



## Dissimilarity between *Andropogon lateralis* ecotypes under different defoliation frequencies and heights

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**ABSTRACT:** *Andropogon lateralis* Nees is a native grass of southern Brazil and is one of the most frequent species found in native grasslands. The species is widely distributed and has a high degree of phenotypic plasticity, which makes it highly adaptable to different edaphoclimatic conditions and management. This study aimed to evaluate the behavior of twelve ecotypes of *A. lateralis*, collected in different regions of the state of Rio Grande do Sul and cut to three different heights and subjected to two different defoliation frequencies. From September to February, the ecotypes were evaluated for total dry matter, leaf and stem yields. In addition, total, vegetative and reproductive tillers and plant height were measured. These characteristics are important for the selection of superior genotypes in terms of genetic variability and forage production. Total dry matter and leaf dry matter are characteristics with agronomic importance and they showed the highest correlation ( $r = 0.77$ ), enabling an indirect selection for one of these characteristics. The natural selection of plants resulted in distinct structural, morphological and productive characteristics with heterogeneity that allows the selection and grouping according to the characteristics, ecotypes with superior agronomic characteristics can be included in breeding programs.

**Key words:** agronomic characteristics, correlation, cut management, native grass.

## Dissimilaridade entre ecótipos de *Andropogon lateralis* submetidos a diferentes frequências de desfolha e alturas de corte

**RESUMO:** *Andropogon lateralis* Nees é uma gramínea nativa do sul do Brasil e uma das espécies mais frequentes na flora dos campos nativos da região. Possui ampla distribuição e alto grau de plasticidade fenotípica, tornando-o adaptável as condições edafoclimáticas e a práticas de desfolha. Este estudo teve como objetivo avaliar a dissimilaridade entre doze ecótipos de *A. lateralis* N., coletados em diferentes regiões do Rio Grande do Sul, submetidos a duas frequências de desfolha e três alturas de corte. No período de setembro a fevereiro, os ecótipos foram avaliados quanto à produção de matéria seca total, de lâminas foliares e de colmo. Além disso, foram medidos o número de perfilhos totais, vegetativos e reprodutivos e a altura das plantas. Essas características são importantes para a seleção de genótipos superiores em termos de variabilidade genética e produção de forragem. A matéria seca total e a matéria seca foliar são características com importância agrônoma e apresentaram a maior correlação ( $r = 0,77$ ), possibilitando uma seleção indireta para uma dessas características. A seleção natural das plantas resultou em características estruturais, morfológicas e produtivas distintas com uma heterogeneidade que permite a seleção e agrupamento de acordo com as características, ecótipos com características agrônomicas superiores podem ser incluídos em programas de melhoramento.

**Palavras-chave:** caracteres agrônomicos, correlação, gramínea nativa, práticas de desfolha.

## INTRODUCTION

The flora of native grasslands in Southern Brazil includes several species with good forage characteristics from the >400 grasses and 150 legumes currently identified (BOLDRINI, 1997). Several of these species have a high number of regional ecotypes which have adapted to the local edaphoclimatic conditions, which represents a unique source of forage germoplasm, but there have been few studies which describe the uses

and potential of these plants for forage production (STEINER et al., 2017; SARAIVA et al., 2021).

Native grasslands are an important food source for herbivores, with the area occupied by non-forest ecosystems accounting for ~30% of the country's total area (OVERBECK et al., 2015). However, over the last five decades these areas have been replaced by crops, forestry, cities and urban spread or exotic forage. Native grasslands have not been considered a conservation priority in southern Brazil, despite losing >50% of the original

area, high natural biodiversity (flora and fauna) and the important ecosystem services they contribute (MENEZES et al., 2015). Poor management has decimated this habitat but, when managed with optimal stocking rates combined with appropriate grazing management, this critically important natural resource presents favorable economical results to producers and preserves existing biodiversity for future generations.

