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PEANUT PLANT NUTRIENT ABSORPTION AND GROWTH[1]

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ABSTRACT – The chemical composition and the accumulation of nutrients in stems, leaves and fruits are essential information to meet the nutritional requirements of a peanut crop. Thus, the goals of the present study were to evaluate the rate of absorption of macro- and micronutrients; identify the critical phases of nutrient absorption in the peanut crop; and perform growth analysis of these plants. For this, an experiment under field conditions using randomized blocks with 15 treatments and four repetitions was assembled. Each treatment corresponded to a sampling time, held from 10 days after planting, until the end of the cycle, which corresponded to 160 days. Peanut plants generally showed higher macro- and micronutrient absorption rates at 110 days after emergence, coinciding with the highest growth rate of the crop. Thus, the higher nutrient absorption rate and increased crop growth rate occurred during the reproductive period, formation of fruit and grain filling.

Keywords: *Arachis hypogaea* L.. Growth rate. Plant nutrition.

ABSORÇÃO DE NUTRIENTES E CRESCIMENTO DE PLANTAS DE AMENDOIM

RESUMO - A composição química tanto quanto o acúmulo de nutrientes em caule, folhas e frutos são informações imprescindíveis para conhecer as exigências nutricionais da cultura do amendoim. Dessa forma, objetivou-se com o presente estudo avaliar a taxa de absorção de macro e micronutrientes, além de identificar as fases críticas de absorção de nutrientes na cultura do amendoim, bem como, realizar a análise de crescimento dessas plantas. Para isso foi montado um experimento em condição de campo no delineamento experimental em blocos ao acaso, com 15 tratamentos e 4 repetições. Cada tratamento correspondeu a uma época de amostragem, realizadas de 10 em 10 dias após o plantio da espécie, até o final do ciclo da cultura, que correspondeu há 160 dias. Foi observado de modo geral nas plantas de amendoim maior taxa de absorção de macro e micronutrientes aos 110 dias após a emergência, período que coincidiu com a maior taxa de crescimento da cultura. Assim, a maior taxa de absorção de nutrientes e a maior taxa de crescimento da cultura ocorreram durante o período reprodutivo, formação dos frutos e enchimento dos grãos.

Palavras-chave: *Arachis hypogaea* L.. Nutrição de plantas. Taxa de crescimento.

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INTRODUCTION

The peanut (*Arachis hypogaea* L.) plant is native to South America and belongs to the group of oilseed plants. Peanuts were spread widely across the world by the Portuguese, due to their pleasant taste and largely for their nuts. Nowadays, peanuts are the fourth-most cultivated oilseed in the world, occupying an area of 23 million hectares with a world production of 36 million tons anually (FAO, 2016).

Currently, with the evolution of the Brazilian Biodiesel Program, peanuts have been included as an alternative for the supply of raw materials. This inclusion is based on their grain oil yield, which varies between 45 and 50% (MARTIM; ASSUNÇÃO; LIMA, 2009; PIGHINELLI et al., 2008). In this scenario, peanut cultivation may enable family farmers to utilize the abovementioned program, since a serious oilseed crop is an alternative for the diversification of production, resulting in income generation. After extraction of the oil, peanut pie or bran is obtained as a high-energy by-product with about 45% protein, an average of 8.5% grease and a maximum of 9.5% cellulose (TASSO JUNIOR; MARQUES; NOGUEIRA, 2004).

The rationalization of fertilization programs requires the definition of stages of development during which a crop has higher nutritional requirements. Otherwise, in general, better management of fertilization would consist of application of the nutrients required at the moment exactly before specific developmental stages of the plant (NASCIMENTO et al., 2012). The establishment of these data and values is being conducted by studies termed "absorption march", which consist of research intended to establish the absorbed amounts of nutrients according to the age and/or physiological stage of a plant (ECHER; DOMINATO; CRESTE, 2009).

Thus, the determination of nutrient uptake and of accumulation during the different phases of plant development is important because it allows for identifying the times at which elements are required most during development of the crop and the distribution of the elements in the different structures of the plant, allowing adequate fertilization management.

The efficiency of utilization of applied fertilizers and the fraction of nutrients supplied by the soil also should be taken into account (LAVIOLA; DIAS, 2008; ROSOLEM et al., 2012). The chemical composition as well as the accumulation of nutrients in leaves and fruits are essential information to determine the nutritional requirements of a plant. Subsequently, this information can aid estimation of the amount of nutrients to supply to plants through fertilization.

In the literature, several studies on the accumulation of nutrients in crops, such as pumpkin (VIDIGAL; PACHECO; FACION, 2007), jatropha (LAVIOLA; DIAS et al., 2008), pepper (FONTES; DIAS; GRAÇA, 2005), melon (SILVA et al., 2008) and onion (PÔRTO et al., 2007), among others, exist. However, information on other crops of interest in Brazil is scarce.

The objectives of this study were to evaluate the absorption rate of macro- and micronutrients in the peanut crop; identify the critical phases of nutrient absorption; and analyze the growth of peanut plants cultivated in field conditions at Alto Vale do Jequitinhonha.

