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Sowing of *Lupinus albescens* Hook. & Arn. in arenization degraded area

Sementeira de *Lupinus albescens* Hook. & Arn. em área degradada por arenização

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ABSTRACT

Lupinus albescens is a species frequent in the locals under arenization in Rio Grande do Sul, with high rusticity and rapid land cover, showing potentialities for recomposition of degraded areas. The objective was to evaluate the emergence and development of *L. albescens*, with and without mineral fertilizer application intercropped with the palm *Butia lallemantii* Deble & Marchiori. Seeds were collected in three populations and submitted to the scarification for 40 seconds. Sowing was done between nine rows (2 x 1 m) of *B. lallemantii* by applying 0 and 30 g/hole of the mineral fertilizer NPK (5-20-20). Evaluations: number of plants per hole (NPH), height (cm) and stem diameter (mm), in the periods of 30 and 60 days, as well as the percentage of plants emergence/m^2 (PEP) and the total of plants emergence (TEP) over 240 days, using randomized block design. The results showed a considerable PEP and height at 30 days for the plants in block 2. Dose of 0g/hole of fertilizer NPK provided higher NPH. Therefore, sowing of *L. albescens* intercropped with *B. lallemantii* presented higher PEP, NPH without the use of fertilization (30 days) and higher height of the plants among the diameter seedlings of the medium stipe.

Keywords: area recovery, erosive processes, sandy soil, seeds.

RESUMO

Lupinus albescens é uma espécie frequente nos locais de arenização no Rio Grande do Sul, com alta rusticidade e rápida cobertura vegetal, mostrando potencialidades para recomposição de áreas degradadas. O objetivo foi avaliar a emergência e o desenvolvimento de *L. albescens*, com e sem aplicação de adubação mineral consorciada com a palmeira *Butia lallemantii* Deble & Marchiori. Sementes foram coletadas em três populações e submetidas à escarificação por 40 segundos. A sementeira foi feita entre nove fileiras (2 x 1 m) de *B. lallemantii* aplicando-se 0 e 30 g/cova do fertilizante mineral NPK (5-20-20). Avaliações: número de plantas por cova (NPC), altura (cm) e diâmetro do caule (mm), nos períodos de 30 e 60 dias, assim como a percentagem de emergência de plantas/m^2 (PEP) e o total emergência de plantas (TEP) ao longo de 240 dias, utilizando delineamento em blocos casualizados. Os resultados mostraram considerável PEP e altura aos 30 dias para as plantas do bloco 2. Dose de 0g/cova do fertilizante NPK proporcionou maior NPH. Portanto, a sementeira de *L. albescens* consorciada com *B. lallemantii* apresentou maior PEP, NPC sem o uso de adubação (30 dias) e maior altura das plantas entre as plântulas de diâmetro do estipe médio.

Palavras-chave: recuperação de áreas, processos erosivos, solo arenoso, sementes.

INTRODUCTION

In southwestern Rio Grande do Sul state, mixed prairie vegetation grows on sandy soils, which are vulnerable to the weathering process, minimizing the vegetation cover due to exposure to water and wind erosive processes (Ab'saber, 1995). This phenomenon deposits unconsolidated sediments on the surface of the areas, causing the predominance of sandy particles and scarcity of vegetation since they are fields inhabited by herbaceous and shrubby species (Vieira and Verdum, 2015). It is an element that belongs to the stability of the Gaucho Campaign's rural ecosystem, being essential for the restoration and preservation of the surrounding plant community in the face of any anthropic activity that would establish in the region (Rovedder and Eltz, 2008b).

The objective of the practices for recovering soils from degraded areas is to obtain the return of the most favorable conditions, involving the initial composition of the species and the community structure for the reconstruction of the functions and services of the ecological system (D'Antonio and Meyerson, 2002; Rovedder and Eltz, 2008a). The return of the original structure of an ecosystem is complex in addition to taking long time, but the immediate coverage of the soil promotes the reduction of impacting agents (Rovedder and Eltz, 2008a).

Rovedder and Eltz (2008a) recommend that the association of exotic forest species, *Pinus elliottii* Engelm. and *Eucalyptus tereticorni* Sm., with cover species, *Lupinus albescens* and *Avena strigosa* Schieb., show important results in reducing the effects of eolic agents and water erosives. Thereby, the selection of species with rapid establishment and growth in adverse areas is of fundamental importance to obtain positive results (Schneider *et al.*, 2014), mainly, the short-cycle plants with high green mass production. However, there are few studies that address field techniques for the recovery of sandstone soils through the use of native plant species set at these sites in order to mitigate the effects of erosive processes.

