DOI: https://doi.org/10.17921/1415-5141.2023v27n1p45-51

Influence of NPK Fertilization on the Growth and Nutrition of Parica in the Field

Influência da Adubação NPK no Crescimento e Nutrição do Paricá em Campo

Cristiane Ramos Vieira*[a]; Oscarlina Lúcia dos Santos Weber[b]; José Fernando Scaramuzza[b]

[a]Universidade de Cuiabá, Programa de Pós-Graduação Stricto Sensu em Ciências Ambientais. MT, Brasil.
[b]Universidade Federal de Mato Grosso, Programa de Pós-Graduação Stricto Sensu em Agricultura Tropical. MT, Brasil.
*E-mail: cris00986@hotmail.com

Abstract

When it comes to forest species it is known that fertilization increases the biomass of the plants, their development and nourishes them, leaving them more strengthened to cope with environmental weather and produce. Therefore, a study was carried out to analyze the growth of *S. amazonicum* in the field, after fertilization. The seedlings were produced by seeds, when reached 15 cm were transplanted to plastic bags containing soil that was limed and fertilized, according each tested treatment. The fertilizations tested were: N = 0, 40, 80 and 120 kg ha^{-1}; P_2O_5 = 0, 50, 100 and 200 kg ha^{-1} e; K_2O = 0, 50, 100 and 200 kg ha^{-1}. At 180 days the seedlings on the 20 treatments that presented the highest growth were planted in the field. The soil was limestoned and fertilized, and the seedlings were distributed in randomized blocks with six replicates. Growth of the seedlings was analyzed at 3, 6, 9 and 12 months. After 12 months, the plants were submitted to analyze of dry biomass, macro and micronutrient contents. The fertilization influenced the growth of *S. amazonicum*, recommending 80 kg ha^{-1} of N, 200 kg ha^{-1} of P_2O_5 and 50 kg ha^{-1} of K_2O.

Keywords: *Schizolobium amazonicum*. Mineral Fertilizer. Forest Soil.

Resumo

Quando se trata de espécies florestais sabe-se que a adubação aumenta a biomassa das plantas, seu desenvolvimento e as nutre, deixando-as mais fortalecidas para enfrentar as intempéries ambientais e produzir. Portanto, foi realizado um estudo para analisar o crescimento de S. amazonicum no campo, após a fertilização. As mudas foram produzidas a partir de sementes, quando atingiram 15 cm foram transplantadas para sacos plásticos contendo solo, que foi corrigido e adubado, de acordo com cada tratamento testado. As adubações testadas foram: N = 0, 40, 80 e 120 kg ha^{-1}; P_2O_5 = 0, 50, 100 e 200 kg ha^{-1} e; K_2O = 0, 50, 100 e 200 kg ha^{-1}. Aos 180 dias, as mudas dos 20 tratamentos que apresentaram maior crescimento foram plantadas no campo. O solo foi calcareado e adubado conforme as doses citadas, e as mudas foram distribuídas em blocos casualizados com seis repetições. O crescimento das mudas foi analisado aos 3, 6, 9 e 12 meses. Após 12 meses, as plantas foram submetidas à análise de biomassa seca e teores de macro e de micronutrientes. A adubação influenciou o crescimento de S. amazonicum, recomendando-se 80 kg ha^{-1} de N, 200 kg ha^{-1} de P_2O_5 e 50 kg ha^{-1} de K_2O.

Palavras-chave: *Schizolobium amazonicum. Fertilizante Mineral. Solo Florestal.*

1 Introduction

Savannah soils are generally highly acid, with high exchangeable Al rates, low availability of Ca and Mg, and low P availability in the form used by plants (VIEIRA *et al*. 2017a). They are features that jeopardize plant growth, their development and consequently their productivity. For this, corrections and fertilization of the soil prior to planting are required.

The success of forest planting depends on seedling quality which, in its turn, requires suitable nutrition. Such concern is recurring mainly when planting occurs in the savannah region and the wood it is final product. Plants need fertilization at the initial phase of growth on the field since they have to endure a stress period due to environment changes. They have to adequate themselves for their survival, adaptation, root lengthening and growth launching. This initial growth conditions will benefit the formation of timber quality and the final price of the product.

Schizolobium amazonicum (called *paricá* in Brazil) is a native leguminous tree commonly employed in commercial plantations. However, few data are known on the best fertilization levels for the native species in greenhouse or in the field. This species belongs to the Caesalpinaceae family and is characterized by fast growth, excellent adaptability and production capacity. Its environmental conditions vary from normal soil to high flood lands with high and low fertility soils (GAZEL FILHO *et al*. 2007). Actually, it is one of the most planted native species in Mato Grosso, Brazil, in savannah soil. Therefore, the fertilization conditions are important, especially when it comes to plantations and wood of quality. So, fertilization conditions are required for the initial development in field plantations.

