COSTA, N.L., PAULINO, V.T. e MAGALHÃES, J.A. Effect of phosphorus fertilization on forage yield, chemical composition and nodulation of *Acacia angustissima*, **PUBVET**, Londrina, V. 8, N. 20, Ed. 269, Art. 1793, Outubro, 2014.

PUBVET, Publicações em Medicina Veterinária e Zootecnia.

Effect of phosphorus fertilization on forage yield, chemical composition and nodulation of *Acacia angustissima*

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Abstract

The effect of phosphorus levels (0, 30, 60, 90 and 120 mg P/kg), on dry matter (DM) yield and chemical composition of *Acacia angustisima*, was evaluated under greenhouse conditions. P fertilization significantly increased ($P<0.05$) DM yields, crude protein, and phosphorus contents, and nodulation (number and dry weight nodules). Maximum DM yield and phosphorus contents were obtained with the application of 104.2 and 108.4 mg P/kg, respectively. Internal phosphorus requirement for 90% maximum DM yield was estimated at 0.169%, corresponding to application of 57.9 mg P/kg. Nodulation (number and dry weight of nodules) was significantly improved ($P<0.05$) by P fertilization up to 90 mg P/kg and inhibited in the absence or at the lower P level. Phosphorus proved indispensable to normal growth and nodulation of *A. angustissima* in the soil studied. The absence of P restricted biomass growth, nodulation and CP and P uptake. In general, P requirements of *A. angustissima* were low, as compared with others tropical legume forage species.

Index terms: crude protein, dry matter, phosphorus

Efeitos da adubação fosfatada sobre a produção de forragem, composição química e nodulação de *Acacia angustissima*

Resumo

O efeito de níveis de fósforo (0, 30, 60, 90 e 120 mg P/kg de solo) sobre a produção de matéria seca (MS) e a composição química da *Acacia angustisima* foi avaliado sob condições de casa de vegetação. A fertilização fosfatada aumentou significativamente (P<0,05) os rendimentos de MS, teores de proteína bruta, fósforo e nodulação (número e peso seco de nódulos). O máximo rendimento de MS e o maior teor de fósforo foram obtidos com a aplicação de 104,2 e 108,4 mg P/kg, respectivamente. O nível crítico interno de fósforo relacionado com a obtenção de 90% do rendimento máximo de MS foi estimado em 0,169%, correspondente à aplicação de 57,9 mg de P/kg. A nodulação (número e peso seco de nódulos) foi significativamente incrementada (P<0,05) pela adubação fosfatada com a aplicação de até 90 mg P/kg e inibida na ausência ou no menor nível de fósforo. A adubação fosfatada mostrou-se indispensável para o crescimento normal e a nodulação de *A. angustissima* no solo estudado. A ausência de fósforo restringiu o crescimento da biomassa, a nodulação e a absorção de fósforo e proteína bruta. Em geral, as exigências de fósforo por *A. angustissima* foram baixas, em comparação com outras espécies de leguminosas forrageiras tropicais.

Termos para indexação: fósforo, matéria seca, proteína bruta

Introduction

The majority of soils in the Brazilian Amazonia are Oxisols and Ultisols characterized by high acidity and low nutrients status, but often with excellent soil structures (Costa et al., 1992). Nitrogen fixing forage leguminous trees is frequently used to rehabilitate degraded lands in different parts of the world. Phosphorus deficiency is probably the major limitation to the establishment, growth and persistence of forage legumes (Patel and Kotecha, 2006). This problem is enhanced by the high phosphorus fixation capacity of these soils which is in general associated with type and percentage of clay components. As a result, high rates of phosphate fertilizers are necessary to be applied in order to achieve adequate crop production when these soils are incorporated in the production (Queiroz et al., 2007; Shetta et al., 2014).

Additional supply of phosphorus is necessary for maintaining the crop growth and improving the nutritional profile of forage legume and potential benefits from biological nitrogen fixation. Phosphorus application not only increases the plant biomass (Patel and Kotecha, 2006; Tariq et al., 2007) but also improves its protein contents (Joshi and Mali, 2004). The deficiency of phosphorus in legumes depressed the activity of nitrogen fixing bacteria (Rahman et al., 2008) for which the availability of nitrogen in root zone is also reduced.

