ISSN 1807-1929
Revista Brasileira de Engenharia Agrícola e Ambiental
Brazilian Journal of Agricultural and Environmental Engineering
v.26, n.6, p.433-440, 2022
Campina Grande, PB – http://www.agriambi.com.br – http://www.scielo.br/rbeaa

DOI: http://dx.doi.org/10.1590/1807-1929/agriambi.v26n6p433-440

Macronutrient absorption rate of a Runner-type peanut cultivar[1]

Marcha de absorção de macronutrientes de uma cultivar de amendoinzeiro do tipo Runner

Antonio M. P. Bertino[2*], Rogerio T. de Faria[2], Eduardo da S. B. Jesus[2], Thayane L. Alves[2], Ancelmo Cazuza Neto[2] & José de A. Barbosa[2]

[1] Research developed at Universidade Estadual Paulista/Fazenda Experimental da Faculdade de Ciências Agrárias e Veterinárias, Jaboticabal, SP, Brazil
[2] Universidade Estadual Paulista/Departamento de Engenharia e Ciências Exatas, Jaboticabal, SP, Brazil

HIGHLIGHTS:
Fertilization recommendations for peanuts are insufficient to meet the nutritional demands of current cultivars.
High nutrient export and inadequate fertilization of successive peanut cycles can exhaust the soil.
Studies of the absorption rate under different conditions are recommended to determine the fertilizer requirements of peanuts.

ABSTRACT: Peanuts are one of the most produced legumes in the world; however, there is a lack of knowledge on their nutritional needs and the growth phases with greater demands; therefore research is required on the nutrient absorption rate of the crop. The objectives of this study were to determine the rates of absorption in the vegetative part and the pods, the accumulation of macronutrients in the vegetative part, pods, and in total, and the nutrient export to pods during the cycle of the peanut, cv Runner IAC 503, grown under full irrigation. The experiment was conducted at the Experimental Farm of the Faculty of Agrarian and Veterinary Sciences, Universidade Estadual Paulista, Jaboticabal campus, SP, Brazil, from March to August 2019 using a randomized block design, with evaluations of the macronutrient absorption rate and accumulation at 35, 49, 63, 77, 91, 105, 119, 133 and 147 days after sowing, with four replications. Higher nutritional demands of peanuts occurred between 63 and 105 days after sowing. Greater total accumulation of nutrients was reached at 118 DAS, with 234.8, 173.5, 79.0, 45.8, 23.4 and 18.8 kg ha^{-1} for N, K, Ca, Mg, P, and S, respectively. Exports of macronutrients contained in the pods totaled 138.8, 43.9, 14.6, 12.0, 7.3 and 5.4 kg ha^{-1} for N, K, P, Mg, S and Ca, respectively. Exported K in the harvest was two times greater than the applied amount at sowing, which followed the current Brazilian recommendation, causing possible depletion of this nutrient in the soil.

Key words: *Arachis hypogaea* L., nutritional demand, nutrients

RESUMO: O amendoinzeiro é uma das leguminosas mais produzidas no mundo, no entanto, há carência de conhecimentos da sua necessidade nutricional e das fases de maior demanda, sendo necessários estudos sobre a marcha de absorção de nutrientes pela cultura. O objetivo deste experimento foi determinar a taxa de absorção na parte vegetativa e vagens, o acúmulo de macronutrientes na parte vegetativa, vagens e total, e a exportação de nutrientes em vagens, durante o ciclo do amendoim, cv Runner IAC 503, cultivado sob irrigação total. A cultivar IAC 503, do tipo Runner, foi conduzida sob manejo de irrigação plena, na Fazenda Experimental da Faculdade de Ciências Agrárias e Veterinárias pertencente a Universidade Estadual Paulista, campus de Jaboticabal, SP, Brasil, de março a agosto de 2019. O experimento foi conduzido em delineamento de blocos casualizados, com tratamentos constituídos por nove avaliações de taxa de absorção de macronutrientes e acúmulo de macronutrientes 35, 49, 63, 77, 91, 105, 119, 133 e 147 dias após a semeadura, com quatro repetições. As maiores demandas nutricionais do amendoim ocorreram de 63 a 105 dias após a semeadura. Maiores acúmulos totais de nutrientes foram alcançados aos 118 DAS, com 234,8; 173,5; 79,0; 45,8; 23,4 e 18,8 kg ha^{-1} para N, K, Ca, Mg, P e S, respectivamente. As exportações de macronutrientes contidos nas vagens foram de 138,8; 43,9; 14,6; 12,0; 7,3 e 5,4 kg ha^{-1} para N, K, P, Mg, S e Ca, respectivamente. O K exportado na colheita foi duas vezes maior que a quantidade aplicada na semeadura, seguindo a recomendação brasileira atual, o que pode causar esgotamento do nutriente no solo.

Palavras-chave: *Arachis hypogaea* L., demanda nutricional, nutrientes

• Ref. 255490 – Received 18 Aug, 2021
* Corresponding author - E-mail: ampbantonio@gmail.com
• Accepted 28 Dec, 2021 • Published 02 Feb, 2022
Editors: Lauriane Almeida dos Anjos Soares & Hans Raj Gheyi

Introduction

Brazil is the second largest producer of peanuts (*Arachis hypogaea* L.) in South America. The average productivity is 3.8 tons per hectare, second only to the United States in world production, with that country generating 4.5 tons per hectare (USDA, 2021). According to CONAB (2021), Brazil produced 596.9 thousand tons in the 2020/21 harvest with an estimated 623 thousand tons expected for the 2021/22 harvest, corresponding to an increase of 4.3% from the prior year, with the state of São Paulo responsible for 95% of Brazilian production in the past two years. Although cultivars exist that have high productive potential in this country, the lack of technical information for the appropriate management of these crops make it difficult to obtain high yields.

