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Aspidosperma discolor A. DC. SEEDLING GROWTH UNDER DIFFERENT SHADING LEVELS

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Resumo

Desenvolvimento de mudas de Aspidosperma discolor *A. DC. sob diferentes níveis de sombreamento*. Este trabalho teve como objetivo avaliar o desenvolvimento de mudas de *Aspidosperma discolor* A. DC., de duas procedências, submetidas a pleno sol e diferentes níveis de sombreamento, em um viveiro florestal, além de identificar seu grupo ecológico efetivo. Folículos amarelo-esverdeados fechados e pré-maduros foram coletados de dez matrizes selecionadas aleatoriamente em duas populações naturais de fragmentos de Floresta Ombrófila Densa de várzea, ambas em Pernambuco, Brasil. As mudas dessas sementes foram desenvolvidas em diferentes níveis de sombreamento. Após o desenvolvimento das mudas, foram avaliadas as seguintes variáveis: número de folhas, área foliar e biomassa seca. A espécie apresentou plasticidade fenotípica favorável à sua aclimatação em ambientes com condições de sombreamento moderado a intermediário, característica evidenciada em pequenas clareiras; à densa, típica de vegetação com dossel fechado. Para a produção de mudas da espécie em viveiro florestal, destaca-se um nível de sombreamento de 50%, pois favorece maior crescimento e biomassa das partes aérea e radicular. Além disso, apresenta um comportamento ecológico peculiar de táxons ciófilos facultativos ou de estágios intermediários de sucessão.
Palavras-chave: mudas florestais; ecologia florestal; biomassa vegetal; fisiologia vegetal; Floresta Ombrófila Densa

Abstract

This study aimed to evaluate the development of *Aspidosperma discolor* A. DC. seedlings two different origins subjected to full sunlight or different shading levels in a forest nursery, in addition to identifying its effective ecological group. Closed and pre-mature greenish-yellow colored follicles were collected from 10 randomly selected mother trees in two natural populations of lowland Dense Ombrophilous Forest fragments, both in Pernambuco, Brazil. The seedlings of these seeds were developed under different shading levels. After the seedlings were developed, the following variables were evaluated: number of leaves, leaf area and dry biomass. The species showed favorable phenotypic plasticity for its acclimatization in environments with moderate to intermediate shading conditions, a characteristic evidenced in small gaps; as well as for dense conditions, typical of vegetation with a closed canopy. A shading level of 50% stood out to produce *A. discolor* seedlings in a forest nursery, as it favors greater growth and biomass of the shoot and root parts. In addition, it presents peculiar ecological behavior of facultative sciophilous taxa or intermediate succession stages.
Keywords: forest seedlings; forest ecology; plant biomass; plant physiology; Dense Ombrophilous Forest.

INTRODUCTION

The significant changes observed in the structure, composition and physiognomy of the Atlantic Forest resulting from a long period of human activities have gradually induced the need to obtain and improve new knowledge of seedling production techniques. This fact is important to meet the demand to recompose degraded areas as a way of ensuring both the continuity of the ecological and economic potential of the fragments, as well as to conserve water, soil, climate, landscape and genetic biodiversity resources (FIORE *et al*., 2019; ARAÚJO *et al*., 2021).

Success in the vegetative recomposition process of degraded areas is directly linked to the seedling quality, since, in addition to resisting environmental conditions, they must develop in order to produce arboreal individuals which phenotypically reflect the characteristic patterns of those that originated them. Disregarding the knowledge of the ecological requirements of a species is one of the reasons for failure in plantations, with inadequate supply of one of the components related to climatic, edaphic, physiographic and biological factors potentially reducing plant vigor and compromising its growth and development (RIZZINI, 1997; TAIZ *et al*., 2017).

Light is a primary source of energy related to photosynthesis, and should be considered as one of the basic components with the greatest influence on plant growth and development, as it regulates the morphogenetic germination processes and the morphological and physiological patterns of plant growth (PÁJARO-ESQUIVIA *et al.*, 2021). Any changes observed in light intensity levels can provide different physiological responses related to the biochemical, anatomical and growth characteristics of the plant in forests (POORTER *et al*., 2019).