Phosphorus is most available for uptake by plants in the pH range 6.5 - 7.5. At pH below 5.5, slowly soluble oxides of iron, aluminium and manganese form, reducing phosphorus availability, while at pH above 7.0, slowly soluble calcium phosphate is formed. Phosphorus in the soil is relatively immobile (Shetta et al., 2014). Phosphorus applied as fertilizer rarely moves any great distance in the soil without some form of physical mixing, e.g. cultivation. The distance that the phosphorus front moves in the soil from fertilizer granules is rarely much more than 5 cm (Costa and Paulino, 1990).

Phosphorus is one of the primary nutrients, along with nitrogen and potassium. It is required in large quantities by plants. Most plants take up the bulk of their phosphorus requirement early in their life, in the seedling stage of annuals and early regrowth of perennials. While phosphorus is not mobile in soils, it is one of the more mobile nutrients in plants. It is readily moved within the plant from old to young tissue. Phosphorus is required for cell division at growing points, and is particularly important in stimulating root development. Consequently, the best responses to phosphorus fertilizer are obtained if it is applied early, e.g. banded with or near the seed at planting in annual crops, and at the start of the main growing season in perennial crops and pastures. Plants require phosphorus to support new growth and good root development. Requirements for phosphorus are highest during seedling development and initiation of growth. Established plants with phosphorus deficiency show purpling of upper leaves. This is often seen in tropical forage legumes in early spring. The *Acacia angustissima* presents high potential to provide a rich source of protein for cattle, mainly during dry season, when occurs low quality forage availability. There are few papers in the literature that describe the *A. angustissima* as forage plant and its nutritional requirements.

The present study assessed the effects of phosphorus fertilization on forage yield, chemical composition and nodulation of *A. angustissima*.

Material and Methods

The trial was performed under greenhouse conditions using samples from a yellow Latosol (Oxisol), having the following chemical characteristics: pH = 4.5; Al = 1.6 cmol/dm^3; Ca + Mg = 1.3 cmol/dm^3; P = 2 mg/kg and K = 78 mg/kg. A randomized complete block design was used, with four replications. The treatments consisted of five levels of phosphorus (0, 30, 60, 90 and 120 mg P/kg). Each experimental unit was represented by a pot with 3.0 kg dry soil capacity. Phosphorus rates as triple superphosphate were applied at sowing and mixed uniformly with the soil. Pots were sown with seeds uninoculated with *Rhizobium*.

Eight days after emergence seedlings were thinned to three plants/pot. Soil water content was assessed daily by weighing the pots and keeping soil at 80% field moisture capacity. Three harvests of the tops were made with cutting frequency of 45 days, and plants were cut at 15 cm height. At 180 days after thinning, the plants were cut at the soil level and oven dried at 65ºC for 48 hours. Shoot dry matter (DM) was analyzed for N and P concentrations. The nodules, detached from the extracted root system, were cleaned and oven-dried at 65ºC for 48 hours, plus counted and weighted.

Results and Discussion

All parameters measured were increased by P fertilization. This high response can be attributable to the initial low P contents of the soil. DM yields were significantly increased with the application of P levels, up to the level of 90 mg P/kg (Table 1). However, the application of 30 mg P/kg produced increases over the control of 155, 175 and 210% in the DM yield and crude protein (CP) and P uptake, respectively. Positive effects of phosphate fertilization on legumes forage production have been reported by Ahlawat and Saraf (1981), Costa et al. (1992), Leônidas et al. (1996). Shetta et al. (2014) showed that the joint application of phosphorus and potassium in *Acacia saligna* provided superior increments to 300% in forage yield and dry weight of roots.

Table 1. Dry matter (DM) yields, crude protein and P contents, and uptake, and nodulation of *Acacia angustissima*, affected by rates of phosphate fertilization.