One of the main reasons for the limited increase in peanut productivity is the lack of nutrients in soil. Crop nutrient uptake is mainly influenced by the supply available in the soil and the genotypes of the plants (Zhao et al., 2021). However, the lack of information on the nutritional needs of the crop frustrates the proper management of fertilization.

The highest nutrient absorption rate in peanut crop occurs between 60 and 100 days after sowing (DAS), and the rate of absorption and export of macronutrients by the crop has been shown to be superior at the recommended fertilization level (Feitosa et al., 1993; Silva et al., 2017).

Based on previous reports, it is essential to study the nutritional requirements of crops to determine the period when macronutrients are in greatest demand; thus, the rate of absorption can be evaluated to establish the optimal time and method of fertilization to increase productivity. Thus, this study aimed to determine the rate of absorption in the vegetative part and pods, the accumulation of macronutrients in the vegetative part, pods, and in total, and the nutrient export in pods during the cycle of the peanut, cv Runner IAC 503, grown under full irrigation.

Material and Methods

The experiment was conducted at the Experimental Farm of the Faculty of Agrarian and Veterinary Sciences, Universidade Estadual Paulista, Jaboticabal campus, SP, Brazil (21° 15' 22" S, 48°18' 58" W, 570 masl), from March to August 2019.

According to the Köppen classification, the climate of the region is Cwa, which is subtropical, with an average annual rainfall of 1425 mm and an annual average temperature of 22.2 °C (Alvares et al., 2013). Meteorological data on temperature, precipitation, and evapotranspiration were collected daily from the UNESP meteorological station. During the experiment, the temperature was within the ideal range for peanut crop cultivation (10-33 °C). It decreased from the beginning to the end of the cultivation cycle, while precipitation was higher than the historical records for the region (Figure 1).

The soil in the experimental area was classified as Oxisol. Soil samples were collected in the 0-20 cm layer for chemical analysis, according to the methodology proposed by Raij (2001), 30 days before, and 180 days after the experiment (Table 1).

The experiment was conducted in a randomized block design with nine treatments and four replications. The treatments were formed by the collection times of 35, 49, 63, 77, 91, 105, 119, 133 and 147 days after sowing (DAS). The dimensions of the experimental plot were 5.4 m in width and 2.4 m in length (12.9 m^2), with six rows spaced 0.9 m apart. The useful area (2.7 m^2) was the two central rows of 1.5 m in length.

The cultivar IAC 503, type Virginia Runner, was mechanically sown after plowing and harrowing the soil, using seeds with 80% germination at a density of 25 seeds m^{-1} and a spacing of 0.9 m between rows, to a final population of 18 plants m^{-1}. All fertilizers were applied at planting, following the crop recommendations based on soil analysis for the state of São Paulo, according Ambrosano et al. (1997) (Table 1),

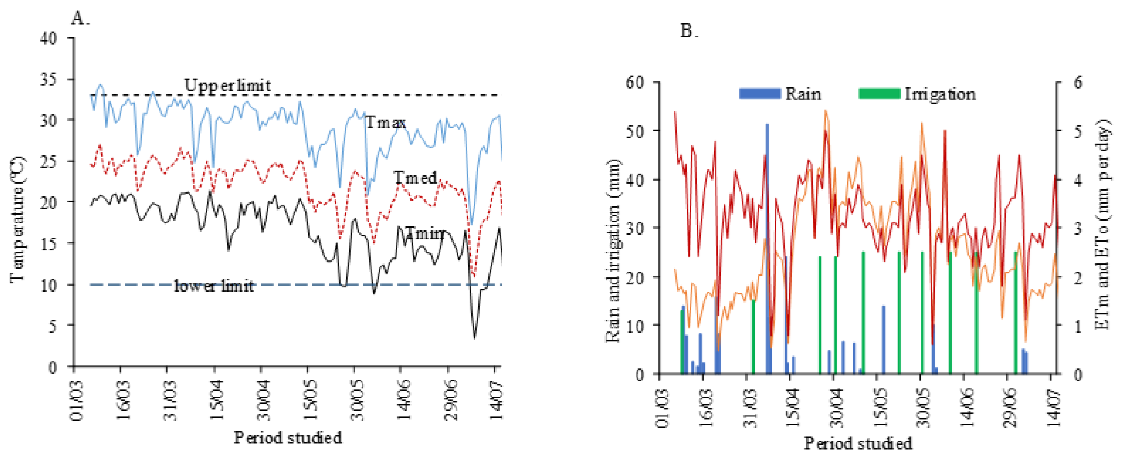


Figure 1. Maximum (Tmax), average (Tmed), and minimum (Tmin) temperatures (A), and precipitation, irrigation, and crop and reference evapotranspiration (ETm and ETo, respectively) (B), during the experimental period in 2019

Table 1. Soil chemical characteristics for the 0-20 cm layer before and after the experiment in Jaboticabal, SP

Period	pH $CaCl_2$	OM (g dm^{-3})	P_{resina}	S	H + Al	Al	K	Ca	Mg	SB	CEC	V%
			(mg dm^{-3})		(mmol$_c$ dm^{-3})							
Before	5.9	21	35	8	23.0	0	3.90	36.0	12.0	51.90	74.90	69.00
After	6.1	23	72	3	15.2	0	3.48	48.2	12.2	63.88	79.08	80.77

OM: organic matter; S: sulfur; H + Al: potential acidity; SB: sum of bases; CEC: cation exchange capacity; V: base saturation. Extractors used: pH in $CaCl_2$ by potentiometry; H+Al - in SMP buffer by potentiometry; M.O by spectrophotometry; P in resin by spectrophotometry; S by turbidimetry; K, Ca, and Mg by atomic absorption spectrometry; Al in KCl by titration which were 20 and 50 kg ha^{-1} of K_2O and P_2O_5, respectively (The sources used were potassium chloride (KCl) and simple superphosphate).