Aspidosperma discolor A. DC., commonly known as *cabo-de-machado*, belongs to the Apocynaceae family and has ecological aptitude to develop in dense ombrophilous forests and semi-deciduous seasonal forests (LIMA *et al.*, 2015; PEREIRA *et al*., 2017). Due to this amplitude of environment, it is necessary to evaluate the behavior of its seedlings under the influence of full light and shading to test the hypothesis that the species may have ombrophilous behavior when participating in the composition of dense ombrophilous forests; and heliophilous when inserted in the structure of seasonal semi-deciduous forests in Central Brazil. Within this assumption, this study aimed to evaluate the development of *A. discolor* seedlings from two origins subjected to full sunlight or different shading levels in a forest nursery, in addition to identifying its effective ecological group.

MATERIAL AND METHODS

Closed and pre-mature greenish-yellow colored follicles of *Aspidosperma discolor* A. DC. were collected from 10 randomly selected mother trees in two natural populations of lowland Dense Ombrophilous Forest fragments, located in the Dois Irmãos State Park in the city of Recife (8° 03'14" S and 34° 52' 51" W); and a private area in the municipality of Camaragibe (8° 01' 14" S and 34° 58' 54" W), both in Pernambuco State, Brazil (Figure 1). The fruits of each origin were packed in black plastic bags and transported to the Laboratory, where they were dried under natural hygrothermal conditions (25°C and 75% relative humidity).

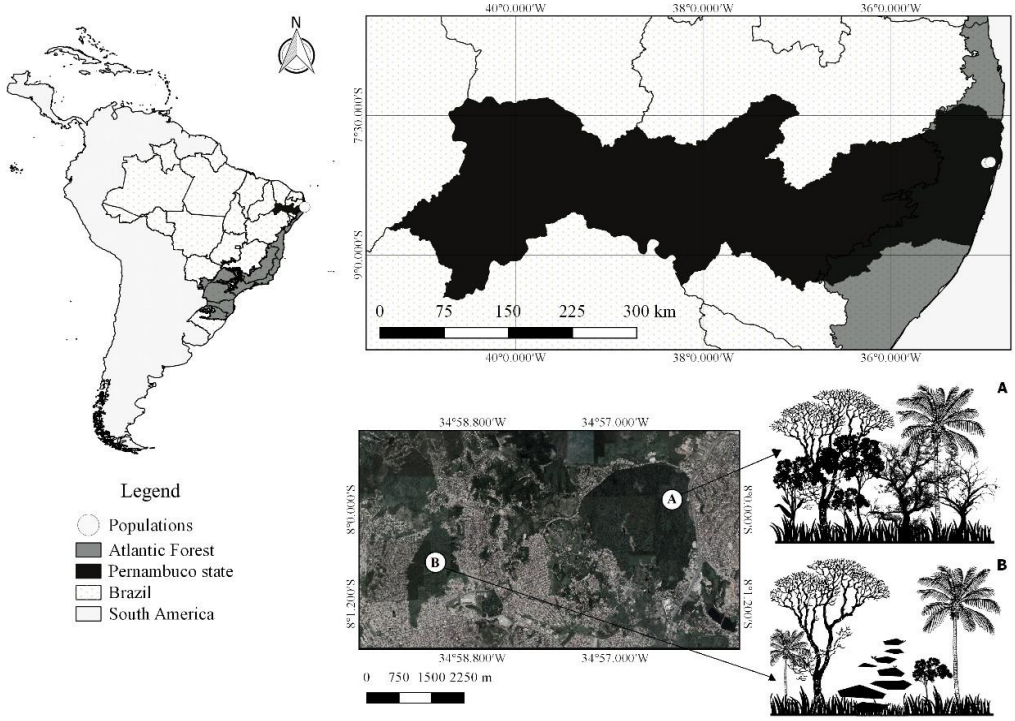

Figure 1. Geographic location of *Aspidosperma discolor* A. DC. reproductive structure collection areas in the State of Pernambuco: (A) Dois Irmãos State Park, Recife; and (B) Mata Privê Vermont, Camaragibe, 2008. Distance between A and B: ≅ 4.7 km. Sources: Frank Silva, www.googleearth.com.

