

SCIENTIFIC ARTICLE

Characterization of the potential of native grasses for use as lawns

Francisco Humberto Dübbern de Souza¹, Marcos Rafael Gusmão^{1*},
Marcelo Mattos Cavallari¹, Waldomiro Barioni Jr¹

Abstract

Since long lawns have been cultivated worldwide to perform a large variety of functions. Brazilian lawns have been constituted by a reduced number of species and cultivars. This work was developed with the purpose of estimating the potential of use as lawns presented by the members of a collection of accesses of native species of *Paspalum* and *Axonopus* (*Poaceae*). The following characteristics were evaluated: maximum vertical growth height, speed of soil cover, speed of regrowth, dry mass production, ornamental quality, weed encroachment and demand for mowing. Several accessions presented desirable characteristics and can therefore be included in programs aiming the development of cultivars for lawns intended for use in a variety of situations. The results here reported and discussed represent an experimental verification of the potential of the Brazilian flora to offer plants for use as lawns, reinforce the importance of native genetic resources and contribute to the continuity of research aimed at the development of this type of cultivars in Brazil.

Keywords: *Paspalum*, *Axonopus*, *Poaceae*, genetic resources, landscaping, turfgrass.

Resumo

Caracterização do potencial de gramíneas nativas para uso como gramados

Desde há muito gramados têm sido cultivados em todo o mundo para o desempenho de grande número de funções. Os gramados brasileiros têm sido constituídos por um número reduzido de espécies e de cultivares. Este trabalho foi desenvolvido com o objetivo de estimar potencial de uso como gramados apresentados pelos membros de uma coleção de acessos de espécies nativas de *Paspalum* e de *Axonopus* (*Poaceae*). As seguintes características foram avaliadas: altura máxima de crescimento vertical, velocidade de cobertura do solo, velocidade de rebrote, produção de massa seca, qualidade ornamental, resistência à invasão de plantas daninhas e demanda por podas. Vários acessos apresentaram características básicas desejáveis e podem, portanto, ser incluídos em diferentes programas de desenvolvimento de cultivares destinadas a ampla variedade de usos como gramados. Os resultados apresentados e discutidos nesse trabalho representam uma constatação experimental do potencial da flora brasileira em oferecer plantas para uso como gramados reforçam a importância dos recursos genéticos nativos e contribuem à continuidade das pesquisas voltadas ao desenvolvimento deste tipo de cultivares no Brasil.

Palavras-chave: *Paspalum*, *Axonopus*, *Poaceae*, recursos genéticos, paisagismo, grama.

Introduction

Lawns are fundamental components of anthropic landscapes almost everywhere in the world. Its cultivation has ornamental, anti-erosive, landscaping, sportive, recreational or multiple purposes. Concomitantly they play important environmental roles such as the attenuation of temperature and of the effects of various types of environmental pollution in urban areas, besides carbon sequestration and facilitation of soil water infiltration (Stier et al., 2013). In Brazil the plants most used for this purpose are perennial species of the *Poaceae* Family, popularly

known as “gramas”. These plants are characterized by the low growth habit and the ability to promote ample and permanent coverage of soil surfaces, resulted from its stoloniferous and/or rhizomatous growth habit. Besides these characteristics, however, for each situation of use the satisfactory performance of the lawn depends on specific sets of other morphological, physiological and agronomic characteristics. The degree of importance each set depends on the functions to be performed by the lawn (Souza et al., 2016).