A sprinkling system was used for irrigation with Christiansen's uniformity coefficient of 91%, and irrigation applied only after the readily available soil water (25.2 mm) had been depleted. This was determined based on the soil water retention curve of the experimental area (soil moisture at field capacity and permanent wilting point of 0.45 and 0.33 cm^3 cm^{-3}, respectively), the depletion fraction (p = 0.7), and the root depth (30 cm), as described in FAO-56 (Allen et al., 1998). The depletion of the soil water was ascertained from the crop evapotranspiration, which was calculated as the product of the crop coefficient (Kc) and reference evapotranspiration (ETo), estimated daily by the Penman-Monteith equation (Allen et al., 1998). During the crop cycle, the accumulated precipitation and irrigation were 207 and 228 mm, respectively, providing a crop evapotranspiration of 324 mm.

During the experiment, phytosanitary controls were performed according to the infestation of pathogens by manual weeding, application of insecticide, fungicide, and acaricide, and irrigation management. The crop was harvested manually at 159 DAS and the following variables were evaluated:

1- Shoot and leaf, pod, and total dry mass weight: Three plants were collected per plot and separated into vegetative (stem and leaves) and reproductive (pods, grain, and shell) parts. Each part was washed, placed into a paper bag, dried in an oven with forced air circulation, maintained at 65 °C to a constant weight, and weighed. The total dry mass was calculated by adding the stem, leaf, and pod masses. To determine the macronutrients, the aerial part (stem + leaves), and pods (grains + bark), were ground and homogenized separately.

2- Absorption of macronutrients: Chemical analyses to determine the nutrient contents of N, P, K, Ca, Mg, and S in each plant fraction (vegetative and pod) were conducted at the Laboratory of Agricultural and Environmental Analysis and Consultancy: Soil Science. Chemical analyses were performed on extracts obtained by nitric-perchloric digestion, except for nitrogen, in which sulfuric digestion was used, and boron, which was incinerated in a muffle furnace (EMBRAPA, 2009).

Nitrogen content was determined using the semi-micro-Kjeldahl method and phosphorus by the colorimetric method with metavanadate. Potassium, calcium, and magnesium levels were identified using flame spectrophotometry. The sulfur content was determined using barium sulfate turbidimetry, while boron content was determined by colorimetry using azometine-H. Copper, iron, manganese, and zinc were measured by atomic absorption spectrophotometry, according to the methodology proposed by EMBRAPA (2009).

The accumulated amounts of macronutrients in each plant fraction were obtained by multiplying the macronutrient content by the vegetative and pod dry masses. The macronutrient daily absorption rate (Tx) was calculated using the following relationship:

$$Tx = \frac{(Mac_{n+1} - Mac_n)}{(DAS_{n+1} - DAS_n)} \quad (1)$$

where:

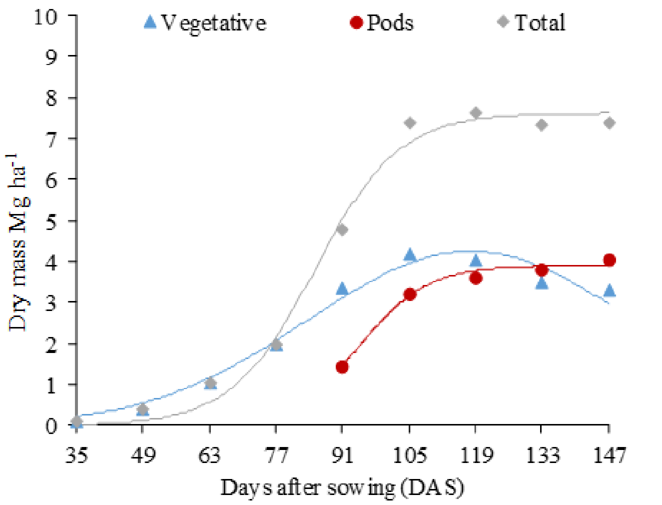
Mac_{n+1} - values observed on the studied date;
Mac_n - values observed in the penultimate evaluation;
DAS_{n+1} - days after sowing on the studied date; and,
DAS_n - days after sowing in the penultimate evaluation.

The data were subjected to analysis of variance and regression at 0.05 significance error using non-linear Gaussian and sigmoidal models with three parameters, using the statistical program SISVAR® 5.3 (Ferreira, 2019).

Results and Discussion

The maximum dry mass weights of the vegetative parts (shoots and leaves), pods, and the total canopy at the end of the crop cycle, were 4.24, 4.07, and 7.61 Mg ha^{-1}, respectively (Figure 2). These values are higher than those found in earlier studies (Feitosa et al., 1993; Silva et al., 2017) and experiments conducted with cultivars other than IAC 503, used in this experiment.