MATERIAL AND METHODS

The experiment was conducted from 19 December 2009 to 18 May 2010 under field conditions in the Horticulture Sector of the Department of Agrarian Sciences of the Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM) in the municipality of Diamantina, Minas Gerais, at 18º10'S and 43º30'W at 1250 meters altitude during the rainy season, with supplemental irrigation. The local climate is of the type Cwb (temperate with dry winters), according to the classification of Köppen. The meteorological data obtained at the INMET meteorological station in Diamantina, Minas Gerais, during the experimental period included maximum (26.6 °C), average (21.7 °C) and minimum (16.7 °C) temperatures and mean precipitation (0.0 mm).

The soil of the experimental area was classified as a typical Quartzarenic Orthodontic Neosol (RQo), with a sandy texture and slope of 2% (SANTOS, 2013). The experimental area was initially corrected with 2 t ha^{-1} of dolomitic limestone. According to the soil chemical analysis after liming, the following results were observed: pH (water) of 5.4; organic matter content of 1 daq kg^{-1}; P, K and Ca of 1.4, 10 and 0.5 mg dm^{-3}, respectively; and Mg, Al, H + Al and effective CTC (Cation exchange capacity) of 0.2, 0.4, 4.4 and 1.7 $cmol_c$ dm^{-3}, respectively. According to the physical analysis, the following values were observed: 44, 44, 8 and 4 dag kg^{-1} for, coarse sand, fine sand, silt and clay, respectively.

The pre-planting fertilization was carried out following recommendations for a peanut crop in the state of Minas Gerais (RIBEIRO et al., 1999). Amounts of 80 kg ha^{-1} of P_2O_5 and 60 kg ha^{-1} of K_2O were added with the sources super phosphate (445 kg ha^{-1}) and potassium chloride (KCl; 100 kg ha^{-1}), respectively. Given the biological N fixation performed by the plant species, applications of N to the crop were not necessary, and no cover fertilization was required. During the experiment, weeds were controlled by manual weeding. There was no incidence of pests or diseases during the cultivation of the crop; therefore, it was not necessary to apply pesticides.

The experiment consisted of a peanut plant (Caiapó cultivar) density following the recommendations for this crop in the state of Minas Gerais (15 plants per linear meter) (RIBEIRO et al., 1999). Plant densities were maintained by thinning.

The experimental design was a randomized complete block design with 15 treatments and four replicates. Each treatment corresponded to a sampling period, performed every 10 days after planting until the end of the crop cycle, which corresponded to 160 days. The experimental plot consisted of 10 linear m, spaced 0.5 m apart (RIBEIRO et al., 1999). The collections alternated in two lines, leaving two lateral lines for a border effect.

After collections, plant material was washed in distilled water and then dried in an oven with forced air circulation at 65 °C until reaching constant weight to determine the mass of the dry matter of the aerial portions. This determination was performed using an electronic scale with an accuracy of 0.0001 g. After drying the samples until reaching a constant mass, milling was performed using a mill equipped with a fine sieve (40 mesh) with the goal of homogenization of the material. The macro- and micronutrient levels were then measured (MALAVOLTA; VITTI; OLIVEIRA, 1997).

The results were presented in the form of area graphs showing the mass accumulation of dry matter in the leaves, stem, fruits and seeds of the crop during the evaluation cycle. The relative growth rate of the crop according to **equation 1** and the rate of N, P and K absorption according to **equation 2** were also calculated.

Equation 1. Relative growth rate (TCR). The growth rate represents the mass production of the total dry matter at each period of time.

$$TCR = \frac{P2 - P1}{T2 - T1}$$

P1 and P2: Mass of the total dry matter (MST) of two successive samplings.

T1 and T2: Interval (in days) between the two samplings.

Equation 2. Absorption rate (TA) of N, P and K. The same interpretation can be given for the rate of absorption representing the absorption of a given nutrient in a given period of time.

$$TA = \frac{TR1 - T1}{TR2 - T2}$$

TR1 and TR2: Nutrient contents of two successive samplings.

T1 and T2: Interval (in days) between the two samplings.

The TCR (g g^{-1} day^{-1}) expresses the growth in grams of dry matter per unit of material present at a period of observation, used in several studies (AGUILERA; FERREIRA; CECON, 2004; CAMPOS et al., 2012; CARVALHO; LÓPEZ-OVEJERO; CHRISTOFFOLETI, 2008).

To represent the total accumulation of the main nutrients, graphs of accumulation of macro- and micronutrients were constructed considering 120 days after the emergence (DAE) of the plants.

All data obtained regarding the absorption rate of macro- and micronutrients and the growth rate of the plants were subjected to analysis of variance (using Sisvar® software 5.6) and regression analysis (using Microsoft Office Excel 2010 software), with the accumulation of nutrients, the dependent variables (Y) and the collection times of the plants, also considering the phenological stages of the crop, the independent variable (X).

