

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].

24 In a survey conducted by foong et al. [3] found in comparison with other major world oilseed
25 crops such as rape girassol and soybeans, palm produces the highest yield of oil per hectare
26 of land. In accordance with the Council of Malaysia Oil Palm [4], the oil palm requires only
27 0.26 ha / t, size less than that required for these crops. The palm oil represents about
28 30% of óleo vegetal produced around the world [3] .

29 Brazil has the largest area of agricultural suitability for the cultivation of Palma approximately
30 70 million hectares [5]. But, today, by only 0.5% of world production, with approximately
31 165,000 thousand hectares planted. In the year 2016 the Brazilian production amounted to
32 340 thousand tons of palm oil [6].

33
34 However one of the limiting factors for the cultivation of culture is low natural fertility of the
35 soils of the region, since they present characteristics of acid reaction, with low values of pH
36 and high levels of aluminum which limits directly the absorption of nutrients by the plant,
37 being needed higher doses of fertilizers with the objective of ensuring the vegetative
38 development of Palma and adequate productivity of clusters [7]. In addition, the continuous
39 use of fertilizers with formulations of N-P-K (nitrogen, phosphorus and potassium), which
40 does not contain Mg+2 in their formulations and not performing the practice of liming has
41 aggravated problems of nutritional deficiency with magnesium in oil palm plantations in the
42 region.

43
44 In accordance with cakmak And lazici [8] the deficiency magnesiana worrying factor is
45 considered to have a predominant role as central atom of the chlorophyll molecule, in
46 addition, the Mg is directly involved in the reactions of carboxylation of photosynthesis, i.e.,
47 as a coenzyme in CO₂ fixation, basic reaction for the synthesis of other constituents of the
48 plant as starch, protein, fats and vitamins. By this fact, the Mg deficiency in plants severely
49 limits the CO₂ fixation [9]. Much has been discussed, and research has shown that the
50 drains organs such as roots in growth also are severely affected by the deficiency of Mg [10].

51
52 The palm has a high requirement of Mg to be necessary for the conversion of sunlight into
53 carbohydrates and its mobilization for the bunches of fruit and consequente conversion into
54 oil. Admit that an efficient fornecimeno Mg in a wide variety of deficient soils can ensure an
55 adequate root development and by consequence, improve the uptake of water and nutrients
56 and improve their productive efficiency [11]. Thus, the objective of this work was to evaluate
57 the effect of doses of magnesium sulphate on the number of fresh fruit bunches, weight
58 and yield of palm oil.

59 60 61 62 63 64 65 66 67 68 69

2. MATERIAL AND METHODS

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

70 71 72 73 74

2.2 Product used

71 The fertilizer used in the experiment was magnesium sulfate (kieserite granular) with
72 chemical formulation (MgSO₄-H₂O) originated in the deposits of salt from Germany,
73 purchased from company K+S KALI Brasileira. According to Carvalho et al. 2011 [14] the
74 KIESERITE granular form, is an excellent product with 25% of Mg and 20 % of S are soluble

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 MgSO₄) 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	MgSO ₄ (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 (MgSO₄, H₂O - 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 canopy¹;