Low dry mass accumulation was observed in the vegetative phase due to the shorter period (49 days) and smaller leaf area when compared to the reproductive phase of the crop (Figure 2). A steep increase in vegetative dry matter weight occurred at the beginning of the reproductive phase, from flowering (R1, 49 DAS) to grain appearance (R5, 89 DAS), followed by stabilization until physiological maturity (R7, 118 DAS), which is characteristic of the crop cycle, regardless of the cultivar, as observed by Coelho & Tella (1967), Feitosa et al. (1993), and Silva et al. (2017). Pod dry mass accumulation increased with grain appearance, in R5 to R7, following the pod addition and seed filling stages.



$$▲ = 4.25^{**} e\left[-0.5\left(\frac{X - 118.02^{**}}{34.12^{**}}\right)^2\right] \quad R^2 = 0.98;\ CV = 12.58\%$$

$$● = \frac{3.90^{**}}{1 + e^{-\left(\frac{X - 94.71^{**}}{7.16^{*}}\right)}} \quad R^2 = 0.96;\ CV = 12.95\%$$

$$♦ = \frac{7.62^{**}}{1 + e^{-\left(\frac{X - 85.27^{**}}{8.80^{**}}\right)}} \quad R^2 = 0.99;\ CV = 20.34\%$$

** - Significant at $p \leq 0.01$ by the F test

Figure 2. Vegetative (stem + leaf), pod, and total canopy (vegetative + pod) dry mass of a peanut crop, cv. IAC 503, during the experimental period in 2019

The macronutrient contents in the vegetative part were in the range that is considered ideal for the full development of the crop, between 35 and 119 DAS, except for Mg (Ambrosano et al., 1997; Furlani, 2004), with values of 20-50 g kg^{-1} for N, 2-5 g kg^{-1} for P, 20-50 g kg^{-1} for K, 10-50 g kg^{-1} for Ca, 15-35 g kg^{-1} for Mg, and 1-5 g kg^{-1} for S (Figure 3).

The macronutrient contents throughout the crop cycle were not statistically significant, except for N and K, which decreased after 63 DAS, and Ca, which increased after 91 DAS until the end of the cycle (Figure 3). There was no significant difference in pod nutrient content over time. The levels of N, P, and K were higher during the cycle than those observed by Coelho & Tella (1967).

The macronutrient content during the cycle is related to its mobility in the plant, such as that of N and K, which are considered to be highly mobile, while Ca is immobile in the phloem (Malavolta, 1980). In this study, N and K were translocated from the vegetative parts to the pods, as shown in Figure 3. Since Ca is immobile in the phloem and has a structural function, an increase accumulated in the leaves occurs because Ca is not translocated to other plant organs (Taiz et al., 2017).

Macronutrient accumulation in the vegetative part occurred from 35 to 105 DAS for N Ca, and S, 35-95 DAS for Mg, and 35-91 DAS for P (Figure 4A). The daily rate of macronutrient accumulation in pods was significantly higher at 105 DAS for N and from 91 to 105 DAS for K. For the remaining macronutrients, the values were similar throughout the cycle (Figure 4B). These results corroborate the findings of Silva et al. (2017), who showed a similar absorption trend.

The rates of N accumulation in the vegetative part varied from 0.1 kg ha^{-1} per day at 35 DAS, to a plateau of 2 kg ha^{-1} per day from 63 to 91 DAS, and then decreased to 1.2 kg ha^{-1} per day at 105 DAS (Figure 4A). Despite the wide variation over the study period, these rates did not differ statistically. The rates of N absorption in the subsequent period (109-147 DAS) were significantly lower. For pods, the N absorption rate increased from 3.5 kg ha^{-1} per day at 95 DAS, to reach the significantly maximum value of 5 kg ha^{-1} per day at 105 DAS, followed by a decrease to approximately 1 kg ha^{-1} per day from 119 DAS until the end of the cycle (Figure 4B).

The rate of P absorption did not differ statistically throughout the crop cycle, varying from 0.01 kg ha^{-1} per day at 35 DAS, to 0.2 kg ha^{-1} at 91 DAS (Figure 4A). The K absorption rates emulated that of the N variation throughout the crop cycle, with an increase from 0.1 kg ha^{-1} per day at 35 DAS to a maximum of 2.4 kg ha^{-1} from 77 to 91 DAS, followed by a decrease to 1.0 kg ha^{-1} per day from 105 DAS to the end of the crop cycle. For the pods, the highest K absorption rate was statistically superior from 91 to 105 DAS, as compared to the other determination periods (Figure 4B).