The species *Lupinus albescens* is an annual herbaceous plant that presents an adaptation to sandy textured soil and sunny locations, denoting a pivotal root system, up to 150 cm deep and satisfactory results in biomass production (Pinheiro and Miotto, 2001; Rovedder, 2007). Moreover, it presents a symbiotic association with nitrogen-fixing bacteria, with active nodules in the root colon and near the coif (Rovedder, 2007). So, it is a plant with potential to reduce the thermal amplitude and the erosive processes that occur in the soils under arenization, making it possible to recolonize of the field areas affected by this phenomenon (Eltz and Rovedder, 2005; Rovedder, 2007; Rovedder and Eltz, 2008b).

Figure 1 - Specimens of *Butia lallemantii* adult plants in a field area of São Francisco de Assis/RS, Brazil.

The species *Butia lallemantii* Deble and Marchiori presents high adaptability to rural-type environments or open areas (Soares *et al*., 2014). In the sandy fields of the western and southwestern region of Rio Grande do Sul, it is clearly visible, besides being very abundant in the sandstone elevations of the municipalities of Alegrete, Manoel Viana and São Francisco de Assis (Deble and Marchiori, 2006) (Figure 1). A species with small size morphology, being able to reach up to 1,0 m in height, with caespitose habit and subterranean stipes (Soares *et al*., 2014). In addition, its stipes are strongly fixed to the soil that allied to a deep root system impair erosion processes. Moreover, its canopy acts in the protection of soil against the impact of rain drops and the action of the wind on the soils under arenization. In this way, it presents important characteristics to recompose areas under arenization, due to their natural presence and perpetuation on these extreme places, with shortage of water and nutrients (Freitas *et al*., 2010; Soares *et al*., 2014).

On the other hand, characteristics such as deep roots, good biomass production and biological nitrogen fixation, as well as the adaptability to poor sandy soils and under intense action of the wind and water erosion processes point to the possibility of using the native species of *L. albescens* (*Fabaceae*) for the softening and positive recovery of these sites. Therefore, the objective of this work was to evaluate the emergence and development of *L. albescens* plants, with and without the application of mineral fertilizer, intercropped with *B. lallemantii* seedlings.

MATERIALS AND METHODS

Collection local and study experimental area

This study started in December 2015, with the collection of *L. albescens* pods in *in situ* matrices in three different populations (Figure 2). Population 1 (Pop. 1) was collected on a road slope, adjacent to a sandy area, in the municipality of São Francisco de Assis, state of Rio Grande do Sul (29°35′02″ S of latitude and 55°21′49″ W of longitude). The second population (Pop. 2) was found on another road slope, near the Cerro do Tigre Bridge (29°39′56″ S latitude and 55°23′31″ W longitude). The third population (Pop. 3) was located in an arenization focus on Fazenda Cerro do Tigre (29°39′29″ S latitude and 55°24′02″ W of longitude) (Pop. 3). Populations 2 and 3 are located in the city of Alegrete, state of Rio Grande do Sul, 1.5 km apart from each other, in a straight line. After the collection, the pods were taken to the Biotechnology Laboratory of the Department of Horticulture and Forestry of the Federal University of Rio Grande do Sul in Porto Alegre, state of Rio Grande do Sul, which were arranged on benches for drying and finishing of their dehiscence.

The study was carried out in the Duas Guias, a rural estate located in Alegrete, state of Rio Grande do Sul (29º47′48″ S of latitude and 55º24′20″ W of longitude), with a total area of 94 ha. It is found in the property an area impacted by the process of arenization with approximately 19 ha, where the experimental area was established. The experimental area had a size of 0.5 ha and slope of around 3%, being isolated with electric fence to prevent the access of domestic herbivores. The collection region and the study area present a subtropical climate, moderately humid to humid, with an average annual rainfall of around 1,500 to 1,800 mm distributed in 90 to 120 rainy days. The average annual temperature ranges from 17 to 20°C, with the average temperature of the coldest month oscillating between 11 and 14°C and the hottest month varying between 23 and 26°C (Rossato, 2011).

Prior to the installation of the experiment in December 2015, 300 seedlings of *B. lallemantii*, aged seven months, were organized in the experimental area of the study, which were collected at Fazenda Três Nascentes, located in the municipality of Alegrete/RS (29°53′16.24″ S and 55°22′54.78″ W). The systematization was in three blocks of 200 m², where 100 seedlings were transplanted in each block, using spacing of 2 x 1 m. One hundred seedlings with a larger diameter of stipe (above 9 cm) were transplanted to block 1, in block 2, there were one hundred seedlings with a mean diameter of stipe (from 6.21 to 9 cm) and in block 3, one hundred seedlings with smaller diameter stipe (less than 6.2 cm).