Figura 1. Localização geográfica das áreas de coletas das estruturas reprodutivas de *Aspidosperma discolor* A. DC. no Estado de Pernambuco: (A) Parque Estadual de Dois Irmãos, Recife; and (B) Mata Privê Vermont, Camaragibe, 2008. Distância entre A e B: ≅ 4,7 km. Fontes: Frank Silva, www.googleearth.com.

The seeds were selected and sown in plastic trays measuring 45 cm x 30 cm x 7 cm with washed sand substrate, then sieved and sterilized in an autoclave (120ºC/1 hour). The substrate was previously moistened with distilled water equivalent to 60% of the substrate's maximum retention capacity (BRASIL, 2009). After

germination, 200 seeds of each origin with rootlets around 2 cm long were transported to polyethylene plastic containers 20 cm wide by 26 cm high, filled with clayey sandy soil.

The recipients were divided into four sets of 50 units per origin, and each batch was later subdivided into five repetitions of 10 recipients per treatment and origin. They were duly conditioned in a 3.5 m x 1.0 m seedling bed. A one-meter-high PVC frame was installed on each seedling bed, covered with a polyolefin screen (sombrite®) with the following specific shading percentages: Treatment 1 – full sun (0% shading); Treatment 2 - 50% shading; Treatment 3 – 70% shading; and Treatment 4 – 90% shading (side screen type sombrite® green 90% and top with sombrite® black 90%).

The average microclimatic conditions of the tree nursery during the 10 months of experimentation were: air temperature of 27°C; relative humidity of 73.9%; and irradiance obtained using a Minipa® digital luxmeter of 10,750 lux (in the bed with seedlings exposed to full sunlight), 4,989 lux (46.41% of full light) at 50% shading, 2,171 lux (20.20% of full irradiance) for 70% shading, and 1,625 lux (15.11% of total sunlight) for 90% shading.

The seedlings were irrigated daily in the morning. Then, 10 recipients were randomly selected per treatment and origin every 60 days, with a total duration of 300 days of evaluation. The containers were broken vertically and the soil removed with running water to remove the seedlings without causing severe damage to the root system. Next, the seedlings were sent to separate and measure the shoot and the root systems using a ruler graduated in centimeters and a Mitutoyo® digital caliper with a precision of 0.05 mm.

The following parameters were evaluated: height (cm) of the hypocotyl and epicotyl, stem diameter (cm), leaf area (cm²), number of leaves and the main root length (cm). The mean leaf area values were obtained from all leaves in images scanned on a flatbed scanner (Scanjet G2710 Hewlett-Packard®), using the Image Tool software program (WILCOX *et al.*, 1997). The shoot and root systems were subsequently submitted to drying in a forced air oven at 65ºC±5ºC until constant weight. After this procedure, all the material was weighed on an analytical scale with precision of 0.01 g to quantify the dry matter production.

A completely randomized design was used to statistically analyze the data, with treatments distributed in a 4 x 2 factorial arrangement (four shading levels and two seed origins). The results were submitted to analysis of variance and the means compared by Tukey's test at the level of 95% probability using the BioEstat version 4.0/2005 statistical program (AYRES *et al.*, 2005).

RESULTS

Evaluation of shoot biomass, root length and stem diameter

The evaluation of seedlings included measuring the height, main root length and stem diameter obtained in a period of 300 days, depending on the shading levels and origins. A means comparison test was applied to compare the difference between treatments (Table 1).

Table 1. Mean height, main root length and stem base diameter values of *Aspidosperma discolor* A. DC. seedlings obtained for 300 days as a function of shading levels and collection origins.

Tabela 1. Valores médios de altura, comprimento da raiz principal e diâmetro do coleto de mudas de *Aspidosperma discolor* A. DC., obtidos durante 300 dias, em função dos níveis de sombreamento e procedências de coleta.