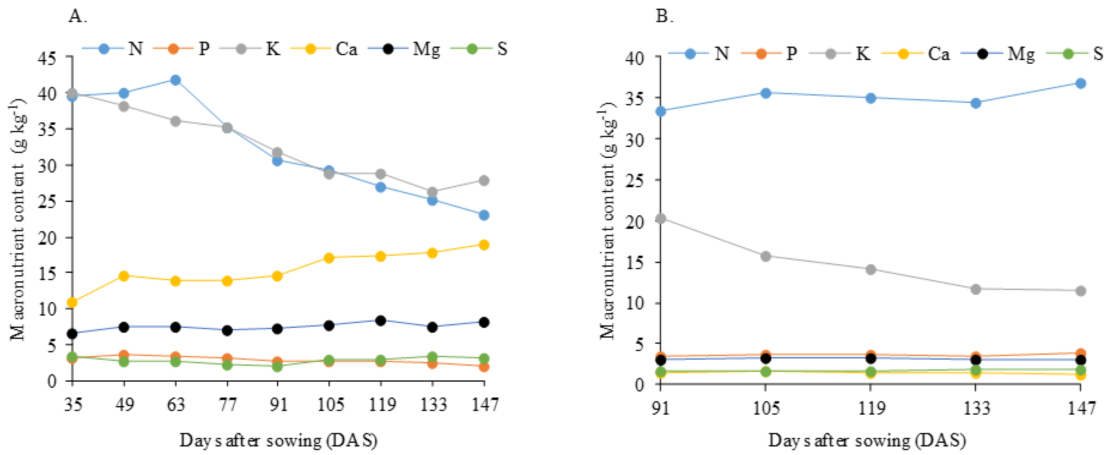
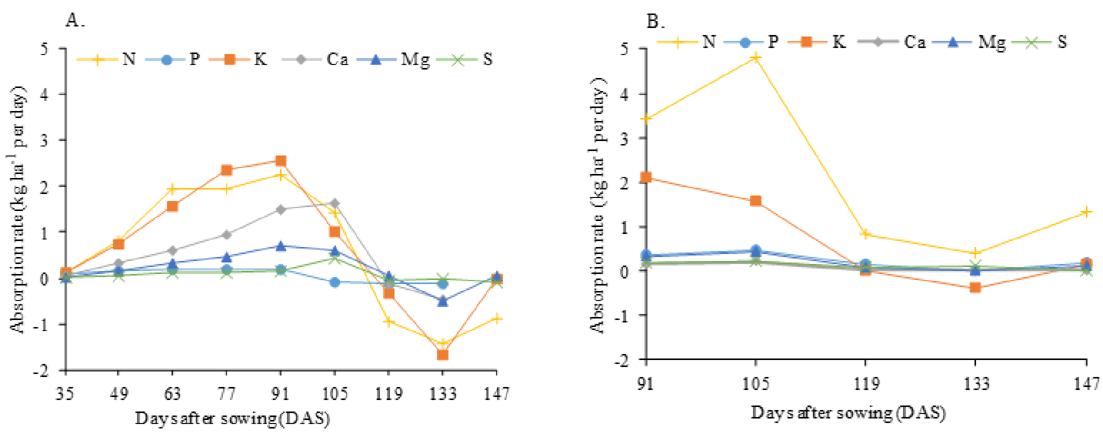


Figure 3. Macronutrient contents in the vegetative (stem + leaf) part (A) and in pods (B) of a peanut crop, cv. IAC 503, during the experimental period in 2019



* Values with the same letters on the nutrient series do not differ from each other at 0.05 probability by the Tukey test

Figure 4. Cumulative macronutrient absorption rate in the vegetative (stem + leaf) part (A), and in pods (B) of a peanut crop, cv. IAC 503, during the experimental period in 2019

The higher nutritional demand for Ca occurred from 63 DAS (0.6 kg ha^{-1} per day) to 105 DAS (1.6 kg ha^{-1} per day), while maximum Mg absorption rates were observed from 77 to 105 DAS, with an average of 0.6 kg ha^{-1} per day (Figure 4A). In the pod filling period, there was no significant effect for the Ca absorption rate, which varied from 0.3 kg ha^{-1} per day up to 91 DAS to 0.4 kg ha^{-1} per day at 105 DAS (Figure 4B).

The higher macronutrient absorption rate for the vegetative part from 63 to 105 DAS coincided with the beginning of seed formation (R5) to the start of physiological maturation (R7) (Figure 4A). After this period, there was a decrease due to natural plant senescence. For the pods, higher demand occurred at the end of the period, from R5 to R7 at 91 to 105 DAS. These results were similar to those of Silva et al. (2017), although the cultivar IAC 503 in our study showed greater demand for nutrients due to its higher productivity (> 4000 kg ha^{-1}).

For the pods, the highest absorption rates occurred from 91 to 105 DAS (Figure 4B), in the fully formed pod stage (R4) and at the beginning of seed formation (R5). The higher absorption rate coincided with the increase in the dry mass of shoots and pods, justifying the need for greater nutrient supply in the reproductive stage, from pod appearance to complete grain formation.

The highest estimated accumulations of macronutrients in the vegetative part occurred from 111 to 123 DAS for all macronutrients (Figure 5).

The higher nutrient accumulation in the pods occurred at 147 DAS. The N accumulations in the total dry mass and the vegetative part were 234.8 and 118 kg ha^{-1} at 105 DAS, respectively. The maximum accumulation was observed at the end of the cycle, with 150.5 kg ha^{-1} at 147 DAS (Figure 5A). These results indicate that the peanut crop is an important source of N for subsequent crops, considering that the vegetative part retains 67 kg ha^{-1} of N at the end of the cycle, despite the export by the pods of 150.5 kg ha^{-1}.

The accumulation of N in the dry mass in this study was higher than that reported in the literature (Halevy & Hartzook, 1988; Feitosa et al., 1993; Silva et al., 2017). Legumes can absorb large amounts of N, and peanuts have a nitrogen demand similar to that of soybeans, averaging 300 kg ha^{-1} (Malavolta, 1980). The accumulation of N in the cultivar IAC 503 in this experiment was superior to the results found by Feitosa et al. (1993) and Silva et al. (2017) for other cultivars, and this effect was a result of the higher biomass production obtained in the present study.