According to Caione *et al*. (2012), information is scanty on N, P and K fertilization in the growth of *S. amazonicum*. As a general rule, different native forest species have distinct nutritional requirements. Since there are no specific recommendations for each species, most recommendations are based on *Eucalyptus* sp., with some adaptations.

Research should follow the specie's fertilization recommendations, especially soil conditions, even though very few assays have been undertaken on the subject. Carvalho *et al*. (2016) reported that N influenced the *S. amazonicum* growth. Results by Marques *et al*. (2004a) showed growth decrease of *S. amazonicum* due to lack of nutrients for treatments without N and Fe. Lack of Mg, S, Cu and Na promoted a decrease in the production of dry matter in the initial phase of the plant´s growth.

Research is required to provide the best NPK doses for the growth of *S. amazonicum*. This experiment aimed to evaluate the influence of mineral fertilization on different NPK levels in the growth and nutrition of *S. amazonicum* in the field, for twelve months.

2 Development

2.1 Metodology

The experiment was installed on the greenhouse of the Faculty of Agronomy and Animal Science (FAAZ) of the Mato Grosso Federal University (UFMT) with *S. amazonicum* seeds collected from matrix trees in the municipality of Alta Floresta – MT, Brazil, in the period from February to September 2012.

For production of seedlings, seeds passed by dormancy breaking using the heat shock method, seeds were immersed in warm water, then in cold water. Subsequently, germinated in nurseries of 1.20 m x 3.00 m filled with sand, on one centimeters of depth recommended by Rosa *et al*. (2009), in full sun. The first germinations were observed five days after seeding, occurring uniformly within 15 days, when the seedlings have reached a length of 15 cm, able to transplantation.

The soil used was Dystrophic Red-yellow Latosol with sandy texture that was collected in a region of native vegetation in the São Vicente campus of the Mato Grosso Federal Institute. It was previously dried, sieved and characterized chemically following methodology by Embrapa (1997), obtaining the following results: pH ($CaCl_2$) = 4.39; H+Al = 4.22 $cmol_c$ dm^{-3}; Al = 1.03 $cmol_c$ dm^{-3}; Ca = 1.0 $cmol_c$ dm^{-3}; Mg = 0.50 $cmol_c$ dm^{-3}; Sum of bases = 1.53 $cmol_c$ dm^{-3}; Total CTC = 5.75 $cmol_c$ dm^{-3}; Effective CTC = 2.56 $cmol_c$ dm^{-3}; K = 13.56 mg dm^{-3}; P = 13.9 mg dm^{-3}; Bases saturation (V%) = 26.5; aluminum saturation (m%) = 40.2.

According to Ribeiro *et al*. (1999), the values for the chemical characteristics presented in Table 1 are: pH - very low; H+Al - medium; Al - high; Ca - low; Mg - adequate; K - very low; P - medium, considering the sandy texture; SB - low; T - medium; T - medium; V - low; M - medium. This soil was limed to raise the saturation per base to 50%, with 1.53 t ha^{-1} of limestone PRNT 100 %, with 30.08 % CaO and 21.1 % MgO. Amount of limestone required to raise the saturation per base was calculated according to the chemical analysis of the soil.

The limestoned soil underwent 15-days incubation period and then used to fill the plastic bags of 50x40 cm. The seedlings with 15 cm in height were transplanted to the bags, and then, the soil was fertilized, in a once, making the crowning of the seedlings, with urea as N source on the levels of: 0, 40, 80 and 120 kg ha^{-1}; simple superphosphate as source of P_2O_5 on the levels of: 0, 50, 100 and 200 kg ha^{-1} and potassium chloride of K_2O on the levels of: 0, 50, 100 and 200 kg ha^{-1}. Using factorial scheme 4x4x4 designed in randomized blocks, with 15 repetitions, one plant per bag.

At the end of 180 days, the seedlings were chosen according to mean height and diameter to be planted in the field. Taking into account the morphological data, seedlings of the best 20 treatments were transplanted to the field (Table 1), where the design consisted of randomized blocks with six repetitions, with similar fertilizations in the greenhouse, sources and doses.