*Andropogon lateralis* Nees is one of the most frequent native species found in native grasslands in the state of Rio Grande do Sul (RS/Brazil) and is important due to its wide ecophysiological distribution (ANDRADE et al., 2016). It is a perennial, tussock-type grass and most dry matter production occurs in spring and summer (ANDRADE et al., 2019). It is characterized as a species with substantial phenotypic plasticity when exposed to abiotic factors (such as drought, frost, etc.) and those imposed by management (fire, grazing, mowing), which result in different defoliation intensities and frequencies. Physiological differences among ecotypes include changing the growth habits, the proportion of leaves, stems and nutritional quality (BOLDRINI, 1997; TRINDADE & ROCHA, 2001).

Identifying the optimum defoliation regime will optimize management and utilization, with canopy structures that allow rapid regrowth extremely important. The canopy structure should allow animals to ingest material with high contribution of young palatable leaves and stems, and management decisions which result in senescence and stem elongation should be minimized (PRADO et al., 2019). However, there is still little research for most native species. Furthermore, there are presently no cultivars of *A. lateralis* N. commercially available and studies that evaluate the variability among ecotypes can contribute to identifying superior plants for selection and inclusion in breeding programs. Selection due to natural variability of materials has been one of the main methods of cultivar development for native forages in Brazil (DO VALLE et al., 2009) and globally.

This study aimed to evaluate the dissimilarity between ecotypes of *A. lateralis* N., collected in different regions of Rio Grande do Sul/Brazil, at two defoliation frequencies and three cutting heights to simulate different defoliation intensities. The morphophysiological responses of the ecotypes were evaluated in order to understand plant growth enabling better management of this species and identify promising genetic material for use in breeding programs for forage production.

## MATERIALS AND METHODS

The experiment was conducted at the Department of Forage Plants and Agrometeorology in the Agronomics School of the Federal University of Rio Grande do Sul. Ecotypes were collected in different physiographic regions of the state of Rio Grande do Sul. A total of 12 ecotypes were collected from Alegrete, Bagé, Caçapava do Sul, Capivari do Sul, Eldorado do Sul, Mariana Pimentel, Montenegro, Passo Fundo, Pelotas, Piratini, Soledade and Tapes.

The plants were kept in a greenhouse during the autumn and winter and in spring were transplanted into 2.8 L pots (22 cm high x 22 cm diameter) and transferred outside the greenhouse. A commercial substrate was used. On September 15<sup>th</sup> 5.0 g N-P-K (05:20:20) fertilizer was applied with an additional 5.0 g of urea (45% N) applied per pot on September 28<sup>th</sup>. The evaluations were carried out during one period active of growth (which encompassed spring, summer and autumn). Pots were irrigated until soil saturation every seven days without precipitation.

A completely randomized factorial design was used with 72 treatments: twelve ecotypes, three defoliation heights (H=6 cm, 12 cm or 18 cm residuals) and two defoliation frequencies (F) (3 weeks or 6 weeks), with four replicates. The ecotypes were named by defoliation frequency (3 or 6 weeks), defoliation cutting height (6, 12 or 18 cm) and the location the ecotype came from. Seedlings with the same number of tillers were used. Initially, plants were cut to a standardized height, the evaluations started when the plants were ~25 cm high. Subsequent cuts were in accordance with the pre-established defoliation frequencies (3 or 6 weeks). At each evaluation, the number of vegetative and reproductive tillers of each plant were counted. Reproductive tillers were those where there was already differentiation that demonstrated the flowering induction of that stem. The plant height was measured with a graduated scale, from the soil surface to the extremity of the highest leaf of the plant. The experiment was concluded when there was a reduction in plant growth, possibly due to a reduction in photoperiod and temperature.