RESULTS AND DISCUSSION

When evaluating the rate of N absorption in peanut plants, from 30 to 80 DAE an increase in the values of this variable were observed. These values remained in the range of 5.5 g day^{-1} until 120 DAE, which corresponded to the end of the vegetative phase and the beginning of the reproductive phase, from flowering to the beginning of grain filling. From 120 DAE, there was a sharp decrease in the rate of N uptake, reaching approximately 1 g day^{-1} until the end of the crop evaluation cycle (Figure 1A). Lobo et al. (2012), working with omission of nutrients in the culture of peanuts, concluded that of the treatments applied, omission of N, P and K was most limiting, demonstrating the importance of the application of these nutrients to peanut plants.

Because it is a legume, the peanut plant fixes, under most conditions, sufficient amounts of N through the symbiotic association with bacteria of the genus *Bradyrhizobium*. According to Freire (1992), peanut plants fix up to 297 kg ha^{-1} $year^{-1}$ of N through biological N fixation. In an area with an expected production in the range of 3 t ha^{-1} of pods, about 190 kg of N are removed (BOLONHEZI et al., 2005).

According to Stancheva and Dinev (1995), the maximum content of the photosynthetic pigments in corn and wheat leaves was observed in plants that exhibited the greatest vegetative growth. Correia et al. (2012) reported that the increase in peanut production is related to the increase in chlorophyll concentration in the leaves due to the higher N absorption.

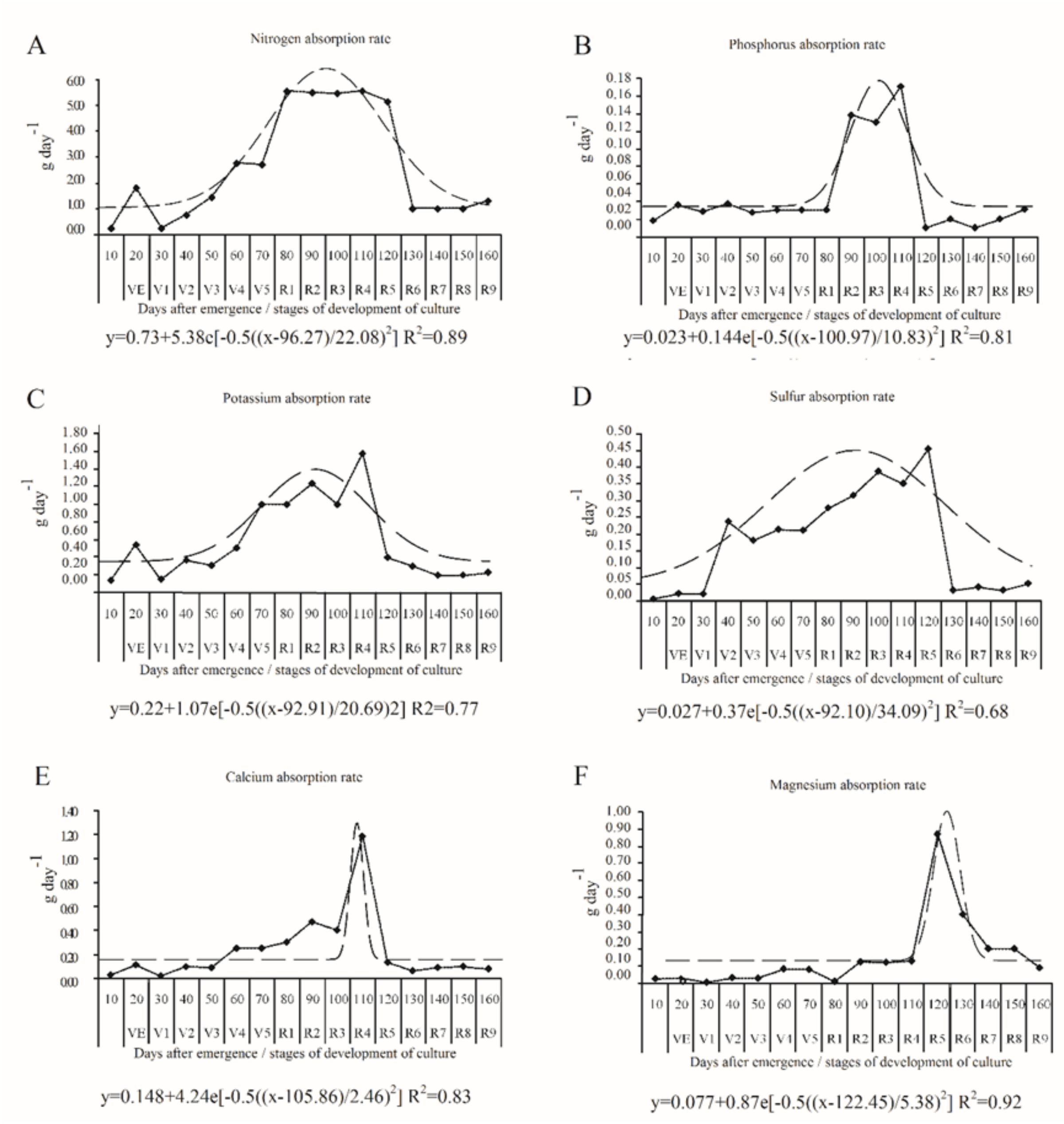

Figure 1. Absorption of macronutrients: A) nitrogen; B) phosphorus; C) potassium; D) sulfur; E) calcium; and F) magnesium in peanut plants at different evaluation periods.