Table 1 - *S. amazonicum* seedlings planted in the field and their treatments in the nursery

Treatment	N-P-K	Treatment	N-P-K
1	0-0-0	11	80-50-200
2	0-100-50	12	80-0-50
3	0-100-100	13	80-0-100
4	0-200-0	14	80-0-200
5	0-200-200	15	80-50-0
6	0-200-100	16	80-50-100
7	0-200-50	17	80-200-50
8	40-200-0	18	80-200-100
9	40-200-200	19	120-0-200
10	40-200-100	20	120-50-100

Source: Research data.

Before being planted, holes of 4x4 meters were made into which limestone was placed directly, for saturation rise per base to 50 %. The quantity of required limestone was undertaken following the natural soil´s chemical analysis. The NPK fertilization occurred after one week directly on holes.

The seedlings were planted 15 days after liming and fertilization of the holes. The area under analysis lies on the São Vicente campus at the Mato Grosso Federal Institute, with typical Savannah vegetation. Some ten years previous, the area had been used for pasture.

Characteristics of plant growth were measured at 3, 6, 9 and 12 months after transplanting, with six seedlings of each treatment chosen. Height was measured by metal tape and the diameter by digital pachymeter. Crowing was undertaken at 60-day intervals with manual crowning of the seedlings. After 12 months, the plants were removed and sectioned for leaves, stem and roots. The material was dried in an air buffer at 65ºC till constant and weight on a 0.01 g precision semianalytic balance. Dry leave matter was ground in a wiley mill for macro and micronutrient analyses, following methodology by Malavolta *et al*. (1997).

Assistat 7.6 Beta was employed for data processing and analysis. Statistical analysis was performed by analysis of variance while compared multiple means were obtained by Scott-Knott´s method at 5 % significance.

2.2 Results

2.2.1 Height

Height growth was affected by NPK fertilization on the field with different significances among treatments (Table 2).

Table 2 - Height (cm) of *Schizolobium amazonicum* seedlings at different levels of NPK fertilization, during 12 months

Treatment	Height 3 months	Height 6 months	Height 9 months	Height 12 months
1	53.33 c	55.00 d	56.00 b	56.67 e
2	66.50 c	75.50 d	82.83 b	84.17 d
3	85.67 b	86.33 c	90.33 b	93.50 c
4	130.83 a	130.83 a	136.33 a	145.00 a
5	95.83 b	108.67 b	112.33 a	117.00 b
6	127.33 a	133.33 a	139.50 a	143.83 a
7	128.33 a	142.17 a	142.17 a	145.83 a
8	112.67 a	122.00 a	123.33 a	127.67 b
9	80.50 b	84.67 c	89.50 b	94.50 c
10	92.33 b	95.67 c	95.67 b	104.17 c
11	85.83 b	91.17 c	91.17 b	101.50 c
12	83.50 b	84.17 c	84.33 b	86.00 d
13	89.17 b	102.17 b	106.33 b	107.83 c
14	93.83 b	106.00 b	116.17 a	120.00 b
15	73.50 b	73.83 d	83.33 b	102.00 c
16	48.17 c	68.67 d	78.50 b	81.50 d
17	72.50 b	77.00 d	138.33 a	145.67 a
18	92.83 b	120.17 a	145.50 a	146.67 a
19	79.50 b	101.17 b	115.67 a	119.67 b
20	76.33 b	87.67 c	101.67 b	109.17 c
F	10.64**	12.57**	4.87**	9.90**
CV(%)	19.23	16.65	26.33	17.79

Means followed by the same letter do not differ from each other by Scott-Knott´s test at 5% significance.
Source: research data.

Considering height growth (Table 2) during the first 3 months, the best treatments were 4 (0-200-0), 6 (0-200-100), 7 (0-200-50) and 8 (40-200-0). In the end, the highest height growth of the *S. amazonicum* plants was observed in treatments 4 (0-200-0), 6 (0-200-100), 7 (0-200-50), 17 (80-200-50) and 18 (80-200-100). Carvalho *et al*. (2016) e Vieira *et al*. (2017 b) also reported the influence of fertilization on the growth of *S. amazonicum*.

Considering height growth during the first 3 months, the best treatments were in treatments demonstrating that the low N requirement during the period, against the high need for phosphate fertilization. The results were also evidenced by Caione *et al*. (2012). However, Marques *et al*. (2004a), Caione *et al*. (2012) and Carvalho *et al*. (2016) reported *S. amazonicum´*s need for nitrogenized fertilization. The low N requirement by *S. amazonicum* in this study may to indicate that concentrations present in the soil were sufficient to maintain the growth of the seedlings until the analysis period, on the organic forma or not, because the planting was located in an area of altitude and, therefore, receives more rays, which can facilitate the entry of N to the soil.