There is ample justification for the development of new cultivars for lawn cultivation in Brazil since only a reduced

¹ Embrapa Pecuária Sudeste, São Carlos-SP, Brazil. *Corresponding author: marcos.gusmao@embrapa.br

number of species and cultivars is available for this purpose despite the wide diversity of its flora (ASSOCIAÇÃO NACIONAL GRAMA LEGAL, 2019). The cultivation of exotic species, mainly of *Zoysia japonica* (“Esmeralda grass”), predominates where medium to intensive lawn care is justifiable as in some types of garden. In the southeastern and central-western regions of Brazil, wherever the lawns are subject to variable or sporadic care (such as at highway and urban avenue or airport runways) a mixture of biotypes and ecotypes of *Paspalum notatum* var. *notatum* (a native species) collectively known as “grama-batatais” among other regional names, is the most popular lawn-grass. Most lawns formed by this grass results from the planting sod pieces hand-collected in areas of degraded pastures where it appears spontaneously as an invasive plant. This extractive system of exploitation supplies a large illegal trade and has resulted in significant negative environmental impact in the areas of collection (Arigoni, 2012).

Based on some characteristics of particular importance for this group of plants, this work aimed to characterize the potential for use as lawns presented by components of a collection of accesses of grass species natives to several Brazilian regions.

Material and Methods

The work was carried out at the headquarters of Embrapa Pecuária Sudeste, in São Carlos, São Paulo State, Brazil (lat. 21°57'42.25”S, long 47°50'32.63”W, altitud 855 m.a.s.l.), Brazil, from January/2011 to December/2012, in an area

of dystrophic red-dark latosol soil. Chemical analysis of soil samples (depth of 0 - 20 cm) of the experimental area, made before mechanical preparation and liming (2 t ha⁻¹), revealed the following values: pH 5.6, organic matter 28 g dm⁻³, P (resin) 8 mg dm⁻³, K 0.9 mmol_c dm⁻³, Ca 20 mmol_c dm⁻³, Mg 9 mmol_c dm⁻³, CTC 61 mmol_c dm⁻³, V% 49 and 445, 476 and 79 g kg⁻¹ respectively, of sand, clay and silt.

The total rainfall volumes at the experimental site in 2011 (1,829 mm) and 2012 (1,839 mm) were identical (Figure 1), but exceeded by about 25% the historical annual average (1,362 mm) and differed between themselves in terms of seasonal distribution. In 2011 around 10% of the total volume fell in the coldest and driest months in the region (April - September), while 33% fell in the same period in 2012. The variation of the monthly averages of maximum and minimum temperatures obeyed the same pattern in both years, viz., sharp decreases occurred from April/May to June/July followed by gradual increase until the beginning of spring.

The evaluations included 34 accessions of grass species from different regions of Brazil (Table 1) selected from about 350 accessions components of the Banco Ativo de Germoplasma of *Paspalum* (which includes some accessions of *Axonopus spp.*) kept in field plots submitted infrequent irrigation and mowing in São Carlos, SP. Selection was based on two years of visual observations which included height and habit of growth, coloration, degree of ground cover and ornamental quality. The chosen ones presented either stoloniferous, rhizomatous or stoloniferous/rhizomatous growth habit, so that the ground cover they provided resulted predominantly from the horizontal growth of the plants.

Table 1. Native accesses of grass species evaluated for their potential use as lawns in São Carlos, SP, Brazil.