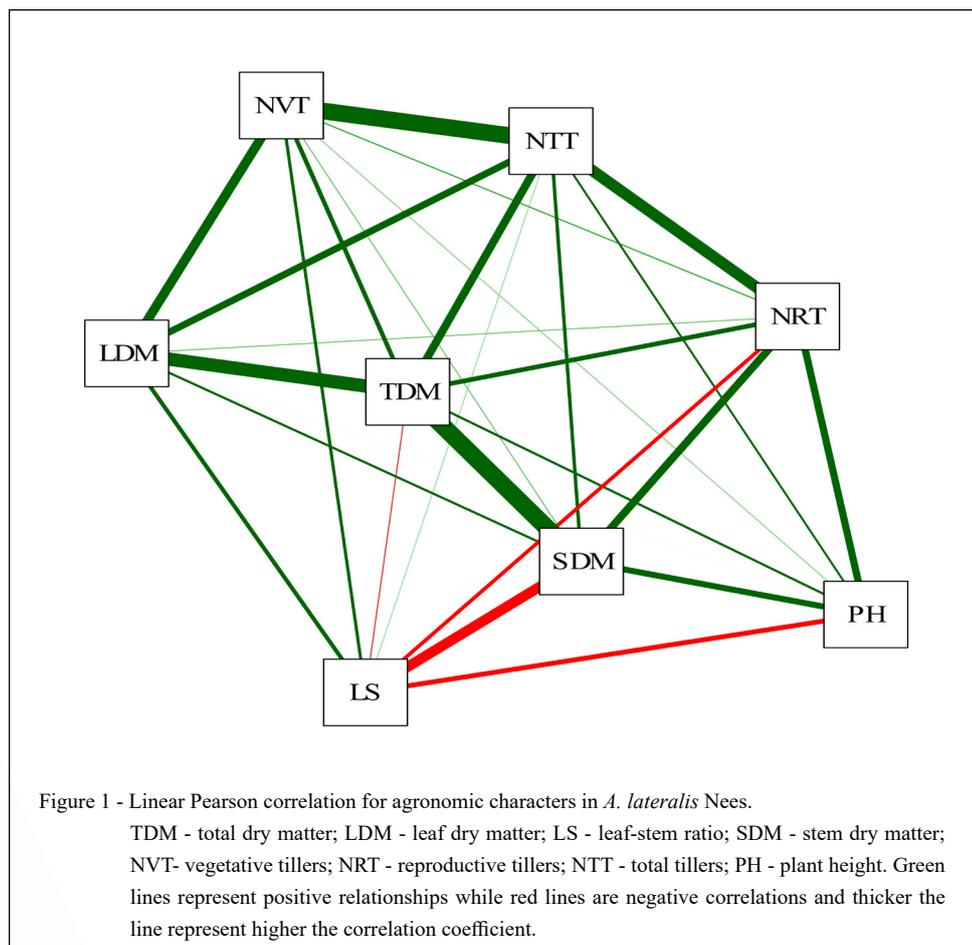
After cutting, samples were morphologically separated into leaf blades, stems and dead material, then placed in a forced air circulation chamber at 65 °C until constant weight. Variables quantified were accumulated total dry mass (TDM, grams plant<sup>-1</sup>), both for the accumulated forage above the cutting height, accumulated leaf blades dry matter (LDM, g plant<sup>-1</sup>), accumulated stem dry matter (SDM, g plant<sup>-1</sup>), total number of vegetative tillers (NVT),

total number of reproductive tillers (NRT), number total of tillers (NTT) and plant height (PH, cm). The leaf:stem ratio (L:S) was obtained by dividing the dry leafmatter by stem dry matter. The data were submitted to Pearson's correlation analysis. The magnitudes of correlation coefficients were classified according to SILVEIRA et al. (2020). The cluster analysis used to assess genetic dissimilarity between treatments was performed using the Tocher optimization method based on the generalized Mahalanobis distance ( $D^2$ ) using the statistical program GENES (CRUZ, 2016).

## RESULTS AND DISCUSSION

Knowledge of the factors that affect the productivity of pastures is essential to make the production system viable. In the present study, the phenotypic correlation was determined for the variables and is presented through a correlation network (Figure 1). The correlation coefficients ranged from 0.26 (NVT and NRT) to 0.85 (TDM and SDM).