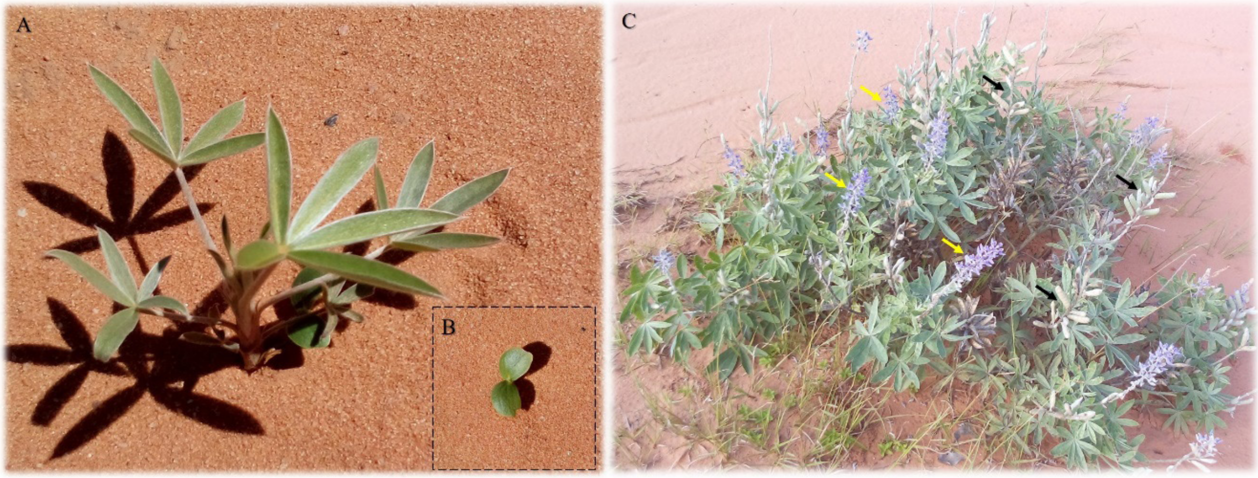

Figure 2 - Specimens of the species of *Lupinus albescens*: a) seedlings with approximately ten days; b) two-day seedlings and c) adult plant in flowering and in the process of forming pods (yellow arrows indicate the flowers and black arrows indicate their pods).

Sowing and procedures in the study area

Prior to the sowing process, the seeds of the three populations were homogenized in a single plot, submitted to the pre-germinative treatment of mechanical scarification between sandpapers no. 120 for 40 seconds. At this scarification time, there were about two friction movements per second, occupying the total length (or width) of the sandpaper, with pressure not exceeding the weight of the loose hand upon the material, for each sample of 25 seeds.

Direct sowing of *L. albescens* seeds was carried out in February 2016 in the study area, approximately 60 days after the transplanting of the *B. lallemantii* seedlings. Sowing was carried out inside the three blocks, among the nine rows (2 m of distance between each row) of *B. lallemantii* seedlings from each block. Thus, each row had 56 holes, in the composition of three to five seeds per hole and depth of 5 cm, totaling 2520 seeds for each block, approximately 350 g. The spacing was systematized for a distance of 2 m between rows, in order to reduce the action of sand particles from the wind erosion process among the *B. lallemantii* plants at the study site, as shown in Figure 3. In order to test the development of the plants under the presence of chemical fertilizer, the zero doses and 30 g/hole of NPK (5-20-20) were applied to the side of each hole with the seeds (about 10 cm away), where the odd rows received the dose of 30 g/hole and the even rows, received the zero dose.

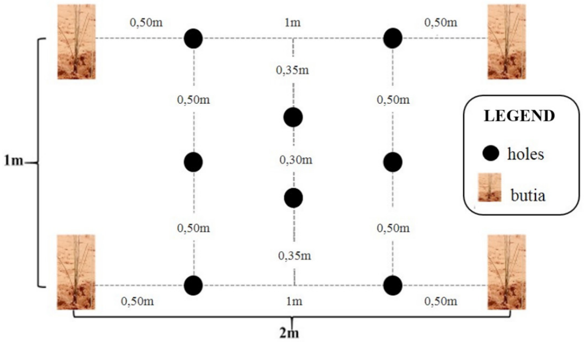

Figure 3 - *Lupinus albescens* seed sowing design among *Butia lallemantii* rows in the experimental area under arenization.