Age (Days)	Shading (%)	Height (cm)		Main root length (cm)		Stem base diameter (cm)	
		Area I	Area II	Area I	Area II	Area I	Area II
60	0	6.19 Aa	6.29 Aa	4.74 Aa	4.70 Aa	0.10 Aa	0.11 Aa
	50	5.88 Aa	6.41 Aa	5.11 Aa	5.47 Aa	0.11 Aa	0.11 Aa
	70	5.70 Aa	6.02 Aa	4.62 Aa	5.20 Aa	0.10 Aa	0.10 Aa
	90	5.57 Aa	5.41 Ab	5.23 Aa	5.13 Aa	0.11 Aa	0.11 Aa
120	0	8.32 Aa	8.82 Aa	5.52 Aa	6.60 Aa	0.14 Aab	0.14 Ab
	50	8.44 Ba	9.92 Aa	5.34 Aa	5.93 Aa	0.13 Bb	0.16 Aa
	70	8.08 Aa	9.15 Aa	5.31 Aa	8.14 Aa	0.13 Bb	0.15 Aab
	90	8.05 Aa	8.97 Aa	5.49 Aa	6.41 Aa	0.15 Aa	0.13 Bb
180	0	9.29 Aa	9.71 Aa	7.30 Aa	7.36 Aa	0.14 Bb	0.19 Aa
	50	10.30 Aa	10.35 Aa	6.89 Aa	5.59 Aa	0.19 Aa	0.16 Bbc
	70	10.02 Aa	10.75 Aa	7.10 Aa	8.13 Aa	0.16 Ac	0.18 Aab
	90	9.56 Aa	10.07 Aa	5.44 Aa	7.36 Aa	0.18 Aa	0.15 Aab
240	0	18.37 Ab	20.09 Ab	10.79 Ab	12.28 Aa	0.33 Ab	0.37 Ab
	50	22.39 Ba	28.12 Aa	11.96 Aa	11.91 Aa	0.44 Aa	0.46 Aa
	70	19.77 Bb	21.65 Ab	11.45 Aab	12.55 Aa	0.39 Ab	0.41 Ab
	90	19.15 Bb	21.47 Ab	11.45 Aab	11.80 Aa	0.38 Ab	0.40 Ab
300	0	20.95 Bb	23.39 Ab	10.87 Ab	12.53 Ab	0.39 Ab	0.42 Ab

	50	28.50 Ba	33.29 Aa	17.59 Ba	22.44 Aa	0.64 Aa	0.66 Aa
	70	22.17 Ab	23.35 Ab	12.70 Ab	13.48 Ab	0.44 Ab	0.42 Ab
	90	21.76 Ab	22.81 Ab	12.46 Ab	13.04 Ab	0.41 Ab	0.42 Ab

Means followed by equal letters do not differ significantly from each other by Tukey's test at the 95% probability level. Uppercase letters correspond to the comparison between the collection areas and the lowercase letters correspond to the comparison between the shading levels. Area I: Recife; Area II: Camaragibe.

At 240 days of age, seedlings of seeds originating from the municipality of Camaragibe (Area II) submitted to 50%, 70% and 90% shading showed significant mean shoot biomass growth in comparison to that observed in seedlings from Recife (Area I). At the end of the experiment, it was also observed that the average height of the plants submitted to full sunlight, from both sources, differed statistically from each other, with those from Camaragibe standing out in relation to those from Recife.

Considering the main root length, it was found that the plants from the two origins exposed to 50% shading had the highest averages at 300 days, which, in addition to differing statistically from each other, significantly differed from the averages of the other shading levels. There was no significant difference between the means regarding the 0%, 70% and 90% shading levels for both origins during the experiment. However, the lowest root growth among these treatments was observed at the end of the evaluations in plants submitted to full sunlight from the two studied origins.

At 120 days, seedlings of seeds harvested in Recife and submitted to 50% and 70% shading had the smallest stem diameters, while this occurred in full sun and 90% shading in those from Camaragibe. However, from 240 days until the end of the experiment it was observed that the stem diameters obtained at the 50% shade level for the two origins revealed similar means among themselves and statistically higher when compared to the means of the other treatments, both between origins and within them.

Evaluation of leaf area and number of leaves per plant

Plants from the two different origins showed significant differences between the average leaf area in the period of 120 days under the 50% shade level (Table 2). However, statistical superiority at the 50% level was only found between 240 and 300 days for plants from Recife, while those from Camaragibe showed this increase in leaf area for the aforementioned level at 120 and 300 days, respectively. A smaller leaf area was observed from 120 days onwards for the treatment submitted to full sun in both areas.

Table 2. Mean leaf area values and number of leaves of *Aspidosperma discolor* A. DC. seedlings obtained for 300 days as a function of shading levels and collection origins.