Since nitrogen is considered a mobile element in the phloem of plants (Furlani, 2004; Taiz et al., 2017; Cerezini et al., 2019), after seed appearance (R5, 89 DAS) there is an increase in N content in pods (Figure 3B) related to translocation from the vegetative part, which showed a decrease in the nutrient (Figure 3A). This effect is presented in the N accumulation curves of Figure 5A, in which N content in the pods increased at the expense of that in the vegetative part, while total N in the canopy remained constant.

Phosphorus was one of the macronutrients with lower accumulations in the peanut crop, with maximum values of 11.1 and 23.4 kg ha^{-1} at 112 and 147 DAS for the vegetative and total parts, respectively (Figure 5B). In pods, the maximum value was 14.6 kg ha^{-1} at 147 DAS. The results of the total accumulation of P followed a similar trend and magnitude as reported by Feitosa et al. (1993), who found P accumulations from 10.0 to 14.5 kg ha^{-1}, which was higher than those observed by Silva et al. (2017). Our results were in the same range as those of Halevy & Hartzook (1988), who found a P accumulation of 27 kg ha^{-1}.

Phosphorus is a required element for height growth and accumulation of dry mass of the leaves and stem (Lobo et al., 2012), in addition to being one of the intermediate compounds for respiration and photosynthesis and the production of photoassimilates acting on metabolic plant energy, such as ATP, DNA, and RNA (Taiz et al., 2017).

Potassium was the second most absorbed nutrient by peanut crops after nitrogen (Figure 4). Similar results were observed by Halevy & Hartzook (1988), Feitosa et al. (1993), and Silva et al. (2017). The crop accumulated 173.5 kg ha^{-1} of K in the total canopy, 121.9 kg ha^{-1} in the vegetative part, and 43.9 kg ha^{-1} in the pods (Figure 5C). Peanut crop is an advantageous crop for potassium and nitrogen cycling, which is suitable for its rotation with grasses.

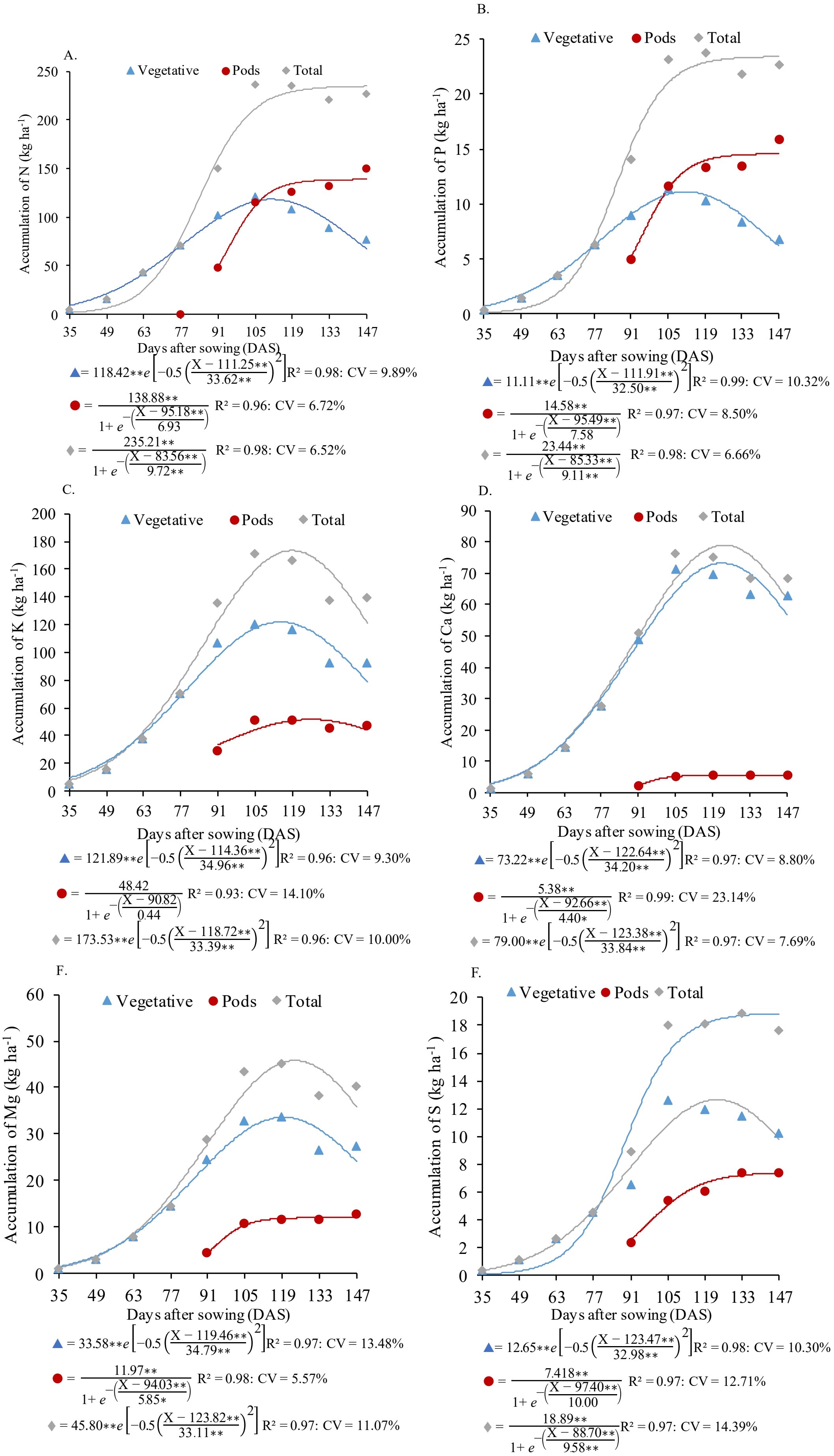
The K accumulated in pods was relatively low when compared to that of the vegetative part, with only 35 % of the accumulated total remaining in the pods during the harvest period (Figure 3). Despite K being considered a mobile nutrient in the phloem of plants, little translocation occurred due to natural defoliation (Malavolta, 1980; Taiz et al., 2017), which may have related to the greater demand from 63 to 105 DAS (Figure 4).