A higher rate of P absorption was observed in peanut plants between 90 and 110 DAE, with a peak absorption at 110 DAE and a P absorption rate equivalent to approximately 0.16 g day^{-1}. During that time of evaluation, there was a decrease in the rate of P absorption to values below 0.03 g day^{-1} until the end of the crop cycle (Figure 1B).

The phosphorus appears in relatively small amounts in peanut plants, but they have the ability to absorb phosphorus in soils that are very poor in Phosphorus. Phosphorus has the function of transporting, accumulating and using energy (TASSO JUNIOR; MARQUES; NOGUEIRA, 2004). This element is considered the main productivity factor of the peanut crop, although it is extracted in smaller quantities compared to other macronutrients (BOLONHEZI et al., 2005). According to Feitosa et al. (1993), more than 70% of the P absorbed by the peanut plant accumulates in the fruits, which shows the importance of this element in the formation and development of fruits.

In relation to the rate of absorption of K, an absorption peak of 0.60 g day^{-1} was recorded at 20 DAE, followed by a decrease at 30 DAE, similar to that observed for the rate of N absorption. After this observed period, there was an increase in the rate of absorption of K, with its highest value observed at 110 DAE, equivalent to approximately 1.6 g day^{-1}. The K absorption rate values were reduced to 0.2 g day^{-1} at 140 DAE (Figure 1C). The amount of K can vary. K is very important to plants and is the second-most absorbed element, overcome only by N. K has the physiological function of an enzymatic activator and, once absorbed, can be transferred from the older parts of the aerial portions to the newer parts (TASSO JUNIOR; MARQUES; NOGUEIRA, 2004).

K plays an important role in the formation of fruits, acting in the transport of photoassimilates in the phloem (TAIZ; ZEIGER, 2013). The deposition of biomass in fruit is necessarily accompanied by the accumulation of K. In addition, K is a required nutrient in the activation of several enzymes essential to the synthesis of organic compounds, among them starch (LAVIOLA; DIAS, 2008).

The responses with K and peanut are, in most cases, lower than expected, even in soils with low levels of this element (FREIRE et al., 2007). According to Bolonhezi et al. (2005), the K levels applied should be considered relative to the levels of other cations, especially Ca, as they compete for absorption for the development of the pods. Uchôa et al. (2011) and Salvador, Carvalho and Lucchesi (2011) cautioned that excessive KCl applications may inhibit Ca^{2+}, Mg^{2+} and P uptake.

There was an increase of approximately 0.03 g day^{-1} from 30 DAE to 0.25 g day^{-1} at 40 DAE in the rate of absorption of sulfur in peanut plants. During this evaluation period, there was a tendency for increasing rates of sulfur absorption, with the highest absorption peak observed at 120 DAE, reaching a sulfur absorption rate of 0.45 g day^{-1}. The sulfur absorption rate reduced to values below 0.05 g day^{-1} at 130 DAE until the end of the cycle (Figure 1D).

The Ca absorption rate increased from 30 to 100 DAE, with values varying from 0.001 g to about 0.4 g day^{-1}, respectively. However, the highest Ca uptake peak was observed at 110 DAE, with an absorption rate of 1.20 g of Ca day^{-1}. During this evaluation period, there was a marked decrease in the rate of Ca absorption to values below 0.20 g day^{-1} at 120 DAE until the last evaluation (Figure 1E).

Mg absorption rates of less than about 0.1 g day^{-1} to 110 DAE were observed in the peanut plants, followed by a peak absorption of this nutrient at 120 DAE, with a value close to 0.90 g day^{-1}. The Mg absorption rate returned to values close to 0.1 g day^{-1} only at 160 DAE, at the end of the cycle (Figure 1F).

When evaluating the rate of Cu absorption, the values of this variable tended to increase from 30 to 110 DAE, and during this evaluation period the absorption peak of this nutrient (approximately 4.0 mg day^{-1}) was observed. After peak absorption, a decrease in Cu absorption rate was observed up to 130 DAE, during which the absorption values of this nutrient remained in the range of 1.0 mg day^{-1} until the end of the cycle (Figure 2A).

There was an increase in Mn absorption rate from 70 to 110 DAE, which equates to about 0.5 to 20 mg day^{-1}, respectively. However, after this evaluation period the values decreased to about 2.0 mg day^{-1} at 130 DAE (Figure 2B).

A large increase in Zn absorption rate was observed from 80 to 110 DAE. During that time of evaluation, the highest-peak Zn absorption by peanut plants was observed. After 110 DAE, a decrease was observed in the values of this variable up to 150 DAE (Figure 2C).

Regarding Fe uptake rate by the plants, an increase in the values of this variable from 10 to 110 DAE was observed, with an absorption peak of 25 mg day^{-1} at 110 DAE. After this evaluation period, there was a decrease in uptake rate of this micronutrient until the end of the crop cycle (Figure 2D).

