in the plant. For obtaining the ideal dose obtained was necessary to the achievement of the derivative of the first equation, which allowed to describe the behavior of the variable, up to a maximum dose of adsorption of

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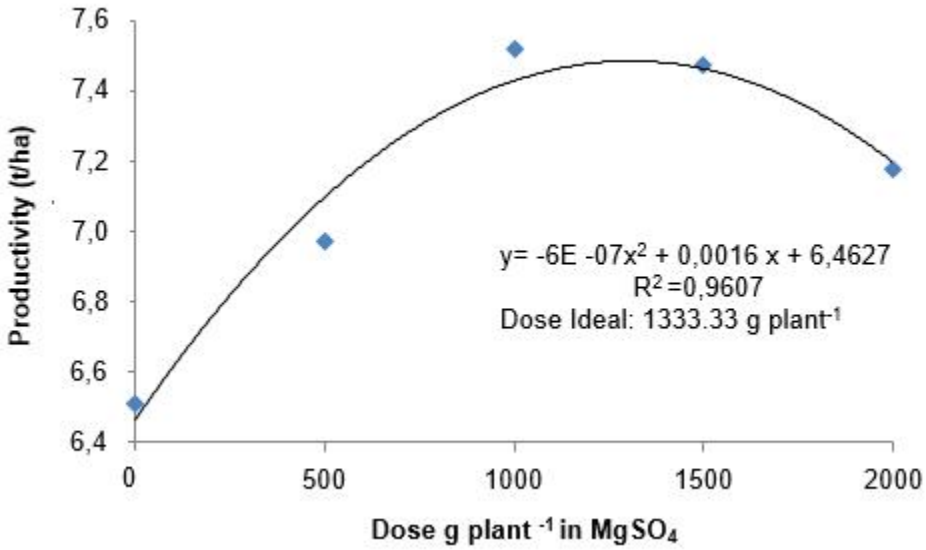
1333 g plant $^{-1}$ (equivalent to 333 g plant $^{-1}$ Mg and 267 g plant $^{-1}$ of S). The ideal dose remained between the doses of 1000 and 1500 g plant $^{-1}$. Equivalent to 143 and 214.5 kg ha-1.

Figure 4. Productivity in function of the superficial application of doses of magnesium sulphate in the cultivation of oil palm.



Source: research data.

Similar results were found by Carvalho et al. [14] In an experiment with the cultivation of cotton, obtained answers with high significant correlation 0.97, for the number of pit and feathers in function of the application of $MgSO_4$. According to Nascimento et al. [20] the increase of the doses of $MgSO_4$ in soybean cultivars provided high production of total dry matter on the plants, and also an increase in leaf area, volume of roots, the contents of chlorophyll and total carotenoids. It is worth noting that there was an increase in productivity of the order of 15 and 14 % for the doses 1000 and 1500 g plant $^{-1}$ respectively, with the application of magnesium sulphate. It is observed that the magnesiana fertilization has increased the productivity of plantations, in the experimental area of the company in the municipality of Marborges DEMIJOHNS of America -PA, which translates into an important tool in conducting the management of fertilization of plantations of oil palm plantations in the region, assigning gains to the producer.

One of the explanations for which the Mg influence on productive efficiency of plants is explained by cakmak and Kirby, [9] according to the author with the reduction of the supply of Mg plants is the partitioning of carbohydrates to the roots, leading to a substantial increase in dry mass ratio between shoot and root. The accumulation of sucrose in leaves occurs due to the concentration of Mg be reduced, there are also severe impairments in the export of these assimilates toward the aerial part and root, causing losses in growth in culture, in addition to significantly alter the photosynthetic rate and reduce the use of

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luminous energy by the plant. In this way to provide fertilization magnesiana culture, it is possible to minimise these losses in the productive system and increase the yield of plants.

The Mg is central constituent of the molecule of chlorophyll, the photosynthetic pigment responsible for the capture of solar energy incident, needed for photosynthesis. The ions free of Mg^{2+} stabilize the membranes and also play role of enzyme activator of important enzymes as ATPases and ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) [20; 22]. In addition, this nutrient is important in the stacking of granas in chloroplasts [23; 24]. These functions in the plant exerted by Mg may adversely affect the photosynthetic performance of plants [25]. The Mg also affects the nodulation of activities of ribulose 1-5- bifosfato CARBOXYLASE oxigenasse in the stroma of the chloroplast, and in this case the activation of enzymes dependent on Mg and pH. The connection of the mg with the enzyme increases affinity for CO2 and doubles the rate of maximum speed of reaction, interfering directly in the photosynthesis performed by plant [22].

Ven the plant is properly nourished, in addition to expressing its genetic yield potential, can also be more efficient in the absorption and use of water in the soil and the absorption of nutrients [23]. Gomes Junior and Bars [24] reported that the soil naturally acidic, have a high content of exchangeable Al^{3+} in subsurface layers, contributed to the reduction of root depth. In the palm, the roots that are responsible for the absorption of nutrients and water, are concentrated in layers of 0-20 and 20-40 cm of soil, this characteristic is important for the management of mineral fertilizers. The magnesium sulfate, is a source that contains Mg and S are soluble in water, the sulfate ion SO_{4-} form ion pairs in the soil, thus have the reduction of Ca^{3+} by the formation $AlSO_4$ less toxic if the plants (25).

The supply of exchangeable bases in the soil is favored by the formation of ion pairs, which in light of the neutrality feature great mobility along the profile, causing the descent of cations to the deeper layers of the soil. This characteristic is important in perennial crops such as oil palm [24]. Sulfur is a structural component of several coenzymes and vitamins such as A and H (biotin) is essential for the formation of fatty acids which together with a multienzimático complex, which contains S is fundamental for the synthesis of fatty acids, this nutrient improves the oil content in plants óleaginosas in their organs of conheita [26; 22]. The response to the magnesium is due to the fact that the African palm has a high requirement of Mg, which easily exceeds the phosphorus. Once the Mg is required for the conversion of sunlight into carbohydrates that in turn are the percusores of oil production. Both the mobilization of carbohydrates for the bunches of fruit as their conversion into oil will depend on the availability of magnesium, similarly a fornecimeno efficient of Mg in a wide variety of deficient soils ensures an adequate root development and consequently improves the uptake of water and nutrients [11]. An experiment conducted in Ivory Coast showed that an increase in the dose of potassium without the addition of MgSO4, which is an important pre-requisite for obtaining a high income in the bunch, significantly decreased the gear oil, bunch. The increase of this relationship and, consequently, the increase in the yield of oil if i got when the K and the MgSO4 were applied in conjunction thus showing a high percentage of oil extracted when you applied the highest dose of potassium [26].

4. CONCLUSION

This study showed that application of magnesium sulphate in the Cultura dose of oil palm in 1000 g plant $^{-1}$ influenced the increase in the number of bunches of fresh fruit, as well as the weight and yield of plants.

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