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PHOSPHORUS AND POTASSIUM FERTILIZATION IN CREEPING PEANUT

Adubação com fósforo e potássio em amendoim de porte rasteiro

Tiago Zoz[1*]; Diego Augusto Fiorese[2]; Laercio Augusto Pivetta[3]; André Zoz[4]; Jardel Zoz[5]; Alan Mario Zuffo[6]

[1] Professor; Departamento de Agronomia; Universidade Estadual de Mato Grosso do Sul; zoz@uems.br
[2] Professor; Departamento de Agronomia; Universidade Federal de Mato Grosso; dafiorese@yahoo.com.br
[3] Professor; Departamento de Agronomia; Universidade Federal do Paraná; laerciopivetta@ufpr.br
[4] Mestrando; Departamento de Agronomia; Universidade Estadual de Mato Grosso do Sul; andre_zoz@hotmail.com
[5] Graduando; Departamento de Agronomia; Universidade Estadual de Mato Grosso do Sul; jardel_zoz@hotmail.com
[6] Pós-Doutorando; Departamento de Agronomia; Universidade Estadual de Mato Grosso do Sul; alan_zuffo@hotmail.com

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Abstract: Phosphorus (P) and potassium (K) fertilization can maximize the profitability of peanut cultivation. Therefore, the aim of this study was to evaluate the basic fertilization with P and K on the grain yield and production components of creeping peanut. The experiment was performed in a randomized block design, in a 2 x 3 + 1 factorial scheme. Two doses of K (30 and 60 kg ha^{-1} of K_2O) and three levels of P (60, 90 and 120 kg ha^{-1} of P_2O_5) at sowing and an additional treatment without the basic fertilization were used, with four replicates. The cultivar Runner IAC 886was adopted. The following traits were evaluated: pod yield, grain yield, number of pods per plant, number of pods with grains per plant, the percentage of pods without grains, 100 grains weight and number of seeds per pod. P and K fertilization at sowing promote an increase in creeping peanut of about 38 and 49% in pod yield and grain yield, respectively. The highest values of pods with grains are observed with the application of 120 kg ha^{-1} P.

Key-Words: *Arachis hypogaea* L., yield, Runner IAC 886.

Resumo – A adubação com fósforo (P) e potássio (K) pode maximizar a rentabilidade do cultivo do amendoim. Dessa forma, objetivou-se com este trabalho avaliar a adubação de base com P e K na produtividade dos grãos e nos componentes de produção do amendoim de porte rasteiro. O delineamento experimental utilizado foi de blocos ao acaso, dispostos em esquema fatorial 2 x 3 + 1, sendo duas doses de K (30 e 60 kg ha^{-1} de K_2O) e três doses de P (60, 90 e 120 kg ha^{-1} de P_2O_5) na semeadura, mais um tratamento adicional sem adubação de base com P e K, com quatro repetições. Utilizou-se a cultivar Runner IAC 886. Foram avaliados a produtividade das vagens, a produtividade dos grãos, o número de vagens por planta, número de vagens granadas por planta, a percentagem de vagens não granadas, massa de 100 grãos, o número de grãos por vagem. A adubação com P e K na semeadura promove aumento em torno de 38 e 49% na produtividade em vagens e de grãos do amendoim de porte rasteiro respectivamente. Os maiores valores de vagens granadas são verificados com a aplicação de 120 kg ha^{-1} P.

Palavras-Chave – *Arachis hypogaea* L., produtividade, Runner IAC 886.

INTRODUCTION

Peanut (*Arachis hypogaea* L) is an oilseed that has stood out in the global agriculture (GODOY et al., 2004). Its cultivation is mainly aimed at oil extraction. It can be consumed fresh or roasted and can also be used in the preparation of sweet dishes (MIRANDA et al., 2010).