The total K accumulation at the end of the cycle was 122.7 kg ha^{-1} (Figure 5C), which was six times the value applied in the base fertilization, according to Ambrosano et al. (1997). The crop residue (vegetative part) contained 78.9 kg ha^{-1} of K, which is suitable for rotation with crops that have a high demand for this nutrient (Oliveira et al., 2010).

Calcium was the third most accumulated nutrient by the peanut crop with 78.6 kg ha^{-1}, of which 73.2 kg ha^{-1} was accumulated in the vegetative part and 5.4 kg ha^{-1} in the pods (Figure 5D). The translocation of calcium from the vegetative part to the pods was small because Ca is immobile in the phloem (Malavolta, 1980; Taiz et al., 2017; Song et al., 2020). The Ca content in the vegetative part was 92% of the level in the pods at the end of the cycle, indicating low export of calcium by the crop.

Mg accumulations for total dry mass, the vegetative part, and pods were 45.8, 33.6, and 12 kg ha^{-1}, respectively (Figure 5E). The ratio of calcium to magnesium throughout the cycle was close to 2:1, corroborating the results of Silva et al. (2017). Sulfur was the least accumulated macronutrient by peanuts, with accumulations of 18.8 kg ha^{-1} in the total dry mass, 12.6 kg ha^{-1} in the vegetative part, and 7.3 kg ha^{-1} in the pods (Figure 5F).

There were exports of 138.8, 43.9, 14.6, 12.0, 7.3, and 5.4 kg ha^{-1} of N, K, P, Mg, S, and Ca, respectively, contained in the peanut pods (Figure 6). Higher values for N and K were found in this study than those reported by Silva et al. (2017). Although it is common to fertilize peanut crops with formulated N, this did not occur in our experiment, demonstrating the ability of peanuts for biological fixation of N (Figure 6).



** - Significant at p ≤ 0.01 by the F test

Figure 5. Macronutrient accumulated in the vegetative (stem + leaf) part, pods, and total canopy (vegetative + pod) in a peanut crop, cv. IAC 503, during the experimental period in 2019

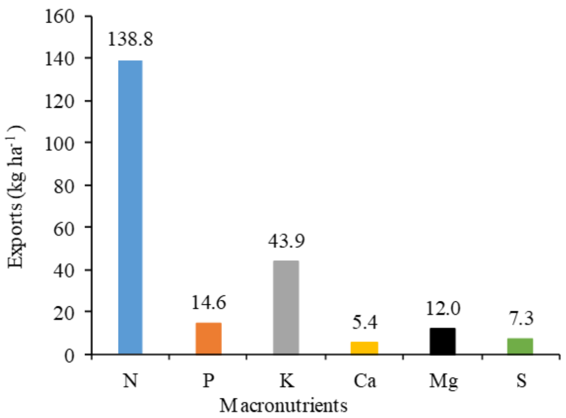


Figure 6. Macronutrients exported by a peanut crop, cv. IAC 503, during the experimental period in 2019

Fertilization with P and K at 50 and 20 kg ha^{-1} at sowing indicated that the quantity exported in the harvest was supplied by the contribution of phosphate fertilizer. However, fertilization with values lower than those exported can cause potassium deficiency. The exported values of K were twice as high as the applied amount, which may cause depletion of the nutrient in the soil, compromising its productive potential in the medium term.

Given the above, the current Brazilian fertilizer recommendations do not meet the nutritional demand of the peanut cultivar, and the export of potassium was greater than that of the application. Therefore, it is suggested to review the nutrient recommendations, especially for K, so that the amount extracted by the pods will meet the required estimated values of approximately 43.9 kg ha^{-1}.

Conclusions

1. Higher nutritional demands of peanuts occurred between 63 to 105 days after sowing.

2. Higher total nutrient accumulations were reached at 118 DAS, with 234.8, 173.5, 79.0, 45.8, 23.4, and 18.8 kg ha^{-1} for N, K, Ca, Mg, P, and S, respectively.

3. Exports of macronutrients contained in the pods were 138.8, 43.9, 14.6, 12.0, 7.3, and 5.4 kg ha^{-1} for N, K, P, Mg, S, and Ca, respectively.

4. Exported K in the harvest was two times greater than the applied amount at sowing, which followed the current Brazilian recommendation, causing possible depletion of this nutrient in the soil.