Tabela 2. Valores médios de área foliar e número de folhas de mudas de *Aspidosperma discolor* A. DC., obtidos durante 300 dias, em função dos níveis de sombreamento e procedências de coleta.

Age (Days)	Shading (%)	Leaf area (cm²)		Number of leaves	
		Area I	Area II	Area I	Area II
60	0	0.41 Aa	0.48 Aa	1.10 Aa	1.50 Aab
	50	0.64 Aa	0,58 Aa	1.40 Aa	1.60 Aa
	70	0.48 Aa	0.48 Aa	1.30 Aa	1.00 Ab
	90	0.43 Aa	0.43 Aa	1.20 Aa	0.80 Aab
120	0	2.56 Ab	3.07 Ab	2.80 Aa	3.40 Aa
	50	3.16 Bbc	5.32 Aa	3.20 Aa	3.50 Aa
	70	4.36 Aa	3.98 Ab	2.50 Aa	3.30 Aa
	90	3.95 Aab	3.67 Ab	2.70 Aa	2.60 Aa
180	0	4.24 Ab	4.21 Ab	4.40 Aab	3.50 Ba
	50	5.31 Aa	6.78 Aa	4.70 Aa	3.80 Ba
	70	4.87 Aab	5.02 Aab	4.20 Aab	3.60 Aa
	90	4.63 Aab	5.81 Aab	4.00 Ab	2.90 Ba
240	0	7.14 Ab	6.68 Ab	6.10 Ab	6.90 Ac
	50	8.73 Aa	8.20 Aa	7.40 Ba	9.10 Aa
	70	7.32 Ab	6.72 Ab	6.40 Bab	7.90 Ab
	90	7.74 Ab	6.98 Aab	5.60 Bb	7.60 Abc
300	0	11.03 Ab	9.86 Ab	7.40 Bb	8.80 Ab
	50	19.54 Aa	19.64 Aa	8.80 Ba	10.70 Aa
	70	12.35 Ab	12.10 Ab	7.30 Ab	8.50 Ab
	90	11.41 Ab	11.63 Ab	7.80 Aab	8.40 Ab

Means followed by equal letters do not differ significantly from each other by Tukey's test at the 95% probability level. Uppercase letters correspond to the comparison between the collection areas and the lowercase letters correspond to the comparison between the shading levels. Area I: Recife; Area II: Camaragibe.

Regarding the number of leaves per plant, it was found that individuals from Camaragibe showed higher values in the levels of 0%, 50% and 90% of shading compared to those from Recife at 180 days. At 240 days, there were statistical differences involving the number of leaves per plant between the provenances in the 50%, 70% and 90% shade treatments. On that occasion, it was noticed that the plants descended from Camaragibe showed a higher level of significance of their means. Among these averages, the one registered for 50% of shading, not only was expressed as the highest among the provenances, but also constituted the most significant among those found in the other treatments applied to plants from Camaragibe, a statistical superiority that remained up to 300 days.

Shoot and root system dry mass and total biomass

The mean shoot dry mass values obtained for *A. discolor* plants submitted to 50% shading for both origins showed differences during the entire experiment period when compared to the 90% shade level. The results are presented in Table 3.

Table 3. Mean shoot, root and total dry mass values of *Aspidosperma discolor* A. DC seedlings obtained during 300 days as a function of shading levels and collection origins.
Tabela 3. Valores médios da biomassa seca das partes aéreas, raízes e totais de mudas de *Aspidosperma discolor* A. DC., obtidos durante 300 dias, em função dos níveis de sombreamento e procedências de coleta.