There were significant correlations and with different magnitudes of response between most of the variables studied. Specifically, TDM showed significant strong correlation with LDM and SDM, with correlation coefficients of  $r = 0.77$  ( $P \leq 0.01$ ) and  $0.85$  ( $P \leq 0.01$ ), respectively. The variables NTT, NRT, NVT and PH also showed significant mean correlations ( $r = 0.53$  ( $P \leq 0.01$ );  $0.45$  ( $P \leq 0.01$ );  $0.40$  ( $P \leq 0.01$ ) and  $0.35$  ( $P \leq 0.01$ ), respectively) with TDM. Both TDM and LDM are the characteristics of greatest agronomic importance, as they are related to the production of forage accumulated in the experimental period and contribute to the quality of forage on offer to grazing stock. The selection to increase the production of leaf blades has been strongly advocated in the improvement of forages (WEILER et al., 2018), as the best nutritional quality is found in the green leaf blade and animals have a preference for this structure during grazing (SOLLENBERGER & BURNS, 2001). In this study, the high correlation ( $r = 0.77$ ), observed between these characteristics is positive,



because when selecting one of these resources, the other is also indirectly being favored.

LDM showed a significant correlation with the variables NVT, NTT, LS and SDM, with correlation coefficients of  $r = 0.57$  ( $P \leq 0.01$ ),  $0.52$  ( $P \leq 0.01$ ),  $0.39$  ( $P \leq 0.01$ ) and  $0.34$  ( $P \leq 0.01$ ), respectively (Figure 1). For each leaf blade formed there is a new phytomer and buds that will be responsible for the origin of new tillers when they receive light stimuli (CUTRIM et al., 2013). Thus, the median correlation observed between LDM, NVT and NTT, may infer that the defoliation management practices tested favored the renewal of plant tissues. In addition, the number of tillers is an agronomic indicator of growth, productivity and pasture persistence (SCHENEITER & ASSUERO, 2010). However, selection for tillering in plant breeding has been questioned as a selection criterion for all species (FASOULA et al., 2020), due to the complexity of genetic control and also due to the differential response to edaphoclimatic conditions and management systems (CORROCHANO-MONSALVE et al., 2020).

As the ecotypes originated from different regions and microclimates, natural selection had resulted in different structural, morphological and productive characteristics and, consequently, heterogeneity. For breeding purposes this allows the selection, differentiation and grouping of treatments according to their characteristics, allowing ecotypes with superior agronomic characteristics. The

cluster analysis methodology optimized by the Tocher (Table 1) showed three groups, with a high concentration of accessions in group I (91.7%). This type of distribution shows a high similarity between the treatments studied (KAUR et al., 2018). The species has a wide distribution and a high degree of phenotypic plasticity, making it adaptable to edaphoclimatic conditions and defoliation practices (TRINDADE & ROCHA, 2001; MACHADO et al., 2013). The effect of phenotypic plasticity found in *A. lateralis* may have contributed to the high similarity between the treatments tested. The presence of plasticity was evident in this study. Specifically, under different management it can behave as a plant of resource capture or conservation according to the defoliation intensity imposed.

The low dissimilarity between the ecotypes indicates that the genetic progress of breeding with the selected quantitative characteristics can be limited. Despite the similarity between the treatments, considering the composition of the groups (Table 1), the Mahalanobis distance matrix ( $D^2$ ) showed high amplitude, and ranged from 0.01 to 3017. Treatments 312Soledade and 612Soledade were the most similar ( $D^2 = 0.01$ ), while treatments 66Bagé and 618Mariana Pimentel were the most distant ( $D^2 = 3017$ ). The presence of variability allows the use of this germplasm in breeding programs for *A. lateralis* and ecotypes with greater distance can be used in future crosses (GUEDES et al., 2013).