A higher peak in the B absorption rate was observed at 110 DAE, with a value of approximately 0.20 mg day^{-1}. After 130 DAE, these values decreased to approximately 0.01 mg day^{-1} (Figure 2E).

In general, the maximum daily absorption of the macro- and micronutrients occurred at 110 DAE, coinciding with the period of highest growth rate of the crop (Figure 3), fruiting period and beginning of grain filling. During this period, the establishment of a nutrient mobilizing force and assimilation, due to an increase of metabolic activity, are associated with hormonal activity as well as division and growth of the cells (TAIZ; ZEIGER, 2013).

When evaluating the growth rate of peanut plants, there was an increase in the values of this variable at 80 to 110 DAE. After this period, there was a trend of reduction in the growth rate of the crop until the end of the crop cycle (Figure 3). The absolute growth rate (grams per day) provides an estimate of the average growth speed of plants throughout the development cycle. Species that grow rapidly produce more leaf area and possibly exhibit greater ecological adaptability than those of slow growth (CAMPOS et al., 2012; CARVALHO; LÓPEZ-OVEJERO; CHRISTOFFOLETI, 2008).

Perin (2001) found that peanuts sown during the wet period (December) provided full soil cover at 110 days after planting. Climatic conditions, especially rainfall during the summer, were determinant in the speed of soil coverage.

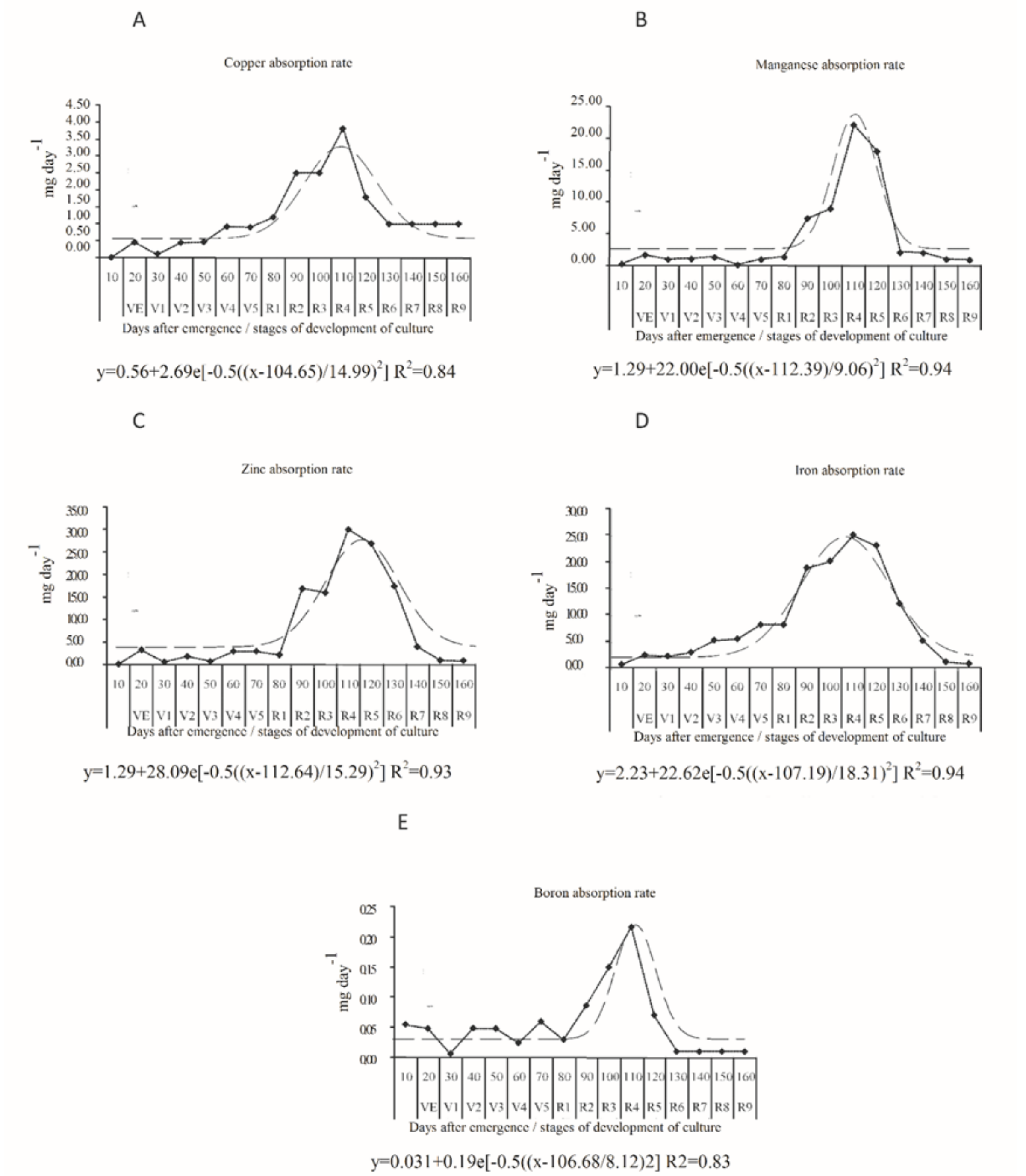

Figure 2. Absorption of micronutrients: A) copper; B) manganese; C) zinc; D) iron; and E) boron in peanut plants at different times of evaluation.