Peanut grains contain about 45% of oil (KASAI et al., 1998), making it the fifth most consumed oleaginous crop, corresponding to 10% of the edible oil produced in the world (GODOY et al., 2004). Currently, besides the human consumption and edible oil extraction, peanut has a significant role as a plant, with potential for biodiesel since its seeds exceed the soybean oil content (GONÇALVES et al., 2004).

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Western Parana has become known for producing creeping peanut after the harvest of winter crops (wheat and second crop corn). The main varieties used by growers are originated in São Paulo, especially the Runner IAC 886 that is a creeping cultivar widely employed in Western Parana. However, the technical information for the cultivation in the state is still incipient, ignoring its response to fertilization. In this sense, the producers have implemented the crop without a basic fertilization, just taking advantage of the residual fertilization of the previous crop (first crop).

Regarding the cultivation development, Malavolta (1980) points out that despite being a plant of low nutritional requirement, its agronomic performance is directly dependent on the availability of nutrients in the soil. Calcium and phosphorus are essential for flowering and the development of pods and seeds, while K promotes the vegetative development (GASCHO; DAVIS 1995). However, the responses of peanut crop to fertilization with nitrogen, phosphorus, and potassium are contradictory, with reports of positive (THIMMEGOWDA 1993; MARUBAYASHI et al., 1997; BASU et al., 2008; HIPPLER et al., 2011), negative (GERIN et al., 1996; SPINOLA; CÍCERO 2002) and absence of responses (KASAI et al., 1998; GASCHO; PARKER 2006).

In recent growing seasons, it has been observed little variation regarding peanut cultivated area, but with increases in yield, mainly due to the introduction of new technologies (MIRANDA et al., 2010). However, the use of appropriate doses of P and K can maximize the profitability in creeping peanuts cultivation. Thus, the aim of this study was to evaluate the basic fertilization with P and K on the grain yield and production components of creeping peanut.

MATERIAL AND METHODS

The experiment was performed in the agricultural area performing a succession planting, following the cultivation of soybean/corn. The trial was implanted from November 2008 to May 2009, in Maripá - PR, at Estância Zoz Farm, situated at 24 ° 22'31 "S latitude, 53 ° 44'23" longitude and altitude of 380 meters.

The soil is classified as eutrudox Red Latossol, with a clayey texture and flat to slightly hilly topography (EMBRAPA, 2013). Before the experiment implementation, soil samples were collected within the 0-20 cm horizon and the chemical analysis showed the following results: pH in $CaCl_2$: 5.4; O.M .: 36.23 g dm^{-3}; P (Melich-1): 15.34 mg dm^{-3}; K (Melich-1): 1.11 cmolc dm^{-3}; Ca (KCl): 6.39 cmolc dm^{-3}; Mg (KCl): 2.26 cmolc dm^{-3}; H + Al: 5.54 cmolc dm^{-3}; Al: 0.00, cmolc dm^{-3} SB: 9.76, cmolc dm-3; CEC: 15.30, cmolc dm^{-3} and V%: 64.

The local climate is Cfa according to Köppen, characterized as subtropical and, the average annual rainfall for the region is between 1600 and 2000 mm. Rainfall and temperature data during the experiment are in Figure 1A and 1B.

The experiment was performed in a randomized block design, in a 2 x 3 + 1 factorial scheme. Two doses of K (30 and 60 kg ha^{-1} of K_2O) and three levels of P (60, 90 and 120 kg ha^{-1} of P_2O_5) at sowing and an additional treatment without the basic fertilization, with four replicates were applied. Potassium chloride and super triple phosphate were sources of P and K, respectively. Each plot consisted of five rows spaced at 0.80 m, six meters long. For the evaluations, the two sidelines and 0.5 m at each end were ignored.

For the nutrient doses definition, the fertilizer recommendations for low fertility soils were taken as the lower limit (SANTOS et al., 1997), and as the upper limit, it was considered the double to obtain responses to the high fertility soil.