Table 1 - Composition of groups formed by the Tocher optimization method based on the Mahalanobis distance matrix ( $D^2$ ) in *A. lateralis* Nees. Treatments are specified by defoliation frequency (3 or 6 weeks), defoliation cutting height (6, 12 or 18 cm) and the location the ecotype came from.

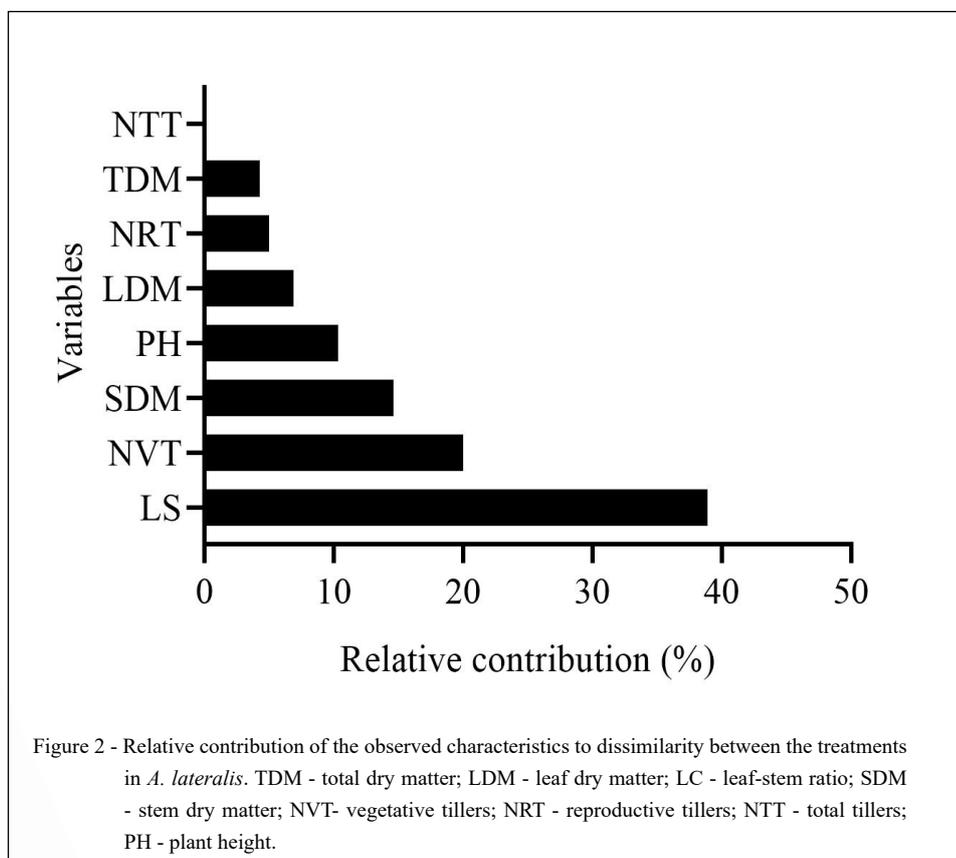
| Group | Treatments   |
|-------|--|
| I     | 312Soledade; 612Soledade; 612Capivari; 618Piratini; 618Capivari; 66Alegrete; 618Pelotas; 312Alegrete; 66Piratini; 318Tapes; 318Capivari; 318Alegrete; 612Alegrete; 612Montenegro; 312Capivari; 312Pelotas; 612Caçapava; 66Caçapava; 66Marianapim; 618Eldorado; 618Soledade; 312PassoFundo; 66Soledade; 612Eldorado; 318Caçapava; 618Marianapim; 36Tapes; 612Marianapim; 66Capivari; 312Piratini; 318PassoFundo; 318Marianapim; 318Montenegro; 618Montenegro; 312Montenegro; 36Soledade; 612Tapes; 612Piratini; 618Caçapava; 618Tapes; 36Eldorado; 66Montenegro; 318Soledade; 318Piratini; 36Montenegro; 36Pelotas; 66Eldorado; 318Eldorado; 36Marianapim; 36PassoFundo; 312Marianapim; 312Caçapava; 618Alegrete; 318Pelotas; 312Tapes; 36Capivari; 312Eldorado; 66PassoFundo; 36Alegrete; 36Piratini; 612Pelotas; 618PassoFundo; 36Caçapava; 66Tapes; 612Bagé; 66Pelotas |
| II    | 36Bagé; 318Bagé; 312Bagé; 612PassoFundo; 618Bagé   |
| III   | 66Bagé   |