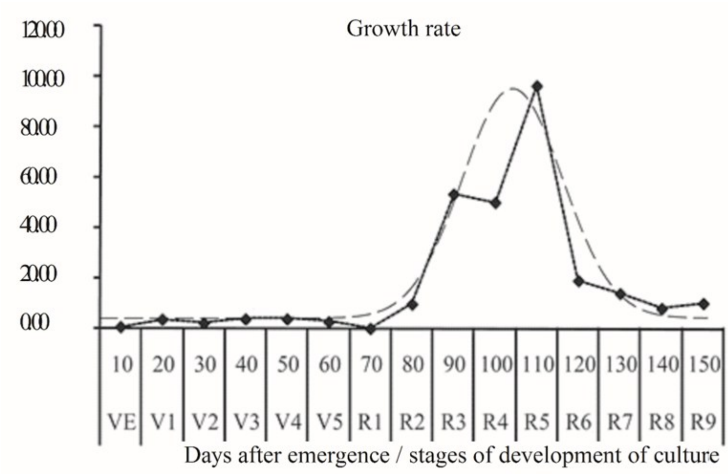

Figure 3. Growth rate of peanut crop.

During the vegetative phase, a greater accumulation of dry matter mass in the leaves of peanut plants relative to the stem was observed; however, the values of dry matter mass in the stem and leaves still increased during the reproductive phase. During this phase, from 70 DAE a large accumulation of dry matter mass in the fruit and seeds until the end of the crop cycle was observed. It was verified, therefore, that the accumulation of dry matter was represented in greater mass by the reproductive structures (fruits and seeds), followed by the stem and finally by the leaves (reproductive structures > leaves > stem) (Figure 4). Among the methods for evaluating the adaptation of a vegetable and its relationship with the environment, growth analysis is a very appropriate tool. This analysis is based on the fact that, on average, 90% of the organic matter accumulated throughout the plant growth results from the photosynthetic activity and the rest from the mineral absorption from the soil. By means of sequential measures, the dry matter of the plant is quantified, which allows for evaluating the contributions of different organs to the total growth (LESSA et al., 2008; PEDÓ et al., 2014; PEREIRA et al., 2015).

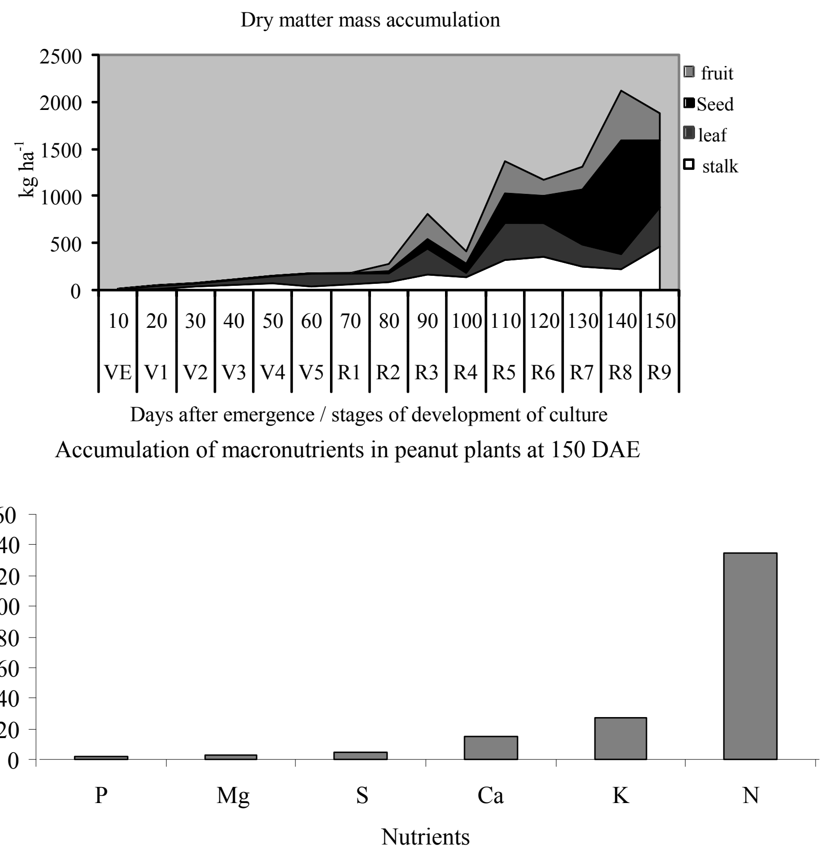

Figure 4. Peak mass accumulation of the peanut crop.