Evaluations

Evaluations were performed at 30 and 60 days after sowing, using the following variables: number of plants per hole, height (cm) and stem diameter (mm), with the aid of a digital caliper. The evaluations were carried out until day 60 because from that period, a great suppression of plants occurred in the sandstone area, due to the action of the wind erosive processes, causing an abrasive effect on the plants. Thus, after 60 days, the plants showed an uneven size in the height and diameter levels, so evaluation could not be carried out in a homogeneous manner.

For the aforementioned evaluations, a 100 x 100 cm (1 m^2) wooden template was randomly positioned between the rows of *B. lallemantii* plants, and all plants found inside it were counted. Thirty-six points were evaluated per block. In addition, the percentage of emergence of plants/m^2 (PEP) and total emergence of plants (TEP) was monitored monthly during the 240-day period.

The PEP data were observational by counting all plants emerged in each block for each month of evaluation, disregarding the use of mineral fertilization. Calculations of the percentage of PEP were performed according to equation 1, where *EBPi* represents the number of plants emerged in a block for a given month, divided by the total of emerged plants in all blocks in the same month.

Equation 1:

$$\text{PEP (months x)} = \left(\frac{\text{EBPi}}{\sum \text{EBPi}}\right) \text{ x } 100$$

For TEP data, the evaluation was done by counting all the plants that emerged in each row of each block, that is, for each dose of fertilization. The TEP percentage calculations were performed according to equation 2, where *EPAi* represents the number of emerged plants in a particular fertilization treatment in one month, divided by the total of emerged plants in all fertilization treatments in the same month.

Equation 2:

$$\text{TEP (months x)} = \left(\frac{\text{EPAi}}{\sum \text{EPAi}}\right) \text{ x } 100$$

Statistical analysis

The study used a randomized block experimental design by means of sowing between the rows of *B. lallemantii* in the three blocks, where the odd rows were fertilized with mineral fertilizer NPK at the dose of 30 g/hole and the even rows were fertilized with the zero dose. Statistical analysis consisted of the Bartlett's normality test, and, after the assumptions of the analysis of variance were met, the ANOVA was performed. The test of Dunnett was used to compare the means between the fertilizer doses and the MSD test (Minimum Significant Difference) was used to compare the blocks using the Costat 6.4 software. In relation to the regression analysis, the SigmaPlot 11.0 software was used. The variables of number of plants per hole and stem diameter did not meet the hypothesis of ANOVA. Therefore, they were submitted to the transformation.

RESULTS

The emergence of plants/m^2 over the evaluated months was high in block two (central), although the evaluations in the three blocks unveiled a lower percentage of 1.2 emerged plants/m^2 (Figure 4).

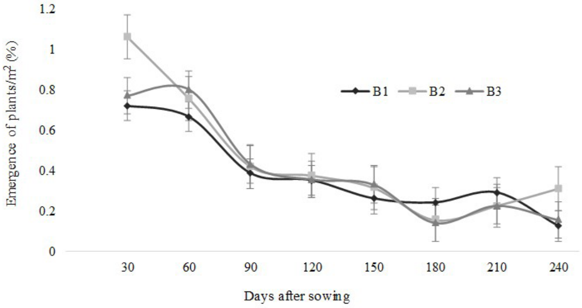

Figure 4 - Monthly evaluation of emergence percentage of plants/m^2 in blocks 1, 2 and 3, over 240 days.

The *L. albescens* plants presented a substantial increase in height in block two, which was superior to block 1, but statistically equal to block 3, for the 30-day evaluation. However, stem diameter of the plants and the number of plants per hole did not show significant results among the three blocks

Table 1 - Average data for height (H), stem diameter (Sd) and number of plants per hole (Nph) for each block on days 30 and 60 after *Lupinus albescens* sowing

Blocks	H (cm)	Sd (mm)	Nph	H (cm)	Sd (mm)	Nph
	30 days			60 days		
1	1.49 b	1.29 ^{ns}	2.25 ^{ns}	3.37 ^{ns}	1.98 ^{ns}	1.86 ^{ns}
2	2.13 a	1.34	2.89	3.67	1.85	1.88
3	1.98 ab	1.59	2.17	4.05	1.95	1.86

^{ns} not significant at 5% probability of error.

analysed. In the evaluation at 60 days, height, stem diameter and number of plants per hole did not differ statistically in the three blocks (Table 1).