In the end, the highest height growth of the *S. amazonicum* plants was observed in treatments 4, 6, 7, 17 (80-200-50) and 18 (80-200-100), demonstrating the necessity of fertilization with N, P and K, in doses that facilitate the positive interaction between the elements in the soil, after 3 months of growth in the field.

The height increase was higher in treatments 16 (80-50-0), 17 (80-200-50) and 18 (80-200-100), than the control, 83.5 %, 79.6 % and 87 %, respectively. According to Bamberg *et al*. (2013), initial highest growth reported in NPK fertilizations is bonded to the fast availability of nutrients to seedlings. Despite that, the fertilization type raises growth rates, the loss by leaching, but provides the growth stabilization.

Fertilizations 6 (0-200-100) and 7 (0-200-50) were those that most favored height of *S. amazonicum*. These results can be explained by the fact that the area when the seedlings was planted is located at an altitude of approximately 700 m, with a higher incidence of lightning and these are the main forms of N entry in the soil. And in this case, when interacting with the elements of the applied fertilizers, they favored the growth of the seedlings. About P, in savannah soils, this macronutrient tends to be adsorbed, in the Fe or Al oxides minerals, requiring fertilization to increase its availability. This element is necessary for plants, especially with fast growth, because is related to energy production and, the photosynthesis.

2.2.2 Diameter

Growth of the diameter (Table 3) was positively affected by NPK fertilization, initially higher in treatments 4 (0-200-0), 6 (0-200-100) and 7 (0-200-50), at 90 days, perhaps because the initial high P requirements.

Table 3 - Diameter (Diam., in mm), leaf biomass, stem biomass and roots biomass of *Schizolobium amazonicum* seedlings at different levels of NPK fertilization, during 12 months

Treatment	Diam 3 months	Diam 6 months	Diam 9 months	Diam 12 months	Leaf biomass	Stem biomass	Roots biomass
1	6.77 d	7.55 d	8.00 c	8.05 c	0,26 e	14,01 g	2,53 d
2	11.30 c	13.75 c	14.32 b	14.67 b	2,17 e	42,74 f	12,95 d
3	13.63 b	14.05 c	14.78 b	15.12 b	4,42 e	40,67 f	19,45 d
4	19.22 a	21.33 a	23.37 a	23.43 a	6,41 e	125,35 d	43,24 b

Treatment	Diam 3 months	Diam 6 months	Diam 9 months	Diam 12 months	Leaf biomass	Stem biomass	Roots biomass
5	14.52 b	17.53 b	18.58 a	18.78 a	14,79 d	82,05 e	32,20 c
6	19.43 a	21.72 a	22.62 a	22.80 a	8,34 e	107,26 d	48,05 b
7	18.25 a	20.45 a	22.52 a	23.05 a	22,02 d	218,64 a	66,89 a
8	13.98 b	15.60 c	20.15 a	21.38 a	32,43 c	122,10 d	36,27 c
9	15.07 b	16.95 b	20.67 a	21.28 a	4,15 e	97,78 d	37,10 c
10	14.17 b	14.93 c	19.98 a	21.43 a	14,91 d	111,34 d	35,10 c
11	14.20 b	15.12 c	15.12 b	16.40 b	16,48 d	50,89 f	15,81 d
12	11.30 c	13.77 c	13.90 b	14.48 b	3,74 e	31,12 g	7,21 d
13	13.47 b	15.93 c	18.45 a	19.27 a	18,06 d	75,36 e	17,41 d
14	13.20 b	15.67 c	18.92 a	19.83 a	11,73 d	151,99 c	30,68 c
15	13.08 b	15.08 c	16.20 b	17.03 b	10,82 d	52,81 f	22,23 d
16	10.27 c	10.42 d	13.17 b	13.73 b	7,01 e	44,17 f	12,61 d
17	10.08 c	12.70 c	20.17 a	22.02 a	40,44 b	158,29 c	61,20 a
18	13.98 b	15.97 c	23.02 a	23.38 a	37,77 b	177,16 b	74,55 a
19	14.78 b	21.57 a	22.58 a	22.75 a	30,14 c	109,57 d	36,99 c
20	13.35 b	17.30 b	21.57 a	22.58 a	65,71 a	116,07 d	50,78 b
F	5.87**	4.55**	4.47**	4.19**	39,49**	77,60**	17,05**
CV(%)	22.29	26.08	25.96	26.36	36,44	15,53	35,82

Means followed by the same letter do not differ from each other by Scott-Knott´s test at 5% significance.
Source: research data.

After 12 months, the treatments with the greatest diameter were 4 (0-200-0), 6 (0-200-100), 7 (0-200-50) and 19 (120-0-200). So, the treatments with the greatest diameter evidenced the effect of nitrogenized fertilization from that period if the phosphate fertilizer is absent.