Significance levels are: \* =  $P \leq 0.05$  \*\* =  $P \leq 0.01$  from t-tests; TDM - total dry matter; LDM - leaf dry matter; LC - leaf-stem ratio; SDM - stem dry matter; NVT - vegetative tillers; NRT - reproductive tillers; NTT - total tillers; PH - plant height.

The accumulation of dry matter is linked to defoliation practices, specifically the frequency and intensity with which these events occur (LEMAIRE et al., 2009). Thus, the structural components of the plant can be used as objective measures in the processes of harvesting and using the forage produced (GRIFFITHS et al., 2003). The variables with the greatest relative contribution to genetic dissimilarity (Figure 2) are allocated to Group III (Table 1). In this analysis, 66Bagé presented higher mean LS and NVT, and a lower mean for SDM and PH, in relation to treatments allocated to Groups I and II. The lower plant height favored desired structural characteristics. This was confirmed by the negative correlations obtained between PH and LS and positive correlations between PH and SDM (Figure 1). Group III concentrated 1.38% of each combination between the factors (frequency, height and ecotype). Group I (Table 1), on the other hand, had lower LS and NVT compared to the other groups (II and III) and higher SDM and PH. Therefore, the highest residual cutting heights had a negative impact on the performance of the treatments assigned to Group I. The highest

SDM characterized the structure of the plants that make up the treatments of Group 1 which have the lowest nutritional value (STOBBS, 1973). Group I concentrated 15.3% of each combination between the factors (frequency, height and ecotype). For the four variables with the greatest relative contribution (Figure 2), Group II presented intermediate values compared with Groups I and III (Table 1). Group II concentrated 6.94% of each combination between the factors (frequency, height and ecotype).

Morphological characteristics are commonly used to assess dissimilarity between ecotypes. These variables are commonly quantified in germplasm evaluations and characterization, and can be related to adaptability, stability and productive potential of the species/ecotype being evaluated (GRAMINHO et al., 2017; STRECK et al., 2017). In our study, the variables that most contributed to genetic dissimilarity were LS, NVT, SDM and PH, which accounted for 83.8% of the dissimilarity between the treatments imposed. Singh (1981) also indicated the importance of identifying the characteristic(s) responsible for the majority



of dissimilarity and it is efficient in pointing out the variables of possible disposal. In this work, NRT and NTT could be considered less important selection criteria, as they contributed only 4.26% to dissimilarity (Figure 2). The selection of genotypes for breeding based only on genetic divergence, without considering characteristics of interest, can be an inefficient strategy in a breeding program (CARPENTIERI-PÍPOLO et al., 2000). This work identifies characteristics of interest and assigned ecotypes to groups to aid breeding programs in identifying material with dissimilar traits.

## CONCLUSION

In this study we evaluated important characteristics for the selection of superior ecotypes in terms of genetic variability and forage production for *Andropogon lateralis*. Total dry matter and leaf dry matter were the main characteristics with agronomic importance and had the highest correlation, enabling an indirect selection for one of these characteristics.

Natural selection of plants within defined ecophysiological environments has created ecotypes with distinct structural, morphological and productive characteristics with a heterogeneity which can be selected and grouped allowing ecotypes with superior agronomic characteristics to be included in breeding programs.

## ACKNOWLEDGEMENTS

We thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Brazil – Fiance code 132455/2010-2.

## DECLARATION OF CONFLICT OF INTEREST

We have no conflict of interest to declare.

## AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

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