Soil preparation was performed with subsoiling and harrowing. The furrows were manually opened in a row, and the fertilizers were deposited on the bottom of the grooves. After closing the furrows, the mechanized peanut sowing was performed. It was used the Runner IAC 886 creeping peanut cultivar. Initially, 12 seeds per meter were sown, and after the crop establishment, the thinning was performed, adjusting the population densities to seven plants per meter.

When was observed 60-65% of mature pods the plants were harvested. Ten plants were randomly selected within the useful area of the plot to make assessments of the number of pods per plant, number of pods with grains per plant, number of grains per pod and number of grains per plant. The difference between the total number of pods per plant and the number of pods with grains per plant was expressed as a percentage of pods without grain. The rest of the plot was threshed, cleaned, weighed and then corrected to 13% moisture to get the peanut pod yield. The grain yield was estimated from the collection of pods sample that has been peeled. One hundred grain weight was determined as described in RAS (BRASIL, 2009).

The results were submitted to analysis of variance by the F test. The means of the components of factorial treatments were compared by LSD test ($P \leq 0.05$). Through the Dunnett test ($p \leq 0.05$), orthogonal contrasts of factorial treatments were

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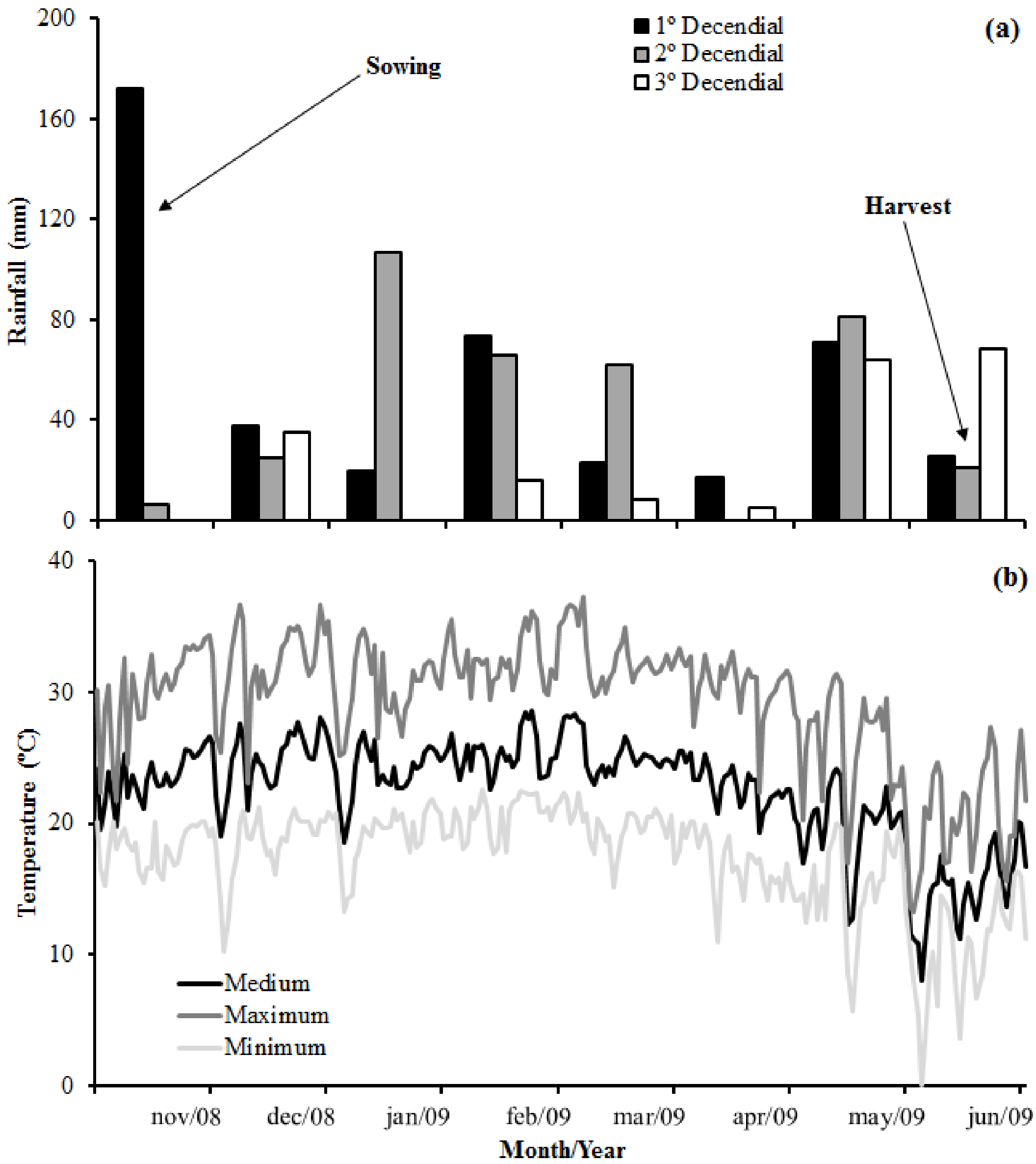