At 12 months, diameter's increase was higher in treatment 17, 61 % higher than in the control. Therefore, fertilizations that favored diameter growth of *S. amazonicum* plants were 4, 6 and 7, with low dose by nitrogenized fertilization (0 kg ha^{-1}), high in P (200 kg ha^{-1}) requirement and the need of K up to 100 kg ha^{-1}. When all treatments underscoring diameter growth have been considered, the levels 0-200-100 were the most underscored. They corresponded to treatment 6 which has also been reported for height growth.

This increase in growth in diameter can be because the K dose. According to Valeri e Corradini (2000), this element promotes the thickening of the seedlings in the production phase, as observed in the experiment. However, K also helps in height growth because increase in root growth, increase in resistance to droughts and low temperatures and, resistance to pests and diseases (MEURER, 2006). In addition, the P may have assisted in increasing the biomass and favored the increase in diameter of the seedlings.

2.2.3 Dry biomass

The production of leaf biomass (Table 3) was higher in treatment 20 (120-50-100) with 65.71 g. The production of leaf biomass (Table 3) was higher in treatment 20 (120-50-100) with 65.71 g and demonstrated the relevance of N for the production of leaf mass, corroborated by Marques *et al*. (2004a) concluding that the omission of N limited the initial production of dry matter of roots, shoot and total dry matter, obtaining 1.02 g/plant in the treatment without N. Lowest productions occurred in treatments without N. Therefore, lack of nitrogenized fertilization did not limit the plants´ growth but jeopardized their mass production which may indicate that plants obtained nutrients from other sources. Maybe for this, Caione *et al*. (2012) also reported the influence of NPK fertilization in the biomass of *S. amazonicum* seedlings.

The production of stem biomass was higher in 7 (0-200-50) like the production of root biomass, but in the last case, 17 (80-200-50) and 18 (80-200-100) also stood out.

The lowest productions of stem biomass were reported in treatments 1 (0-0-0) and 12 (80-0-50) and demonstrated the need of P for the biomass production, with 14.0 and 31 g, respectively. In fact, N fertilization was not primordial on stem, perhaps due to the plant´s movable element, translocating to the leaves, since it is essential for the photosynthesis process.

The production of root biomass showed the need of NPK fertilization for suitable root growth of *S. amazonicum*, mainly in phosphated fertilization. According to Vilela e Anghinoni (1984), high P concentration induced the formation of longer and thinner root system which was efficient in the absorption of other nutrients and contributed to the growth in height and diameter of plants.

The best doses in the production of the biomass of *S. amazonicum* plants were 80 kg ha^{-1} of N; 200 kg ha^{-1} of P_2O_5; 50 kg ha^{-1} of K_2O, with the equilibrium of the highest biomass productions in the plant (leaf, stem and root).

2.2.4 Nutrition of *Schizolobium amazonicum* plants

There are no adequate macro and micronutrient levels in *Schizolobium amazonicum* plants in the literature, after planting in the field. In relation to the N (Table 4), the concentrations tended to be higher in treatment 20 (120-50-100), but not significant for the other treatments.

Table 4 - Macronutrients concentrations (g kg^{-1}) in the leaves of *Schizolobium amazonicum* seedlings at different levels of NPK fertilization, after 12 months

Treat.	N	P	K	Ca	Mg	S
1	9.70 a	0.40 b	4.70 b	1.60 a	2.97 a	1.29 d
2	8.50 a	0.35 b	4.63 b	2.08 a	2.40 a	1.35 d
3	6.37 a	0.35 b	4.90 b	1.92 a	2.54 a	1.92 c
4	8.70 a	0.37 b	6.70 a	1.76 a	2.54 a	2.32 b
5	8.13 a	0.67 a	5.10 b	1.76 a	2.40 a	3.01 a
6	11.67 a	0.45 b	7.43 a	1.52 b	2.06 a	1.85 c
7	8.57 a	0.30 b	5.57 b	2.00 a	1.63 b	2.00 c
8	8.57 a	0.17 c	2.47 c	1.84 a	1.82 b	0.90 d
9	11.40 a	0.42 b	6.73 a	1.28 b	1.48 b	1.53 c
10	7.83 a	0.27 c	7.40 a	1.92 a	2.06 a	1.69 c
11	10.73 a	0.25 c	4.73 b	1.92 a	1.68 b	1.04 d
12	11.20 a	0.42 b	5.13 b	1.52 b	1.58 b	0.74 e
13	14.57 a	0.20 c	3.83 c	1.76 a	1.06 b	0.72 e
14	11.03 a	0.30 b	5.90 b	1.52 b	1.73 b	1.11 d
15	11.03 a	0.12 c	1.47 c	1.12 b	1.29 b	1.11 d
16	9.70 a	0.40 b	2.77 c	1.36 b	1.15 b	0.50 e
17	7.57 a	0.12 c	1.97 c	1.60 a	1.48 b	1.62 c
18	8.50 a	0.10 c	2.87 c	1.12 b	1.78 b	0.87 d
19	9.23 a	0.15 c	4.70 b	1.20 b	2.16 a	0.35 e
20	14.07 a	0.07 c	2.47 c	1.12 b	2.35 a	0.35 e
F	1.92	6.72**	12.29**	3.27**	3.68**	18.41**
CV (%)	26.66	39.64	19.34	21.70	28.15	24.45