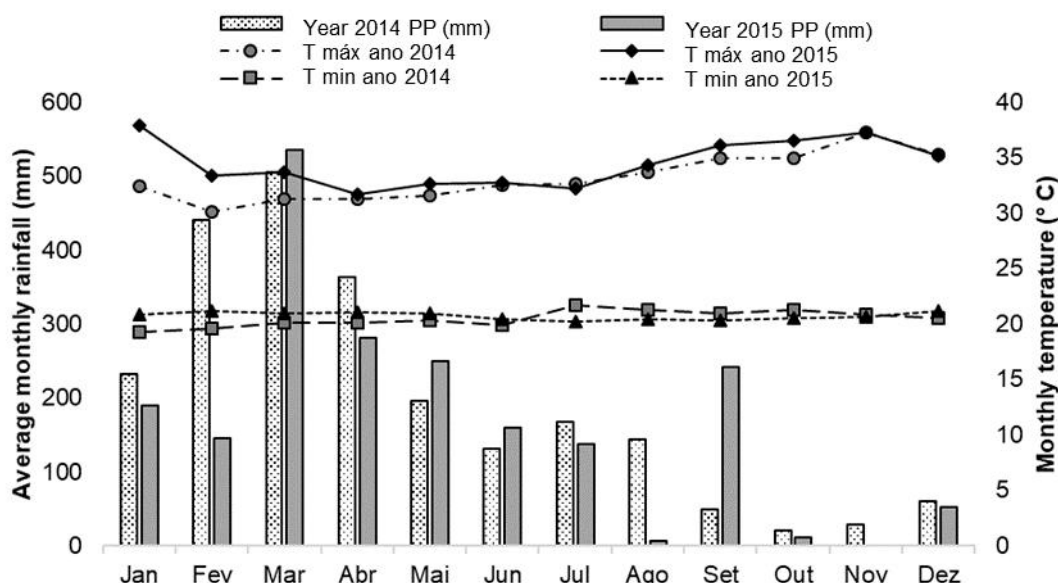
Collect held in the middle of rows of crops².

Data source for research.

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

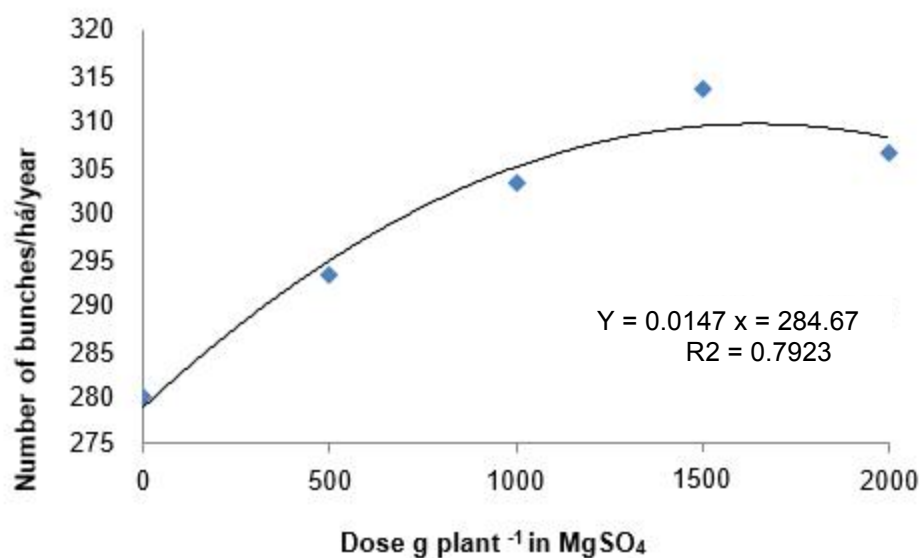
139 minimum value found was not less than 20 °C and 37 °C. With regard to rainfall, it was
140 observed that in the year 2014 the months of June, August, September, October, November
141 and December had less than 150 mm rainfall per month. However, the annual sum for the
142 same year was 2,341 mm, being in the range adequate for the crop. With respect to the year
143 2015 this rainfall variation was even greater for the second half of 1997, except for the
144 month of September, the annual sum was equivalent to 2,003 mm.

145
146 It appeared as the analysis of soil, before application of $MgSO_4$, taking as a basis the
147 standards for interpretation of results offered by Carvalho et al. [14] used in the state of
148 Pará, Brazil was possible to observe that in general the soil where it was deployed the
149 experiment showed, characterized by acidic pH values below 5.0, i.e., soils with high acidity
150 in both depths evaluated, besides presenting nutritional content of nitrogen, phosphorus,
151 potassium and magnesium mainly far below the ideal in soil exchangeable phase (<0.2
152 $cmolc/dm^3$). Another characteristic of the utmost importance in plant nutrition is the base
153 saturation (V%) which must be in the range of 45% for the cultivation of oil palm and the
154 cation exchange capacity of the soil (CTC), which to the area of the experiment were far
155 below the desired for culture.