Rates	DM Yield	Crude Protein		Phosphorus		Nodulation	
mgP/kg	g/pot	%	g/pot	%	mg/pot	Number[1]	mg/pot
0	3.26 d	18.60 c	0.606 c	0.134 d	0.437 d	8.1 d	0.518 d
30	8.30 c	20.10 abc	1.668 b	0.163 c	1.353 c	14.4 c	0.919 c
60	9.59 b	21.02 a	2.016 a	0.173bc	1.659 b	18.3 b	1.154 b
90	10.39 ab	20.76 ab	2.156 a	0.181ab	1.881 ab	22.7 a	1.373 ab
120	11.34 a	18.89 bc	2.142 a	0.185 a	2.098 a	25.1 a	1.507 a

- Means followed by the same letters in each column are not significantly different at the 5% probability by Tukey´s test.
1 - Values analyzed after sq.rt. (X + 1) transformation

The effects of P fertilization on the DM yields were estimated according to a quadratic model ($y = a + bx - cx^2$) (Table 2). P requirement for maximum DM yield was 104,2 mg P/kg. This value was lower than those reported by Paulino and Costa (1996) for *Pueraria phaseoloides* (141 mg P/kg), *Desmodium ovalifolium* CIAT-350 (127 mg P/kg) and *Centrosema acutifolium* CIAT-5277 (131 mg P/kg).

CP contents and uptake were improved up to the level of 30 and 90 mg P/kg, respectively. Such positive effects of phosphorus are attributed to better nodulation and, consequently, improved atmosphere nitrogen fixation. These results agree with previous observations (Ogunwale and Olaniyi, 1978; Costa and Paulino, 1990). P requirements for maximum CP contents and yields were estimated at 63.3 and 91.4 mg P/kg, respectively (Table 2).

Table 2. Coefficients for P response data fitted to the model $y = a + bx - cx^2$, and P requirement for maximum dry matter yield, crude protein (CP) and P contents, and uptake of *Acacia angustissima*.

Variables	a	b	c	R^2	P requirement (mg P/kg)
Dry matter	3.683	0.14358	- 0.0006893	0.95**	104.2
CP content	18.494	0.07966	- 0.0006296	0.98**	63,3
CP uptake	0.675	0.03442	- 0.0001884	0.98**	91,4
P content	0.136	0.00088	- 0.0000041	0.97**	108.4
P uptake	0.519	0.02651	- 0.0001144	0.96**	115,9

** Significative at the 1% probability by F-test

P contents and uptake increased with its application and were significantly improved up to 90 mg P/kg. Such increases are due to increase in P availability in the soil, which is function of the P added to the soil. P requirements for maximum P contents and uptake were estimated at 108.4 and 115.9 mg P/kg, respectively. These values were lower than those reported by Paulino and Costa (1996) for *P. phaseoloides* (133 mg P/kg), *D. ovalifolium* CIAT-350 (124 mg P/kg) and *C. acutifolium* CIAT-5277 (125 mg P/kg). P internal requirement for 90% maximum DM yield was 0.169%. The critical value was inferior to those for *Cajanus cajan* (0.197%) and *A. pintoi* (0.200%), reported by Costa et al. (1992) and Leônidas et al. (1996), respectively.

Nodulation (number and dry weight of nodules) was significantly improved by P fertilization up to 90 mg P/kg and inhibited in the absence or at the lower P level (Table 1). This shows that P has an active role in the process of nodulation. The effects of P fertilization on dry weight of nodules was adjusted according to a linear model: $y = 0.611 + 0.007843x$ ($r^2 = 0.94$). For leucaena, the application of P (60 mg/kg) increased the weight of individual nodule up to 4 times over control (Shetta et al., 2014). Jakobsen (1985) observed that P increases symbiotic dinitrogen fixation by stimulating host plant growth rather than exerting a direct effect on nodule initiation, growth, development, or function. On the other hand, Israel (1987) found that P has a specific role in nodule initiation, growth, and function in addition to its direct involvement in host plant growth.

Conclusions

Phosphorus proved indispensable to normal growth and nodulation of *A. angustissima* in the soil studied. The absence of P restricted biomass growth, nodulation and CP and P uptake. In general, P requirements of *A. angustissima* were low, as compared with others tropical legume forage species.