Means followed by the same letter do not differ from each other by Scott-Knott´s test at 5% significance.
Source: research data.

What indicates the need for interaction with other fertilizers so that adequate availability of nutrients and, consequently, higher growth occurs. These results are relevant since N is the most required element on the plant. Nitrogen is the structural constituent of amino-acids and proteins and the constituent or activator of enzymes. It also participates in the processes for ion absorption, photosynthesis, respiration, synthesis, multiplication and in cell and inherited differences (MALAVOLTA *et al*. 1997). In this case, the concentrations obtained in the treatment 17 (7.57 g kg^{-1}) was enough to maintain the growth of the seedlings in the 12th month, however, in interaction with fertilizations with P and K.

The P concentrations (Table 4) was higher in treatment with 200 kg ha^{-1} de P_2O_5 e de K_2O (treatment 5: 0-200-200), like in the case of the concentrations of K, demonstrating high requirement in P, which may have been higher in the first months of seedling growth in the field. In fact, plants did not demonstrate limitations in growth and/or other P deficiency symptoms.

Highest K concentrations (Table 4) were reported in treatments 4 (0-200-0), 6 (0-200-100), 9 (40-200-200) and 10 (40-200-100). Higher concentration in 0 kg ha^{-1} dose of K may have been favored by dose 200 kg ha^{-1} of P_2O_5. These results may have been obtained because the highest K demands occurred in the first months of seedling growth. Vieira *et al*. (2005) did not report any influence of K in the growth of *S. amazonicum* in combinations. But report adequacy of the species to the nutrient´s low availability due to the efficacious provision and/or use of K to the growth of seedlings. A good supply of K in the substrate is highly recommended since the element warrants the plant´s vigorous and healthy growth with the opening and closing of the stomata and, among other factors, transpiration, which favors a better use of water (MALAVOLTA *et al*. 1997).

The supply with Ca in forest plantation occurred through fertilization with simple superphosphate (Table 4). Similar results were observed for Mg and S concentrations.

The supply with Ca possibly, were higher in the first months. But these concentrations appear to have been enough because no symptoms of Ca deficiency were observed. Similar results were observed for Mg concentrations (Table 4); however, these were higher than Ca in plants. This may be related to the type of limestone applied, was dolomite limestone, or to the higher demand for Mg in this period of growth. About the S (Table 4), highest concentrations occurred in treatment 5 (0-200-200), because the application of superphosphate.

The highest Cu concentrations (Table 5) occurred in treatments 5 (0-200-200), 6 (0-200-100), 7 (0-200-50), 8 (40-200-0), 9 (40-200-200), 10 (40-200-100), 11 (80-50-100), 12 (80-0-50), 13 (80-0-100) and 14 (80-0-200).

Table 5 - Micronutrients concentrations (mg kg^{-1}), in the leaves of *Schizolobium amazonicum* seedlings at different levels of NPK fertilization, after 12 months