Figure I. Rainfall (a) and maximum, medium and minimum temperatures (b) during the experiment, Maripá - PR, 2009.

compared to the control. When there was a significant interaction by F test for the factorial, orthogonal contrasts between each treatment and the control were performed. For the variable in which the F test detected the simple effect of factors, orthogonal contrasts between the means of each factor and the control were performed. When the F test found no significant effect for the factorial, the only orthogonal contrast between the mean factorial and the control was performed.

RESULTS AND DISCUSSION

K fertilization only influenced the percentage of pods with grains. There were no statistical differences for the other variables. The number of pods per plant, number of pods with grains, the percentage of pods without grains and the number of grains per pod were influenced only by the application of P. For the interaction K x P, it was

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Table I. Analysis of variance (F values) obtained for pod yield (PY), grain yield (GY), number of pods per plant (NPP), number of pods with grains (NPG), the percentage of pods without grains grenades (PPWG) , 100 grains weight (100GW) and number of grains per pod (NGP) of creeping peanut submitted to the application of P and K at sowing.

S.V.	PY	GY	NPP	NPG	NPWG	100GW	NGP
Potassium (K)	0.05ns	0.48ns	0.45ns	0.04ns	4.42*	0.00ns	1.38ns
Phosphorus (P)	3.29ns	3.34ns	22.51**	38.48**	31.00**	0.47ns	11.08**
K x P	3.73*	0.08ns	3.44ns	1.01ns	3.36ns	6.18**	1.07ns
Factorial x Adit.	13.26**	16.48**	3.12ns	3.91ns	0.33ns	6.49*	19.45**
C.V. (%)	11.62	15.75	13.80	15.42	16.94	5.94	1.96

** and * significant at 1 and 5% probability by the F test, respectively. ns - not significant; CV - coefficient of variation; SV - Source of variation.

Table II. Mean values for pod yield, grain yield and number of pods per plant in creeping peanut submitted to P and K application at sowing. The combination contrast of P and K compared to the control by Dunnett test.

K (kg ha-1)	P (kg ha-1)			Mean
	60	90	120	
	---------------------- Pod Yield (kg ha-1) ---------------------			
30	3847 aA*	3122 aB	3836 aA*	3602
60	3221 bB	3586 aAB	3893 aA*	3567
Mean	3534	3354	3864	3584
Additional Mean = 2791				d' = 807
	-------------------- Grain Yield (kg ha-1) --------------------			
30	2316	1950	2129	2132
60	2235	1796	2097	2043
Mean	2275	1873	2113	2087*
Additional Mean = 1400				d' = 479
	----------------- Number of pods per plant -----------------			
30	33.97	32.23	50.93	39.04
60	43.56	30.37	47.63	40.52
Mean	38.76 B	31.30 C	49.28 A*	39.78
Additional Mean = 34.64				d' = 9,34

Means followed by different lowercase letters in the column and capital letters in the line within each factor differ at 5% probability by Tukey test; d 'is the least significant difference of Dunnett; * Indicates the contrast between the mean value and the additional factor, significant ($P \leq 0.05$) according to Dunnett's test.

found that there was a significant effect in pod yield and 100 grains weight (Table 1). The interaction of factor and additional treatment affected pod yield, grain yield, 100 grains weight and in the number of grains per pod (Table 1).