Age (Days)	Shading (%)	Dry biomass (g)					
		Shoots		Roots		Total	
		Area I	Area II	Area I	Area II	Area I	Area II
60	0	0.050 Bb	0.060 Aa	0.032 Aa	0.024 Bb	0.082 Aa	0.084 Aa
	50	0.060 Aa	0.060 Aa	0.036 Aa	0.036 Aa	0.096 Aa	0.096 Aa
	70	0.052 Aab	0.050 Aab	0.030 Aa	0.034 Aa	0.082 Aa	0.084 Aa
	90	0.050 Ab	0.042 Ab	0.032 Aa	0.024 Ab	0.082 Aa	0.066 Ab
120	0	0.190 Aab	0.221 Aab	0.051 Ab	0.054 Ab	0.241 Ab	0.275 Aab
	50	0.234 Aa	0.245 Aa	0.068 Aa	0.071 Aa	0.302 Aa	0.316 Aa
	70	0.206 Aab	0.212 Aab	0.052 Ab	0.058 Aab	0.258 Aab	0.270 Ab
	90	0.183 Ab	0.184 Ab	0.063 Aab	0.062 Aab	0.246 Ab	0.246 Ab
180	0	0.277 Ab	0.284 Ab	0.072 Ab	0.081 Aa	0.349 Ab	0.365 Ab
	50	0.367 Aa	0.381 Aa	0.104 Aa	0.099 Aa	0.471 Aa	0.480 Aa
	70	0.316 Aab	0.313 Aab	0.073 Ab	0.087 Aa	0.389 Ab	0.400 Aab
	90	0.283 Ab	0.293 Ab	0.078 Ab	0.077 Aa	0.361 Ab	0.370 Ab
240	0	1.294 Ac	1.317 Ac	0.550 Ab	0.515 Ab	1.844 Ac	1.832 Ac
	50	1.990 Aa	2.061 Aa	1.030 Aa	1.019 Aa	3.020 Aa	3.080 Aa
	70	1.527 Ab	1.569 Ab	0.676 Ab	0.689 Ab	2.203 Ab	2.258 Ab
	90	1.506 Ab	1.572 Ab	0.665 Ab	0.650 Ab	2.171 Ab	2.222 Abc
300	0	2.705 Ac	2.760 Ac	0.837 Ab	0.821 Ab	3.542 Ac	3.581 Ac
	50	7.541 Ba	8.175 Aa	2.408 Aa	2.431 Aa	9.949 Ba	10.606 Aa
	70	3.618 Ab	3.624 Ab	0.990 Ab	0.942 Ab	4.608 Ab	4.566 Ab
	90	3.488 Ab	3.503 Ab	0.925 Ab	0.899 Ab	4.413 Ab	4.402 Ab

Means followed by equal letters do not differ significantly from each other by Tukey's test at the 95% probability level. Uppercase letters correspond to the comparison between the collection areas and the lowercase letters correspond to the comparison between the shading levels. Area I: Recife; Area II: Camaragibe.

Regarding full sun (0% of shading) and 50% shading, it was found that individuals from Recife were only similar at 120 days of age, while this behavior was verified at 60 and 120 days in Camaragibe seedlings. On the other hand, the averages from the 70% shade level showed differences in relation to those verified in the 50% treatment, from 240 days onwards for the two origins. There were no statistical differences between individuals submitted to 70% and 90% shading for the two origins. Significant differences were found at 60 days for full sun treatment, and at 300 days for 50% shade in both locations, with final shoot dry mass practically three times higher than that presented by individuals submitted to full sun.

Statistical divergence was observed in the root system dry mass only at 60 days in the 0% treatment between the two origins. However, it was found that the averages obtained in seedlings from Recife from 180 days to 300 days at the 50% shading level within each origin were highly significant compared to the other treatments. This behavior was detected from 240 days until the end of the experiment for the Camaragibe seedlings.

Although there is a small difference in the accumulation of total dry mass in the 90% shading treatment in Camaragibe at 60 days of age, there was a predominance of similarity of accumulated dry mass in the other treatments within and between origins. It was found that the accumulation of total dry mass in plants subjected to 50% shading was higher from 120 to 300 days than that recorded for individuals exposed to 90% for both

origins. The mean dry mass values accumulated at 180, 240 and 300 days for the plants in the 70% treatment were lower when compared to those obtained at the same time for the 50% shading treatment in the Recife origin. This behavior for the respective shade levels was evident at 240 and 300 days of age for Camaragibe. the total dry mass obtained under 50% shading at the end of the experiment was practically three times greater than those recorded in the full sun treatment.

It was also observed that the general averages in the total biomass distribution process obtained between the tested shading levels for *A. discolor* were 74.73% for shoots and 25.27% for the root system in seedlings from Recife. In addition, seedlings from Camaragibe presented percentages of 75.63% for shoots and 24.37% for the root system.