156 157 3.1 Income productive harvest year 2015

158
159 The improvement in the chemical characteristics of the soil in the experimental area harvest
160 year 2015, with the superficial application of $MgSO_4$, promoted a significant increase
161 ($P<0.05$) for the number of bunches of fresh fruits per plant in relation to witness, the
162 addition of fertilizers thermophosphate contributed to the income of the number of bunches
163 in the cultivation of oil palm, in this study, it was observed a correlation coefficient of 0.79,
164 adjusting the linear equation, it is possible to determine the optimal dose for this variable.
165 Furthermore, it was observed an increase in the number of bunches of fresh fruit produced
166 by the plant for all doses of $MgSO_4$, but the dosage of 1500 g plant^{-1} allowed an increase of
167 12 % in the harvest year of 2015 in relation to witness (Figure 2).

168
169 **Figure 2.** The number of bunches of fresh fruit in function of the superficial application of
170 doses of magnesium sulphate in the cultivation of oil palm.

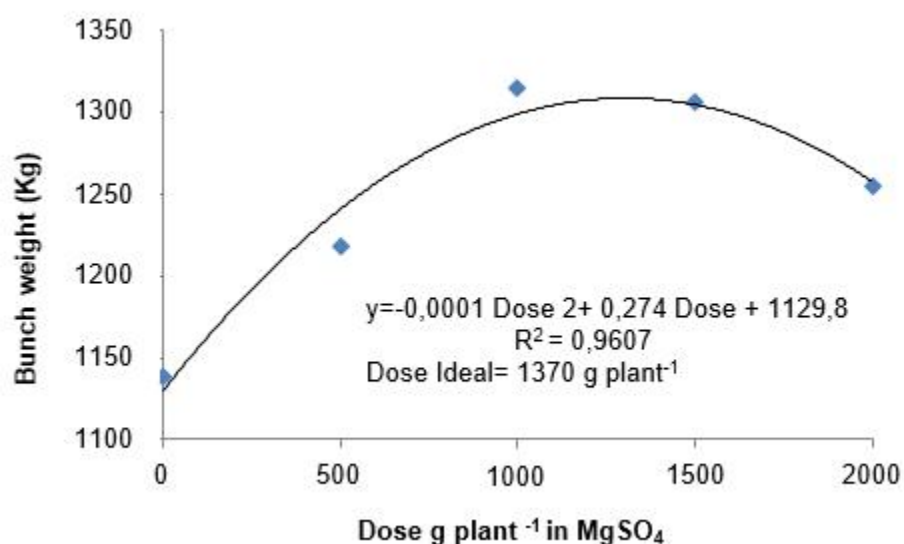


171
172 **Source:** research data.

173

174 The regression analysis, performed with the doses (0, 500, 1000, 1500 and 2000 g plant⁻¹)
 175 of magnesium sulphate enabled a quadratic adjustment for the variable weight of bunch of
 176 fresh fruit for the cultivation of oil palm (Figure 3). By means of the parameters of the
 177 equation shown in figure 3 it was possible to calculate the maximum dose by the method of
 178 the derived from the first equation for the variable weight of bunch of fresh fruit. The ideal
 179 dose was 1370 g plant⁻¹ MgSO₄ (342 g plant⁻¹ Mg and 274 g plant⁻¹ S), for the conditions
 180 observed in this experiment, the ideal dose remained in the range of 1000 to 1500 g plant⁻¹.
 181 These doses provided 250 to 325 g plant⁻¹ Mg and 200 to 300 g plant⁻¹ of S, therefore
 182 catering for the cultivation of oil palm. With respect to the increment for the weight variable
 183 bunch of fresh fruit, it was observed that the dose of 1000 g plant⁻¹ allowed an increase of
 184 15 % for the variable weight of bunches of fresh fruits produced by Palm.
 185