Treat.	Cu	Fe	Mn	Zn	B
1	14.20 b	7.80 e	1442.82 d	7.70 b	73.28 e
2	18.70 b	11.02 e	1603.57 d	9.42 b	11.90 f
3	22.70 b	41.85 c	2032.15 c	71.10 a	272.69 b
4	24.70 b	36.52 c	2175.00 b	14.27 b	54.02 e
5	30.00 a	24.10 d	2407.15 b	21.82 b	84.92 e
6	28.00 a	38.30 c	2371.42 b	10.45 b	330.51 a
7	32.75 a	52.50 b	2550.00 b	15.35 b	328.57 a
8	33.50 a	31.30 c	2460.72 b	7.45 b	267.54 b
9	27.97 a	20.55 d	2514.27 b	14.40 b	265.08 b
10	28.75 a	40.07 c	2746.42 a	13.90 b	376.42 a
11	39.05 a	52.50 b	2585.72 a	8.62 b	172.04 c
12	30.75 a	47.17 b	2657.15 a	14.62 b	190.14 c
13	34.02 a	72.00 a	2710.72 a	4.62 b	224.66 b
14	28.97 a	86.17 a	2746.42 a	7.27 b	282.99 b
15	22.97 b	34.75 c	2496.45 b	2.95 b	116.18 d
16	25.47 b	41.85 c	2692.85 a	8.35 b	144.86 d
17	19.95 b	84.37 a	2764.27 a	3.82 b	268.56 b
18	18.20 b	86.20 a	2585.72 a	3.52 b	126.57 d
19	23.45 b	54.25 b	2675.00 a	7.10 b	268.56 b
20	18.70 b	41.85 c	2514.30 b	3.37 b	126.57 d
F	4.08**	22.26**	13.97**	5.16**	29.55**
CV(%)	24.13	21.39	8.03	103.23	16.54

Means followed by the same letter do not differ from each other by Scott-Knott´s test at 5% significance.
Source: research data.

Soils previously fertilized may provide residues of the micronutrient which may have contributed towards the rise of concentrations in the leaves of the *S. amazonicum*. Further, high concentrations may be related to the soil´s material. The above results are important since Cu is an essential chemical element for plants, due to its catalyzing effect on biochemical reactions, in the metabolism of carbohydrates, nitrogen, in the synthesis of chlorophyll and in the constitution of proteins (TAIZ; ZEIGER, 2004).

The highest Fe concentrations (Table 5) occurred in treatments 13 (80-0-100), 14 (80-0-200), 17 (80-200-50) and 18 (80-200-100). The highest Fe concentrations (Table 5) were dependent on N rates of 80 kg ha^{-1}. However, the concentrations seem enough, because they directly influenced the growth of plants. Fe is basic in chlorophyll formation; therefore, its lack may bring difficulties in photosystem. Marques *et al*. (2004a) reported that, when Fe lacks, the *S. amazonicum* plants have a high growth decrease.

The highest Mn concentrations (Table 5) occurred in treatments 10 (40-200-100), 11 (80-50-100), 12 (80-0-50), 13 (80-0-100), 14 (80-0-200), 16 (80-50-100), 17 (80-200-50), 18 (80-200-100) and 19 (120-0-200); with 2746.42 mg kg^{-1}, 2585.72 mg kg^{-1}, 2657.15 mg kg^{-1}, 2710.72 mg kg^{-1}, 2726.42 mg kg^{-1}, 2692.85 mg kg^{-1}, 2764.27 mg kg^{-1}, 2585.72 mg kg^{-1} and 2675.00 mg kg^{-1}, respectively. Concentration of Mn (Table 5) may in fact have increased due to the decrease in Ca concentrations and/or to liming effects, or due to the concentration of the element in the soil. In fact, the savannah region may have high concentration of this element caused by the source material, contributing to the growth of the *S. amazonicum* seedlings.

The treatment 3 (0-100-100) provided the highest Zn concentrations (Table 5) in *S. amazonicum*, but was not considered adequate for the seedlings of the species studied. In their analysis on the influence of nutrients on the quality of *Pinus taeda* timber, Castelo *et al*. (2008) reported that Zn rates had a positive co-relationship with height, volume, fiber length and felting index growth. This is important because, according to Rodrigues *et al*. (2012) low Zn concentrations may be related to the plantation area since the savannah soils present Zn deficiencies or to the fertilization.

Highest B concentrations (Table 5) occurred in treatments 6 (0-200-100), 7 (0-200-50) and 10 (40-200-100). The concentration of B with P and K fertilization, indicating that the fertilization was, therefore, very important since savannah soils, are generally poor in B rates. B deficiency is more pronounced in the savannah regions or in sandy soils with low rates of organic matter and with the seasonal occurrence of water deficits (TIRLONI *et al*. 2011).

The present study indicates high requirements of *S. amazonicum* for nutrients in the first months in the field that may be related to the high rate of its growth. For this, is interesting to know the appropriate doses of NPK so that there is no negative influence on the initial growth of the plants and, consequently, on the wood.

3 Conclusion

Doses that favored the growth of *Schizolobium amazonicum* seedlings were: 80 kg ha^{-1} N; 200 kg ha^{-1} P_2O_5; 50 kg ha^{-1} K_2O, balancing the growth in height and diameter with the biomass production.

The concentrations of macro and micronutrients in the leaves of the seedlings demonstrate different demands according to the stage of establishment of the species, with high requirements in P in the first months of growth.