Pod yield at a dose of 30 kg ha^{-1} K had higher mean values when associated with doses of 60 and 120 kg ha^{-1} P (Table 2). However, with the application of 60 kg ha^{-1} K, a higher pod yield was observed with doses of 120 kg ha^{-1} P (Table 2). Regarding the additional treatment, combinations between doses of 30 kg ha^{-1} K with 60 and 120 kg ha^{-1} P; 60 kg ha^{-1} K with 120 kg ha^{-1} of resulted in pod yield growth of 1056, 1045 and 1102 kg ha^{-1}, respectively (Table 2).

The pod yield is considered high according to the classification proposed by Quaggio and Godoy (1996). About the grain yield, there was no influence of K and P doses. However, the factorial was greater than the control in 687 kg ha^{-1}, demonstrating that the creeping peanut responds to phosphate and potassium fertilizer in the conditions of the study (Table 2). Basu et al. (2008), evaluating the peanut grain yield with different levels of fertilization, found that at all levels of NPK fertilization, the yield was significantly superior to the treatment without fertilization. These reports also corroborate the ones checked by Thimmegowda (1993), who also reported positive effects of NPK fertilization in peanut plants.

Feitosa et al. (1993) found an absorption of 10 kg ha^{-1} P and 52 kg ha^{-1} K, of which 59.4 and 32.7% were translocated to the grain, respectively, in creeping peanut cv.Penapolis.

Rodrigues Filho et al. (1988), studying the omission of macronutrients in peanut cv. Tatu found a

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Table III. Mean values for the number of pods with grains, the percentage of pods without grains, 100-grain weight and number of grains per pod in creeping peanut submitted to P and K application at sowing. The combination contrast of P and K compared to the control by Dunnett test.

K (kg ha^{-1})	P (kg ha^{-1})			Mean
	60	90	120	
	----------------- Number of pods with grains-----------------			
30	28.10	20.76	41.22	30.03
60	31.33	19.33	38.32	29.66
Mean	29.71 B	20.05 C	39.77 A*	29.84
Additional Mean = 25.04				d' = 7.79
	----------- Percentage of pods without grains (%) -----------			
30	17.65	35.58	19.26	24.16 b
60	28.11	36.37	19.46	27.98 a
Mean	22.88 B	35.98 A*	19.36 B*	26.07
Additional Mean = 27.46			d' K = 7.27	d' P = 7.71
	---------------- 100-grain weight (g) ----------------			
30	110.3 bB	121.0 aA*	111.5 aAB	114.2
60	120.8 aA*	108.2 bB	113.3 aAB	114.1
Mean	115.6	114.6	112.4	114.2
Additional Mean = 105.0				d' = 134.0
	--------------- Number of grains per pod ---------------			
30	1.75	1.66	1.72	1.71
60	1.73	1.67	1.68	1.69
Mean	1.74 A	1.66 C*	1.70 B*	1.70
Additional Mean = 1.78				d' = 0.06

Means followed by different lowercase letters in the column and capital letter in the line within each factor differ at 5% probability by Tukey test; d 'is the least significant difference of Dunnett; * Indicates the contrast between the mean value and the additional factor, significant ($P \leq 0.05$) according to Dunnett's test.

reduction of 43% in the plant dry matter with P and K omission; they also observed a decrease of 35 and 43% for plant height with the omission of P and K, respectively. The authors report that P deficiency in peanut plants culminate in a slight reduction in the growth and development of plants. However, K deficiency reduces the growth of plants; initially causing brown spots on the leaf edges, then affecting the entire leaf; subsequently, promotes the death of foliage and the leaves fall.