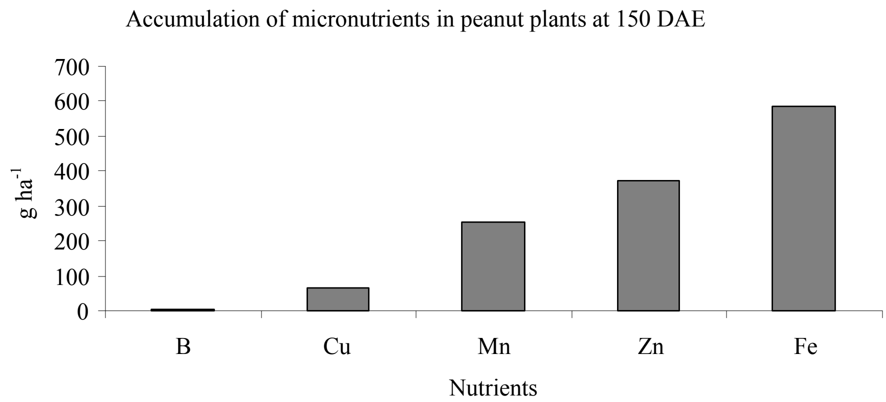

Figure 5. Accumulation of macro- (A) and micronutrients (B) in peanut plants at 150 DAE.

The accumulation of macro- and micronutrients at 150 DAE in descending order was: N > K > Ca > Mg > S > P and Fe > Zn > Mn > Cu > B, respectively (Figure 5). According to Malavolta, Vitti and Oliveira (1997), the majority of crops, in general, obey the N > K > Ca > Mg > P ≈ S order of macro- and Fe > Mn > Zn > Cu ≈ B order of micronutrients. However, in peanuts, an inversion of Mn with respect to Zn occurs.

CONCLUSIONS

The highest rate of nutrient absorption and highest rate of growth of the plant culture occurred during the reproductive period, the formation of fruit and the filling of grain. The accumulation of nutrients intensifies to 110 DAE, with the following sequences of accumulation in descending order for macro- and micronutrients, respectively: N > K > Ca > Mg > S > P and Fe > Zn > Mn > Cu > B.

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REFERÊNCIAS

AGUILERA, D. B.; FERREIRA, F. A.; CECON, P. R. Crescimento de *Siegesbeckia orientalis* sob diferentes condições de luminosidade. **Planta Daninha**, Viçosa, v. 22, n. 1, p. 43-51, 2004.

BOLONHEZI, D. et al. Manejo cultural do amendoim. In: SANTOS, R. C. (Ed.). **O agronegócio do amendoim no Brasil**. Campina grande: Embrapa – CNPA, 2005. v. 2, cap. 6, p. 451-475.

CAMPOS, L. H. F. et al. Crescimento inicial de Merremia cissoides, Neonotonia wightii e Stizolobium aterrimum. **Planta Daninha**, Viçosa, v. 30, n. 3, p. 497-504, 2012.

CARVALHO, S. J. P.; LÓPEZ-OVEJERO, R. F.; CHRISTOFFOLETI, P. J. Crescimento e desenvolvimento de cinco espécies de plantas daninhas do gênero Amaranthus. **Bragantia**, Campinas, v. 67, n. 2, p. 317-326, 2008.

CORREIA, M. A. R. et al. Avaliação da desordem nutricional de plantas de amendoim cultivadas em solução nutritiva suprimidas de macronutrientes. **Scientia Agraria**, Curitiba, v. 13, n. 1, p. 21-28, 2012.

ECHER, F. R.; DOMINATO, J. C.; CRESTE, J. E. Absorção de nutrientes e distribuição da massa fresca e seca entre órgãos de batata-doce. **Horticultura Brasileira**, Vitória da Conquista, v. 27, n. 2, p. 176-182, 2009.

FEITOSA, C. T. et al. Avaliação do crescimento e da utilização de nutrientes pelo amendoim. **Scientia Agrícola**, Piracicaba, v. 50, n. 3, p. 427-437, 1993.

FONTES, P. C. R.; DIAS, E. N.; GRAÇA, R. N. Acúmulo de nutrientes e método para estimar doses de nitrogênio e de potássio na fertirrigação do pimentão. **Horticultura Brasileira**, Vitória da Conquista, v. 23, n. 2, p. 275-280, 2005.

FOOD AGRICULTURE ORGANIZATION OF UNITED NATIONS - FAO. **Statistics at FAO**. Disponível em: <http://www.fao.org/corp/statistics/> acesso em: 03 mai. 2016.

FREIRE, J. R. J. Fixação biológica de nitrogênio pela simbiose rizóbio/leguminosas. In: CARDOSO, E. J. B. N. (Eds.). **Microbiologia do solo**. Campinas: SBCS, 1992. v. 1, cap. 9, p. 121-155.

FREIRE, M. L. F. et al. Análise de crescimento não-destrutiva do amendoinzeiro submetido a doses de $CaSO_4$ e P_2O_5. **Revista Brasileira de Ciências Agrárias**, Recife, v. 2, n. 3, p. 193-199, 2007.

LAVIOLA, B. G.; DIAS, L. A. S. Teor e acúmulo de nutrientes em folhas e frutos de pinhão-manso. **Revista Brasileira de Ciência do Solo**, Viçosa, v. 32, n. 1, p. 1969-1975, 2008.