References

BAMBERG, R. *et al*. Relação entre nutrição e tempo de permanência de mudas de *Bauhinia forficata* em casa-de-vegetação. *Sil. Lus.*, v.21, n.1, p.87-101, 2013.

CAIONE, G.; LANGE, A.; SCHONINGER, E.L. Crescimento de mudas de *Schizolobium amazonicum* (Huber ex Ducke) em substrato fertilizado com nitrogênio, fósforo e potássio. *Sci. For.*, v.40, n.94, p.213-221, 2012.

CARVALHO, A.O. *et al*. Initial growth of 'paricá' (*Schizolobium amazonicum*) seedlings under different nitrogen doses. *Nat.*, v.4, n.2, p.112-115, 2016. doi: 10.31413/nativa.v4i2.3254.

CASTELO, P.A.R. *et al*. Influência de diferentes sítios de crescimento sobre a qualidade da madeira de *Pinus taeda*. *Flor.*, v.38, n.3, p.495-506, 2008.

EMBRAPA. Centro Nacional de Pesquisa de Solos. *Manual de métodos de análise de solos*. 2. ed. Rio de Janeiro: Embrapa, 1997.

GAZEL FILHO, A.B. *et al*. Produção de biomassa em quatro procedências de paricá (*Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke)) Barneby no estádio de muda. *Rev. Bras. Bioc.*, v.5, supl.2, p.1047-1049, 2007.

MALAVOLTA, E.; VITTI, G.C.; OLIVEIRA, A.S. *Avaliação do estado nutricional das plantas*: princípios e aplicações. Piracicaba: Potafos, 1997.

MARQUES, T.C.L.L.S.M. *et al*. Crescimento inicial do paricá (*Schizolobium amazonicum*) sob omissão de nutrientes e de sódio em solução nutritiva. *Cer.*, v.10, n.2, p.184-195, 2004a.

MARQUES, T.C.L.L.S.M. *et al*. Exigências nutricionais do paricá (*Schizolobium amazonicum* Herb.) na fase de muda. *Cer.*, v.10, n.2, p.167-183, 2004b.

MEURER, E.J. Potássio. In: FERNANDES MS. *Nutrição mineral de plantas*. Viçosa: SBCS, 2006. p.281-298.

RIBEIRO, A.C.; GUIMARÃES, P.T.G.; ALVAREZ V., V.H. *Recomendação para o uso de corretivos e fertilizantes em Minas Gerais*: 5. aproximação. Viçosa: Comissão de Fertilidade do Solo do Estado de Minas Gerais, 1999.

RODRIGUES, F.A.V. *et al*. Disponibilidade de zinco para mudas de eucalipto em solos de cerrado. *Rev. Bras. Cie. Sol.*, v.36, n.4, p.1249-1257. 2012. doi: https://doi.org/10.1590/S0100-06832012000400019

ROSA, L.S. *et al*. Emergência, crescimento e padrão de 1ualidade de mudas de *Schizolobium amazonicum* Huber ex Ducke sob diferentes níveis de sombreamento e profundidades de semeadura. *Rev. Cie. Agr.*, v.52, n.1, p.87-98. 2009.

TAIZ, L.; ZEIGER, E. *Fisiologia Vegetal*. Porto Alegre: Artmed, 2004.

TIRLONI, C. *et al*. Crescimento de *Corymbia citriodora* sob aplicação de boro nas épocas secas e chuvosas no Mato Grosso do Sul, Brasil. *Sil. Lus.*, v.19, n.2, p.197-206, 2011.

VALERI, S.V.; CORRADINI, L. Fertilização em viveiro para produção de mudas de eucaliptus e pinus. In GONÇALVES, J.L.M.; BENEDETTI, V. *Nutrição e fertilização florestal*. Piracicaba: Ipef, 2000. p.169-190.

VIEIRA, C.R.; WEBER, O.L.S.; SCARAMUZZA, J.F. Influência da adubação NPK no crescimento inicial de *Tectona grandis* L.f. em campo. *Rev. Inst. Flo.*, v.29, n.1, p.57-69. 2017a. doi: http://dx.doi.org/10.24278/2178-5031.201729104.

VIEIRA, C.R. *et al*. Estudo comparativo de metodologias de preparo de soluções nutritivas no crescimento de mudas de paricá. *Amb.*, v.13, n.2, p.273-292. 2017b. doi: :10.5935/ambiencia.2017.02.08.

VILELA, L.; ANGHINONI, I. Morfologia do sistema radicular e cinética de absorção de fósforo em cultivares de soja afetados pela interação alumínio-fósforo. *Rev. Bras. Cie. Sol.*, v.8, n.1, p.91-96. 1984.