Root/shoot dry mass ratio

The allocation of dry mass in the roots and shoots of *A. discolor* plants only differed statistically at 60 days of age between the treatments 70% shading and full sun for Camaragibe; and at 180 days between 50% and 70% shading levels for Recife. The shoots generally produced a greater amount of dry mass than the root system (Table 4).

Table 4. Mean root/shoot ratio values for *Aspidosperma discolor* A. DC seedlings obtained for 300 days as a function of shading levels and collection origins.

Tabela 4. Valores médios da relação raízes/partes aéreas de mudas de *Aspidosperma discolor* A. DC., obtidos durante 300 dias, em função dos níveis de sombreamento e procedências de coleta.

Age (Days)	Shading (%)	Root/shoot ratio	
		Area I	Area II
60	0	0.640 Aa	0.410 Ab
	50	0.600 Aa	0.600 Aab
	70	0.600 Aa	0.680 Aa
	90	0.640 Aa	0.600 Aab
120	0	0.268 Aa	0.244 Aa
	50	0.291 Aa	0.290 Aa
	70	0.252 Aa	0.274 Aa
	90	0.344 Aa	0.337 Aa
180	0	0.260 Aab	0.285 Aa
	50	0.283 Aa	0.260 Aa
	70	0.231 Ab	0.278 Aa
	90	0.276 Aab	0.263 Aa
240	0	0.425 Aa	0.391 Aa
	50	0.518 Aa	0.494 Aa
	70	0.443 Aa	0.439 Aa
	90	0.442 Aa	0.413 Aa
300	0	0.309 Aa	0.297 Aa
	50	0.319 Aa	0.297 Aa
	70	0.274 Aa	0.260 Aa
	90	0.265 Aa	0.257 Aa

Means followed by equal letters do not differ significantly from each other by Tukey's test at the 95% probability level. Uppercase letters correspond to the comparison between the collection areas and the lowercase letters correspond to the comparison between the shading levels. Area I: Recife; Area II: Camaragibe.

DISCUSSION

The light intensity received by the plant is closely linked to the photosynthesis process, and consequently to the growth and establishment of the individual. In an experiment with seedlings of the same genus, *Aspidosperma subincanum* Mart., submitted to 0%, 50%, 70% and 90% shading for 16 months, it was observed that the seedling shoots showed slow growth, with no significant difference during the evaluation period (FELFILI *et al*., 2005).

With the exception of the time 120 days, it is only possible to verify the difference between the origins from day 240 onwards (Table 1). Such variation can be attributed to adaptive genetic patterns of collection matrices related to the environment. This plasticity demonstrated for the height of *A. discolor* seedlings subjected to a luminous gradient has been verified quite frequently with other tropical native species (PÁJARO-ESQUIVIA *et al*., 2021; PARADIZO *et al*., 2015; SILVA *et al*., 2017; SOUZA; JOLY, 2017; VALLE *et al*., 2018), however studies for the species in question are still scarce.

Given the ecological classification of the species, the full sun condition is not suitable for the satisfactory development of the plant. Likewise, low light intensities also provide an increase in height. Thus, an intermediate intensity seems to be the most suitable for seedling production. Felfili *et al*. (2005) showed that the taproot length of *A. subincanum* seedlings showed similar behavior in both the presence of full sunlight and in different shading levels, therefore demonstrating the absence of plasticity of this organ under divergent light conditions. The natural shade environment provided the highest root/shoot ratio values, which indicates a greater allocation of photoassimilates.

The stem diameter should be considered one of the most important morphological parameters to assess the seedling quality of forest species, and thereby estimate their ability to survive after the definitive planting. This variable has shown variable behavior for seedlings of several forest species when submitted to different shading levels and also to the presence of sunlight. In this study, only the initial phase showed no difference between areas or levels of shading, which suggests that the observation time was not long enough to express variation in behavior. The variation in the period between 120 and 180 days occurred in both between areas and between levels, however this variation did not present a similar behavior for the two environments. There was stabilization in the growth process in the last two evaluations when the collection environments were compared, with largest stem diameter at the 50% shading level, which can be related to the ecological classification of the species.

Leaf area expansion is considered an important parameter in determining the physiological processes related to growth and development as it influences the leaf area index, transpiration intensity and net assimilation rate, and it has been indicated as the way in which the plant seeks to compensate for the luminous deficit when submitted to varied shading conditions (BARTIERE *et al*., 2020). Shade-tolerant species expand their leaf surface under low light, since they need more light capture per unit area. In this study, there was greater sensitivity to the action of sunlight in plants from both origins subjected to full sun, since they developed the smallest leaf areas from 120 days until the end of the experiment.