References

AGANGA, A.A; TSHWENYANE, S.O. Lucerne, Lablab and *Leucaena leucocephala* forages: production and utilization for livestock production. **Pakistan Journal of Nutrition,** v.2, n.2, p.46-53, 2003.

AHLAWAT, I.P.S.; SARAF, C.S. Response of pigeonpea (*Cajanus cajan* L.(Millsp.) to plant density and phosphorus fertilizer under dryland conditions. **Journal of Agriculture Science,** v.97, n.119-124, 1981.

COSTA, N. de L.; PAULINO, V.T. Effect of liming and phosphorus application on growth, mineral composition, and nodulation of leucaena. **Leucaena Research Reports,** v.11, p.39-41, 1990.

COSTA, N. de L.; PAULINO, V.T.; VEASEY, E.A. Phosphorus fertilization affects *Cajanus cajan* growth, mineral composition, and nodulation. **Nitrogen Fixing Tree Research Reports,** v.10, p.127-128, 1992.

ISRAEL, D.W. Investigation of the role of phosphorus in symbiotic dinitrogen fixation. **Journal of Plant Physiology,** v.84, p.835-840, 1987.

JAKOBSEN, I. The role of phosphorus in nitrogen fixation by young pea plants (*Pisum sativum*). **Physiology Plant,** v.64, p.190-196, 1985.

JOSHI, N.L.; MALI, P.C. Effect of application of phosphorus and time of harvest on seed, crude protein and gum yield of cluster bean. **Journal of Arid Legumes,** v.1, p.27-31, 2004.

LEÔNIDAS, F.C.; COSTA, N. de L.; TOWNSEND, C.R. **Resposta de *Arachis pintoi* à fertilização fosfatada.** Porto Velho, EMBRAPA/CPAF Rondônia. 1996. 3p. (Comunicado Técnico, 118).

OGUNWALE, J.A; OLANIYI, J.K. Response of pigeonpea (*Cajanus cajan* (L.).Millsp.) to phosphorus on a phosphorus-marginal soil in Nigeria. **East African Agricultural and Forestry Journal,** v.43, p.274-280, 1978.

PATEL, P.C.; KOTECHA, A.V. Effect of phosphorus and potassium on growth characters, forage yield, nutrient uptake and quality of Lucerne (*Medicago sativa* L.). **Indian Journal of Agronomy,** v.51, p.242-244, 2006.

PAULINO, V.T.; COSTA, N. de L. Níveis críticos internos de fósforo em leguminosas forrageiras tropicais. In: REUNIÃO BRASILEIRA DE FERTILIDADE DE SOLOS E NUTRIÇÃO DE PLANTAS, 22., Manaus, 1996. **Anais...** Manaus: SBCS, 1996, p.492-493.

QUEIROZ, L.R.; COELHO, F.C.; BARROSO, D.G.; QUEIROZ, V.A.V. Avaliação da produtividade de fitomassa e acúmulo de N, P, K em leguminosas arbóreas no sistema de aléias, em Campos dos Goytacazes, RJ. **Revista Árvore,** v.31, n.3, p.383-390, 2007.

RAHMAN, M.M.; BHUIYAN, M.H.; SUTRADHAR, G.N.C.; RAHMAN. M.; PAUL, A.K. Effect of phosphorus, molybdenum and rhizobium inoculation on yield and yield attributes of mungbean. **International Journal of Sustainable Crop Production,** 3:26-33, 2008.

SHETTA, D.; EL-SAYED, A.W.B.; NASR, T.A.; SHAARAWY, N.M. Influences of mineral fertilization with NPK, inoculation and methods of inoculation on seedling growth of two woody legume trees. **World Applied Sciences Journal,** v.29, n.7, p.825-834, 2014.

TARIQ, S.; ALI, S.; IJAZ, S.S. Improving nitrogen fixation capacity and yield on mung bean and mash bean by phosphorous management in pothowar. **Sarhad Journal of Agriculture,** v.23, p.1027-1032, 2007.