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



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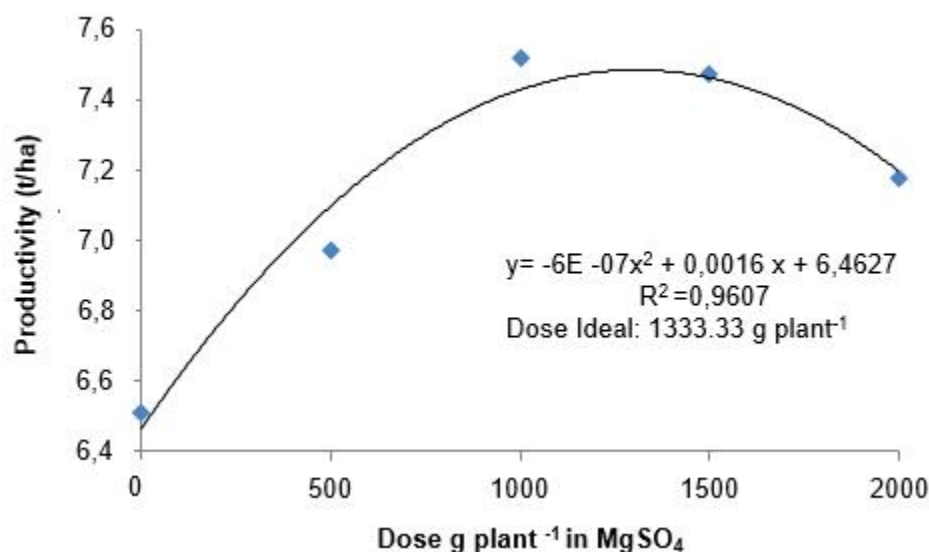
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191 The use of magnesium sulphate also provided increment in other cultures among which we
 192 can mention the maize [17], potatoes and sugar beet [18]. According to Wang et al. [19]
 193 evaluating areas of coffee production in Africa observed increases in production of arabica
 194 coffee in relation to the increase in the Mg content in the soil, and consequent increase in
 195 the production of coffee to provide greater dose of magnesium plants.
 196

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

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 MgSO₄. According to Nascimento et al. [20] the increase of the doses of MgSO₄ 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

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 CO_2 and doubles the rate of maximum speed of reaction, interfering directly in the photosynthesis performed by plant [22].

When 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 oleaginosas 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 $MgSO_4$, 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 $MgSO_4$ 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.

REFERENCES

1. Gomes Junior R, Viégas I J M, Ramos A N D J, Teixeira P C. Nitrogen in the culture of palm oil. In: technical bases for the cultivation of palm oil integrated into productive unit of the family unit / technical editor, Rui Alberto Gomes Junior. - Bethlehem, PA: Embrapa Amazônia Oriental, 2010.
2. Malaysian Palm Oil Board (MPOB), 2017. 2017 <http://bepi.mpob.gov.my/yield.Index.php/en/statistics/yield/181-yield-2017/817-yield-2017.html>. (Accessed 21 February 2018).
3. Foong S Z Y, Goh C K M, Supramanjam C V, Ng D K S. Input-output optimisation model for sustainable oil palm plantation development. 2019. 17: 31-46.
4. Morais R P, Rodrigues V K M, Veras T R, granddaughter L C B. fisiógrafos aspects of the landscape in São João da Goal - RR and its favorability in planting of palm oil for biodiesel production., 2012. Geonorte Magazine Special Edition, 3 (4): h.
5. United States. Department of Agriculture. Foreign Agricultural Service. **Oilseeds**: world market and trade. 2016.
Available at: <<https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery>>. Access in: 21 10. 2016.
6. Franzini V I, Silva R B, Gomes Junior R A. soil acidity and its correction in palm oil. Bethlehem, PA: Embrapa Amazônia Oriental, 2012.
7. Cakmak I, Yazici M. Magnesium a forgotten element in agricultural production. 2010. Better Crops, 94 (2): 23-25.
8. Cakmak I, Kirby AND A. Role of magnesium in carbon partitioning and alleviating photooxidative damage. 2008. Physiologia Plantarum, Hoboken, 133: 692-704.
9. Martins P.O. Efficiency of sources, dynamics of magnesium in soil under the cultivation of coffee in Brazil and comparison analysis of K, Ca and Mg in soils of the Arkansas-USA oven-dried and wet field. 2016. 64f. Doctoral thesis (Soils and Plant Nutrition) - Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo.
10. Marschner P. Mineral nutrition of higher plants. 3ª ed. Australia. Elsevier, 2012.
11. The Brazilian Institute of Geography and Statistics. Database. Available in:< <http://www.sidra.ibge.gov.br>>. Access in: 27 10. 2016.
12. Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA. Centro Nacional de Pesquisa de Solos. Brazilian system of soil classification. 3.ed. Brasília, 2013.
13. Carvalho M C S, WIENDL T, Ferreira C B, Dos Santos F C. Use of this KIESERITE granular in the cultivation of cotton. 31Th Brazilian Congress of Soil Science" Available at: <<http://ainfo.cnptia.embrapa.br/digital/bitstream/item/60939/1/uso-esta.pdf>>. Accessed on: 10 jan. 2017.
14. The HARPSICHORD M S, Viégas I J M, BRAZIL AND C. adduction and Liming Recommendation for the state of Pará. Belém: Embrapa, 2010.