The percentage of total emergence of plants at 30 days was higher in the absence of chemical fertilization, however, after 60 days, a decrease was observed in the number of emerged plants for the two doses of the applied fertilizer (Figure 5).

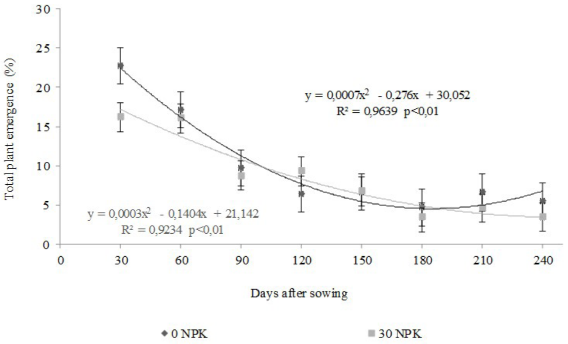

Figure 5 - Total emergence percentage of plants in treatments with 0 and 30 NPK mineral fertilization over 240 days.

In the 30-day period, the height and stem diameter variables of the plants did not show any significant results, however, the number of plants per hole was higher at the zero-fertilization dose (Table 2). Moreover, in the evaluation at 60 days, no significant difference was identified for height, stem diameter and number of plants per hole in relation to the presence of mineral fertilization (Table 2).

Table 2 - Average data for height (H), stem diameter (Sd) and number of plants por hole (Nph) for each dose of fertilization (Df) on days 30 and 60 after *Lupinus albescens* sowing

Df (g/hole)	H (cm)	Sd (mm)	Nph	H (cm)	Sd (mm)	Nph
		30 days			60 days	
0*	2.01 ^{ns}	1.52 ^{ns}	2.65 a	3.80 ^{ns}	1.90 ^{ns}	2.06 ^{ns}
30**	1.76	1.29	1.92 b	3.61	1.92	1.72

^{ns} not significant at 5% probability of error; * 0 = 0 NPK fertilizer; ** 30 = 30 NPK fertilizer.

DISCUSSION

In the State of Rio Grande do Sul, the arenization phenomenon has threatened the rural areas of the Pampa biome, according to Rovedder *et al.* (2010), causing impact on their ecosystem functions, phytosociological composition and soil properties. So, the lithological characteristics of the areas under arenization and the aspects of the surface structure of this soil have contributed to the increase of degradation processes, the wind degradation process, in particular (Rovedder *et al.*, 2005). Moreover, the vulnerability factors related to the extension of the areas, speed and intensity of the winds and the degree of soil moisture favor the force of wind erosion on soils under arenization (Souto, 1984). The intensity of the wind erosion processes leads to the removal of native vegetation cover, contributing to the formation of sand fields and dunes at small heights in sandy areas (Eltz and Rovedder, 2005). Thus, the intense action of the winds in the study area may have negatively influenced the establishment of *L. albescens* plants, especially for newly emerged seedlings of the soil (Figure 4). The authors Rovedder and Eltz (2008b) cite the consequences of the wind erosion process, which causes an abrasive effect of the sand particles on the plants, burial of the plants by the deposition of the particles, soil suppression and, consequently, the exposure of the roots, characteristics that result in the death of the plants or in damages during the growth.

The *L. albescens* plants showed higher averages of growth in height in block two, which is located in the central part of the area under arenization in the study (Table 1). It is possible that the plants evaluated at 30 days in the summer season were protected from erosive wind action in this block due to its location between the other blocks. Since sand particle movement occurs with higher volume in the spring-summer months, which correspond to the periods of greater intensity of the winds in the region of the soils under arenization, which are the data obtained by the quantification of sand displaced in a sandy area over a sixteen-month study (Rovedder, 2003). Even though the use of a native species of the region such as *L. albescens*, which presents a covering function for the control of erosive processes, is an economically and ecologically viable alternative (Rovedder *et al.*, 2010), a sharp displacement of sand particles still occurs in the spring-summer seasons at these sites. According to Rovedder and Eltz (2008b), who verified in an arenization degraded area in the spring-summer period, a higher intensity of winds and, consequently, greater movement of sand particles, despite the sowing of coverage plants such as *Avena strigosa* Schieb. and *L. albescens*. Therefore, the low degree of resilience of this ecosystem after the establishment of the sand area, causes its unstable expansion over the surrounding areas, causing the need for the use of cover species combined with the efficient control strategies to soften the wind erosion processes and the advance of arenization (Rovedder *et al*., 2009).