The total number of pods per plant was influenced only by P doses. The highest number of pods per plant was found with the application of 120 kg ha^{-1} P. The greatest number of pods on the additional treatment was also observed with the application of 120 kg ha^{-1} P; there were no differences for the other doses of P (Table 2). Zucareli et al. (2006) also found an increase in the number of pods per plant in bean crop with increasing doses of P.

Doses of P only influenced the number of pods with grains and the highest values was observed with the application of 120 kg ha^{-1} P. It was also found that the dose of 120 kg ha^{-1} P was the only one that differed from the additional treatment (Table 3).

Assessing the interaction between increasing doses of P and native mycorrhizal fungi, Hippler et al. (2011) concluded that phosphorus fertilization enhanced the development of peanut plants (Runner IAC 886), regardless the inoculation with native fungi. For Malavolta et al. (1997) the P function is related to energy production in plants, stored as adenosine triphosphate (ATP) and adenosine diphosphate (ADP). It is worth mentioning that as P promotes increased growth of peanut plants, there is an increase in the number of branches and, consequently, there is an increase in the number of pods per plant.

The highest percentage of pods without grains among doses of K was observed at a dose of 60 kg ha^{-1}, whereas among the doses of P, it was observed at a dose of 90 kg ha^{-1} (Table 3). Regarding the additional treatment, there was no difference among the doses of K; however, for P doses, it was found that with the application of 120 kg ha^{-1}, the percentage of pods without grains was significantly lower than the control (Table 3).

For 100 grains weight, there was no influence of the interaction between doses of P and K. It was found a greater 100 grains weight with the combined application of 60 kg ha^{-1} K + 60 kg ha^{-1} P and also 30 kg ha^{-1} K + 90 kg ha^{-1} P (Table 3). The 100 grains weight of the reported combinations was also significantly higher than the 100 grains weight of the control (Table 3). The results confirm that K supply to peanuts at sowing is enough to provide the crop in the periods with higher nutrient demand which occurs from the 30th to the 55th day after sowing (Miranda *et al.*, 2010). Marubayashi et al. (1997) studying P fertilization on the yield of three varieties and two peanut strains, verified an increase in the 100 grains weight with P application on a cultivar and both strains.

The lower values for the 100 grains weight with the application of 30 kg K +60 kg P and 60 kg K + 90 kg P compared to other fertilizers and their similarity to the additional treatment are consistent with the results obtained by Spinola and Cicero (2002). The authors did not report positive effects of P and K fertilization in peanut at sowing on the 100 grains weight.

The number of grains per pod was affected by doses of P, reaching the highest value at a dose of 60 kg ha^{-1} with similar means to the additional treatment. This result is consistent with the one obtained by Nakagawa (2000) who attributed the higher crop yield to the contribution of P that is in the soil. The additional treatment showed a greater number of grains per pod at doses of 90 and 120 kg ha^{-1} P (Table 3).

There are more pronounced responses to the doses of P possibly due to the high content of K in the soil (1.11 $cmol_c$ dm^{-3}). This is also reported by Machado *et al.* (2005) who studied peanut production of forage fertilized with different combinations of K and P in an Albaqualf. The authors concluded that the dry matter production of the phosphate fertilizer is more crucial than the potassium one, attributing this result to the average content of K in the soil (0.32 $cmol_c$ dm^{-3}). For Kerridge (1995), peanut responds to K doses on dry matter yield only when the exchangeable K in the soil is low.

CONCLUSION

Fertilization with P and K promotes an increase of 38 and 49% in the pod and grain yield, respectively. The greatest values of pods with grains are verified with the application of 120 kg ha^{-1} P.

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