This trend was confirmed in *A. discolor* for the studied origins, where it was found that the highest leaf area index occurred in seedlings under the influence of intermediate shading (50%), whose statistical significance revealed high phenotypic plasticity in relation to the other shading levels evaluated. This more expressive growth verified in this allometric variable is another parameter which firmly contributes to confirm the ecological behavior of *A. discolor* individuals as typical of a heliophilous species with a certain degree of shade tolerance.

The number of leaves is characterized as a phenotypic variable of lesser ecological weight to represent differences in plant growth when submitted to different shading levels, since the fall and the emission of new leaves are continuous processes. However, this variable associated with the other allometric parameters is relevant in the ecological behavior of the growth of certain tropical species, being directly conditioned to the development of plants, as these organs are responsible for photosynthesis (TAIZ *et al*., 2017). Therefore, the greater number of leaves verified in *A. discolor* plants submitted to 50% of shading was a consequence of the greater vegetative growth verified in the shoots due to the better nutrient absorption efficiency by the roots of these seedlings when compared with those submitted to the other shading conditions.

Although *A. discolor* showed the lowest shoot dry mass production in full sun, the ability to accumulate significant amounts of assimilates under intermediate shading conditions (50%) is another strong indication that the species has predominantly verified phenotypic plasticity. The higher dry mass concentration in the root system of the plants provides better performance of seedlings under field conditions, especially in degraded areas, as it increases the probability of survival both by facilitating support and by increasing the water and nutrient absorption area (GAZEL-FILHO *et al*., 2007). Thus, the 50% shading treatment presented the best results, corroborating the previous results.

These results allow us to conclude that there was a significant accumulation of assimilates in both situations, equivalent to three and a half times in the shoot portion compared to that verified in the root system, demonstrating the high productivity of the species despite its restricted capacity for root dry mass growth and production. This distribution of total dry mass presented by *A. discolor*, in which a greater proportion is evident in the shoots to the detriment of the root, is frequently detected by several researchers in tropical tree species. The biomass allocation can define the potential use of a species, meaning that if the accumulation is greater in its shoot, it has greater aptitude for silviculture; if it is in its root system, it has greater aptitude to replace vegetation cover in degraded environments (GAZEL-FILHO *et al*., 2007).

It is important to emphasize that the way in which the plant uses resources affects the development and proportion of the shoot/root biomasses. This characteristic becomes relevant for these plants because it increases their photosynthesis/respiration ratio, and thereby enables both the maintenance of a positive carbon balance and optimizes growth under diffuse light conditions.

Species typical of seasonal forest environments subjected to variations in light intensity probably have a greater capacity to acclimate to shading conditions and better performance when exposed to more illuminated environments. This deduction is noticeable in *A. discolor* which, although it has shown significant performance in both shoot growth and dry matter accumulation when subjected to 50% shading, regardless of origin, it also presented satisfactory development in the other shading levels (70% and 90%) at the end of the evaluations; this also gives it aptitude to develop in environments with less light availability. Therefore, it is possible to infer that the studied species presents ecological behavior which is typical of a heliophilous species with a certain degree of shade tolerance in view of the high phenological plasticity detected between 50% shading (similar to a clearing condition) (CONCEIÇÃO; DIAS-FILHO, 2013; LENHARD *et al*., 2013), and the other shading levels used.

CONCLUSIONS

The evaluations carried out allow us to conclude that:

- *Aspidosperma discolor* showed phenotypic plasticity favorable to its acclimatization in environments with moderate to intermediate shading conditions, a characteristic evidenced in small gaps; and to dense conditions, typical of vegetation with a closed canopy.
- A shading level of 50% is recommended to produce *A. discolor* seedlings in a forest nursery, as it favors greater shoot and root growth and biomass. *A. discolor* presents a peculiar ecological behavior of facultative sciophilous taxa or of intermediate succession stages.
- *A. discolor* can be used in the silvicultural context and in the recovery of degraded areas in an effective reconstitution process and to enrich Dense Ombrophilous Forest fragments.

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