The use of mineral fertilization provided a lower percentage of emerged *L. albescens* plants. So, the fertilizer may have had a negative effect on this legume species, inhibiting the biological nitrogen fixation processes (Figure 5, Table 2). Similarly, the legume species *Swartzia argentea* Benth. and *S. laevicarpa* Amshoff. were subjected to N-mineral treatment and control (with no mineral fertilizer), in which an inhibitory effect of N-mineral on the formation of the nodule was evaluated, impairing the symbiotic process of plants (Vieira and Souza, 2011). In this context, nitrogen (N) is one of the essential nutrients for plant growth and production, generally being added to the soil via nitrogenous fertilizers, which is a high cost practice, however (Eiras and Coelho, 2011), which may influence the inhibition of symbiotic efficiency of legume species. As a result, it is very important to use native species of the areas that are to be recovered as an alternative to maintain the original structure of the ecosystem (Kageyama *et al*., 1989). However, for the efficient establishment of the species, it is necessary to use control methods combined with exploratory studies on the morphological characteristics of these species (nodular roots, foliar system, etc.), in order to obtain satisfactory results in the recovery of the areas.

The native species with biological nitrogen fixation capacity (BNF) deserve attention. According to Nogueira *et al.* (2012), this speciality of the legume plants in relation to other plants, provides the association with soil microorganisms and, as a result, to transform the nitrogen of the air into nitrogenous compounds, assimilable by the plant species, being able to make the plant partially or completely independent of the external supply of this nutrient. It is an ability that has proved to be indispensable for the sustainability of Brazilian agriculture, due to the nitrogen supply to the crops with low economic cost and low environmental impact (Hungria *et al*., 2007). The FBN is characterized as an environmental practice that contributes to the recovery of degraded soils, and plants are able to effectively promote the recycling of nutrients (Franco and Campelo, 2005). Therefore, BNF-potential legumes and recovery of soil fertility act as an ecological alternative to the supply, substitution or complementation of nitrogenous mineral fertilization (Scivittaro *et al*., 2000).

In the areas under arenization process, there are several factors that intensify erosion processes, such as the fragility of sandy soils composition, slope and inadequate management (Rovedder *et al*., 2005; Binda and Verdum, 2015). The high intensity of the wind and water erosion processes causes re-balancing of the sandstone sediments and the exposure of these soils, making it difficult the establishment of plant species (Suertegaray *et al*., 2001). As a consequence, when the ecological integrity of an ecosystem is reduced, that is, in its efficiency of conserving the evolutionary potential for a longer period, soon its capacity to resist impacts will be lower (Rovedder *et al*., 2009). Each community of an ecological system will respond unequally to disturbances, particularly in relation to sensitivity, response and recovery (Pinheiro, 2004). Undoubtedly, areas under arenization are vulnerable to degradation processes, since according to Hendrix *et al*. (1990) and Entry *et al.* (2002), the absence of native vegetation in the ecosystem alters the composition of the environment and the fundamental components for soil quality security such as its structure, organic matter, fertility and the microbial community.

Hence, the use of conservation or recovery methods, especially those of low cost and easy applicability, should be prioritized in the management of these soils (Rovedder and Eltz, 2008b). In addition, it is necessary to study native species with high rusticity and soil protection qualities, in order to mitigate the effect of erosive agents in areas under arenization. In addition, it is possible to reduce the erosion losses and to reduce water losses, minimizing evaporation and surface runoff (Nogueira *et al.*, 2012). In addition, species with biological nitrogen fixation characteristics, by means of symbiotic processes (Rovedder, 2007), are able to supply the need for mineral fertilization. Thus, *L. albescens* is a native species that exhibits the characteristics of rusticity previously mentioned, in addition to naturally colonizing the sandstones soils, and therefore has advantages over a large number of species. In view of this, it becomes an alternative cover plan to act in the protection of the sandstones soils of the southwest region of the state of Rio Grande do Sul.

Thus, in the synthesis, the presence of native vegetation is of extreme importance for the recomposition of areas under arenization, maintaining the soil protected against the effects of erosive effects (Okin *et al*., 2001), where legume species, especially *L. albescens*, and some grasses should be highlighted.

CONCLUSION

The species of *Lupinus albescens* is promising for the consortium with *Butia lallemantii* in sandstones soils due to its high emergence of plants in the first 30 days. In addition, the species presented higher growth in height when allied to *B. lallemantii* plants of intermediate diameter, and there was no need for the application of NPK mineral fertilization.

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