LESSA, L. S. et al. Desempenho fisiológico de mudas de bananeira na fase inicial de crescimento. **Magistra**, Cruz das Almas, v. 20, n. 3, p. 305-312, 2008.

LOBO, D. M. et al. Características de deficiência nutricional do amendoinzeiro submetido à omissão de N, P, K. **Bioscience Journal**, Uberlândia, v. 28, n. 1, p. 69-76, 2012.

MALAVOLTA, E.; VITTI, G. C.; OLIVEIRA, S. A. **Avaliação do estado nutricional das plantas: princípios e aplicações**. 2. ed. Piracicaba, SP: POTAFOS, 1997. 319 p.

MARTIM, A.; ASSUNÇÃO, H. F.; LIMA, T. M.; Avaliação do desempenho produtivo de quatro variedades de amendoim, no sudoeste de Goiás. In: CONGRESSO BRASILEIRO DE PLANTAS OLEAGINOSAS, ÓLEOS, GORDURAS E BIODIESEL, 6., 2009, Montes Claro. **Anais...** Monte Claros: UFMG, 2009. p. 1-5.

NASCIMENTO, M. S. et al. Nutrient extraction and exportation by castor bean hybrid lyra. **Revista Brasileira Ciência do Solo**, Viçosa, v. 36, n. 1, p. 113-124, 2012.

PEDÓ, T. et al. Análise de crescimento de plantas de rabanete submetidas a doses de adubação nitrogenada. **Bioscience Journal**, Uberlândia, v. 30, n. 1, p. 1-7, 2014.

PEREIRA, G. A. M. et al. Crescimento de cultivares de cenoura em diferentes ambientes. **Comunicata Scientiae**, Teresina, v. 6, n. 3, p. 317-325, 2015.

PERIN, A. **Desempenho de leguminosas herbáceas perenes com potencial de utilização para cobertura viva e seus efeitos sobre alguns atributos físicos do solo**. 2001. 144 f. Dissertação (Mestrado em Agronomia: Área de Concentração em Ciência do Solo) - Universidade Federal Rural do Rio de Janeiro, Seropédica, 2001.

RIBEIRO, A. C. et al. **Recomendações para o uso de corretivos e fertilizantes em Minas Gerais**. 5. ed. Viçosa, MG: CFSEMG, 1999. 359 p.

PIGHINELLI, A. L. M. T. et al. Otimização da prensagem a frio de grãos de amendoim em prensa contínua tipo expeller. **Ciência e Tecnologia de Alimentos**, Campinas, v. 28, n. 1, p. 66-71, 2008.

PÔRTO, D. R. Q. et al. Acúmulo de macronutrientes pela cultivar de cebola "Superex" estabelecida por semeadura direta. **Ciência Rural**, Santa Maria, v. 37, n. 4, p. 949-955, 2007.

ROSOLEM, C. A. et al. Acúmulo de Nitrogênio, fósforo e potássio pelo Algodoeiro sob irrigação cultivado em sistemas convencional e adensado. **Revista Brasileira de Ciência do Solo**, Viçosa, v. 36, n. 2, p. 457-466. 2012.

SALVADOR, J. T.; CARVALHO, T. C.; LUCCHESI, L. A. C. Relações cálcio e magnésio presentes no solo e teores foliares de macronutrientes. **Revista Acadêmica: Ciências Agrárias e Ambientais**, Curitiba, v. 9, n. 1, p. 27-32, 2011.

SANTOS, H. G. **Sistema Brasileiro de Classificação de Solos**. 3. ed. Brasília, DF: EMBRAPA, 2013. 353 p.

SILVA, M. O. et al. Crescimento de meloeiro e acúmulo de nutrientes na planta sob irrigação com águas salinas. **Revista Brasileira de Engenharia Agrícola e Ambiental**, Campina Grande, v. 12, n. 6, p. 593–605, 2008.

STANCHEVA, I.; DINEV, N. Response of wheat and maize to different nitrogen sources: II Nitrate reductase and glutamine synthetase enzyme activities, and plastid pigment content. **Journal of Plant Nutrition**, Philadelphia, v. 18, n. 1, p. 1281-1290, 1995.

TAIZ, L.; ZEIGER, E. **Plant physiology**. California: The Benjamin/Cummigs Publishing, 2013. 559 p.

TASSO JUNIOR, L. C.; MARQUES, M. O.; NOGUEIRA, G. A. **A Cultura do Amendoim**. 1. ed. Jaboticabal, SP: UNESP, 2004. 220 p.

UCHÔA, S. C. P. et al. Adubação de potássio em cobertura nos componentes de produção de cultivares de girassol. **Revista Ciência Agronômica**, Fortaleza, v. 42, n. 1, p. 8-15, 2011.

VIDIGAL, S. M.; PACHECO, D. D.; FACION C. E. Crescimento e acúmulo de nutrientes pela abóbora híbrida tipo Tetsukabuto. **Horticultura Brasileira**, Vitória da Conquista, v. 25, n. 1, p. 375-380, 2007.