- 347
348 15. Silva F of S, Azevedo, C V of. Principal Components Analysis in the Spftware assistat-
349 statistical Attendance. In: WORLD CONGRESS ON COMPUTERS IN AGRICULTURE, 7,
350 Reno, NV-USA: American Society of Agricultural and Biological Engineeers, 2009.
351
- 352 16. Hardter R, Martin R, Kristian O. Effects of different Mg fertilizer sources on the
353 magnesium availability in soils. 2005. Nutrient Cycling in Agroecosystems 70 (3): 249-259.
354
- 355 17. Orlovius K., Mchoul J. Effect of Magnesium Fertilizers on Leaf Magnesium
356 Concentration, Yield, and Quality of Potato and Sugar Beet. 2015. Journal of Plant
357 Nutrition 38 (13), 2044-2054.
358
- 359 18. Wang N, Jassogne L, Van Aster P J, mukasa Wanyyama I, D, G, Egiller
360 KAGEZI E. Evaluating coffee yield gaps and important biotic, abiotic, and management
361 factors limiting coffee production in Uganda. 2015. European Journal of Agronomy, 63: 1-11.
362
- 363 19.The Birth R, S, Ferreira Deuner L S, Badinelli P G, Curber, R S. growth and levels of
364 chlorophyll and carotenoid in three soybean cultivars in function of fertilization with
365 magnesium. 2009. Revista Ceres 56 (3): 364-369.
366
- 367 20. Taiz L Zeiger. Plant Physiology. 5.ed. Porto Alegre, Hucitec, 2013.
368
- 369 21. Tränkner M, Jákli Tavakol , B, and C, Martin Geilfus cakmak I Dittert K, Senbayram
370 MMagnesium deficiency decreases biomass water-use efficiency and increases leaf water-
371 use efficiency and oxidative stress in barley plants. 2016. Plant and Soil 406: 409-423.
- 372 22. Manure B V. soil fertility and nutrient management. Piracicaba: International Plant
373 Nutrition Institute, 2011.
- 374 23. Freire F J, Freire M B G OF S, Rock T, Oliveira C. mineral plaster of the Araripe and its
375 implications for the agricultural productivity of sugarcane in the state of Pernambuco, Brazil.
376 Anais da Academia Pernambucana de Ciência Agronômica, v. 4, p. 199-213, 2014
377
- 378 24. Gomes Junior R, V R. Selection of suitable areas for the sustainable cultivation of palm
379 oil. In: technical bases for the cultivation of palm oil integrated into productive unit of the
380 family unit / technical editor, Rui Alberto Gomes Junior. - Bethlehem, PA: Embrapa
381 Amazônia Oriental, 2010.
382
- 383 25. Marschner H. Mineral nutrition of higher plants. 2Nd ed. London: Academic Press, 1995.
384
- 385 26. Dubos B, Jean-Pierre C, Francis C, Pierre Q, Sayanto S, Bertrand, T. Importance of
386 magnesium nutrition in oil palm. Result of several years' experiments. 2000.
387
388