Acknowledgments

The authors thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the award of the Doctoral scholarship to the first author (Process: 156219/2019-0), the Cooperativa Agroindustrial (COPLANA) for partnership and cooperation, and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

Literature Cited

Allen, R. G.; Pereira, L. S.; Raes, D.; Smith, M. Crop evapotranspiration - Guidelines for computing crop requirements. Rome: FAO, 1998. 50p. FAO Irrigation and Srainage Paper 56

Alvares, C. A.; Stape, J. L.; Sentelhas, P. C.; Gonçalves, J. L. G. de M.; Sparovek, G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, v.22, p.711-728, 2013. https://doi.org/10.1127/0941-2948/2013/0507

Ambrosano, E. J.; Tanaka, R. T.; Mascarenhas, H. A. A. Leguminosas e oleaginosas. In: Raij, B. van.; Cantarella, H.; Quaggio, J. A.; Furlani, A. M. C. (eds.). Recomendações de adubação e calagem para o Estado de São Paulo. Campinas, SP: Instituto Agronômico de Campinas, 1997, p.187-202. Boletim Técnico, 100

Cerezini, P.; Kuwano, B. H.; Neiverth, W.; Grunvald, A. C.; Pípolo, A. E.; Hungria, M.; Nogueira, M. A. Physiological and N_2- fixation-related traits for tolerance to drought in soybean progenies. Pesquisa Agropecuária Brasileira, v.54, p.1-10, 2019. https://doi.org/10.1590/s1678-3921.pab2019.v54.00839

Coelho, F. A. S.; Tella, R. Absorção de nutrientes por plantas de amendoim na cultura do outono. Bragantia, v.26, p.335-352, 1967. https://doi.org/10.1590/S0006 87051967000100018

CONAB - Companhia Nacional de Abastecimento. Acompanhamento de safra brasileira - grãos: Décimo levantamento, julho 2020 - v.7, safra 2019/2020, Brasília: CONAB, 2020. Available on: <https://www.conab.gov.br/info-agro/safras/grãos>. Accessed on: Jul. 2020.

EMBRAPA. Manual de análises químicas de solos, plantas e fertilizantes. Silva, F. C. (ed.). 2.ed. Brasilia: Embrapa. 2009. 627p.

Feitosa, C. T.; Nogueira, S. S. S.; Gerin, M. A. N.; Rodrigues Filho, F. S. O. Avaliação do crescimento e da utilização de nutrientes pelo amendoim. Scientia Agricola, v.50, p.427-437, 1993. https://doi.org/10.1590/S0103-90161993000300015

Ferreira, D. F. Sisvar: A computer analysis system to fixed effects split-plot type designs. Revista Brasileira de Biometria, v.37, p.529-535, 2019. https://doi.org/10.28951/rbb.v37i4.450

Furlani, A. M. C. Nutrição mineral. In: Kerbauy, G. B. (ed.). Fisiologia vegetal. Rio de Janeiro: Guanabara Koogan, 2004. p.40-75.

Halevy, J.; Hartzook, A. Dry matter accumulation and nutrient uptake of high-yielding peanut (*Arachis hypogaea* L.) grown in a sandy soil. Peanut Science, v.15, p.5-8, 1988. https://doi.org/10.3146/i0095-3679-15-1-2

Lobo, D. M.; Silva, P. C. C.; Couto, J. L. do; Silva, M. A. M.; Santos, A. R. dos. Características de deficiência nutricional do amendoinzeiro submetido à omissão de N, P, K. Bioscience Journal, v. 28, p.69-79, 2012.

Malavolta, E. Elementos de nutrição mineral de plantas. São Paulo, SP: Agronômica Ceres, 1980. 251p.

Oliveira, E. C. A. de; Freire, F. J.; Oliveira, R. I. de; Freire, M. B. G. dos S.; Simões Neto, D. E.; Silva, S. A. M. da. Extração e exportação de nutrientes por variedades de cana-de-açúcar cultivadas sob irrigação plena. Revista Brasileira de Ciência do Solo, v.34, p.1343-1352, 2010. https://doi.org/10.1590/S0100-06832010000400031

Raij, B. van; Andrade, J. C.; Cantarella, H.; Quaggio, J. A. Análise química para avaliação da fertilidade de solos tropicais Campinas Instituto Agronômico, 2001. 285p.

Silva, E. B.; Ferreira, A. E.; Pereira, G. A. M.; Silva, D. V.; Oliveira, A. J. M. Peanut plant nutrient absorption and growth. Revista Caatinga, v.30, p.653-661, 2017. http://dx.doi.org/10.1590/1983-21252017v30n313rc

Song, Q.; Liu, Y.; Pang, J.; Yong, J. W. H.; Chen, Y.; Bai, C.; Gille, C.; Shi, Q.; Wu, D.; Han, X.; Li, T.; Siddique, K. H. M.; Lambers, H. Supplementary calcium restores peanut (*Arachis hypogaea*) growth and photosynthetic capacity under low nocturnal temperature. Frontiers in Plant Science, v.10, p.1-15, 2020. https://doi.org/10.3389/fpls.2019.01637

Taiz, L.; Zeiger, E.; Møller, I. M.; Murphy, A. Fisiologia e desenvolvimento vegetal. 6.ed. Porto Alegre: Artmed, 2017. 858p.

USDA - United States Department of Agriculture. Foreign Agricultural Service. World agricultural production. 2017. Circular Series, October, 2021. Available on: <https://apps.fas.usda.gov/psdonline/circulars/production.pdf>. Accessed on: Nov. 2021.

Zhao, S.; Lü, J.; Xu, X.; Lin, X.; Rosso, L. M.; Qiu, S.; Ciampitti, I.; Ping, H. Peanut yield, nutrient uptake and nutrient requirements in different regions of China. Journal of Integrative Agriculture. v.20, p.2502-2511, 2021. https://doi.org/10.1016/S2095-3119(20)63253-1