Acesso - nº	Espécie	Origem
1	<i>Paspalum notatum</i>	Bagé - RS
2	<i>Paspalum modestum</i>	Santana do Livramento - RS
3	<i>Paspalum notatum</i>	Uruguaiana - RS
4	<i>Paspalum lividum</i>	São Gabriel - RS
5	<i>Paspalum notatum</i>	Alegrete - RS
6	<i>Paspalum modestum</i>	Uruguaiana - RS
7	<i>Paspalum notatum</i>	Uruguaiana - RS
8	<i>Paspalum conjugatum</i>	Corumbá - MS
9	<i>Paspalum indecorum</i>	Santo Antonio das Missões - RS
10	<i>Paspalum lividum</i>	Lajes - SC
11	<i>Paspalum vaginatum</i>	Laguna - SC
12	<i>Paspalum notatum</i>	Laguna - SC
13	<i>Paspalum notatum</i>	Macapá - AP
14	<i>Paspalum subciliatum</i>	Felixlândia - MG
15	<i>Paspalum notatum</i>	São Carlos - SP
16	<i>Paspalum jesuiticum</i>	Juiz de Fora - MG
17	<i>Paspalum indecorum</i>	São Luiz Gonzaga - RS
18	<i>Paspalum indecorum</i>	Santo Antonio das Missões - RS
19	<i>Paspalum notatum</i>	Capivari do Sul - RS
20	<i>Paspalum notatum</i>	Capivari do Sul - RS
21	<i>Paspalum notatum</i>	Desconhecida
22	<i>Paspalum notatum</i>	Coronel Sapucaia - MS
23	<i>Paspalum notatum</i>	Japorã - MS
24	<i>Paspalum notatum</i>	Japorã - MS
25	<i>Paspalum leptum</i>	Dourados - MS
26	<i>Paspalum notatum</i>	Costa Rica - MS
27	<i>Paspalum notatum</i>	Candói - PR
28	<i>Axonopus parodii</i> [Valls; ined.]	Capivari do Sul - RS
29	<i>Paspalum notatum</i>	Capivari do Sul - RS
30	<i>Paspalum lividum</i>	Capivari do Sul - RS
31	<i>Paspalum lividum</i>	Tavares - RS
32	<i>Paspalum lividum</i>	Tavares - RS
33	<i>Axonopus fissifolius</i>	São Carlos - SP
34	<i>Paspalum notatum</i>	São Carlos - SP

In January 2011, sprigs composed of tillers, segments of stolons and/or rhizomes (depending on the access) presenting 3 - 5 vegetative buds were planted 15 cm apart in field plots measuring 3 x 2 m and irrigated by sprinkling. Thirty days later all plots received 200 kg ha⁻¹ of the 10-

10-10 granulated fertilizer as broadcast; in January/2012, another application of the same fertilizer (100 kg ha⁻¹) was made. The plots received 10 mm of irrigation water per week, except for the weeks in which rainfall occurred (Figure 1).

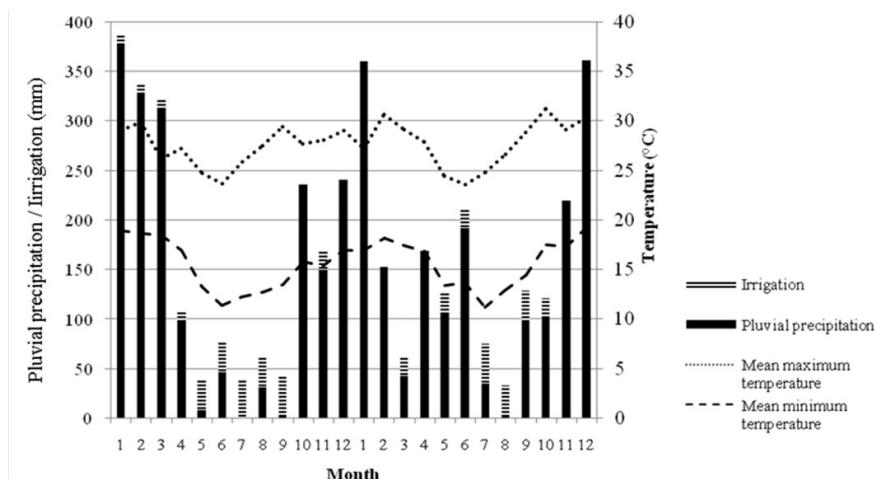


Figure 1. Cumulative monthly volumes (mm) of rainfall and irrigation water and monthly averages of minimum and maximum temperatures (°C) verified at the Embrapa Pecuaría Sudeste headquarters in São Carlos, SP (Fazenda Canchim), Brazil, between January/2011 and December/2012.

After planting the percentage of ground cover resulted from the horizontal growth of the planted sprigs was weekly estimated based on a visual scale ranging from 1 (absence of coverage) to 5 (total plot surface coverage). These data (not shown) were used to identify the occasion of total plot surface coverage, at which time they were submitted to a uniformization mow at 5 cm above soil level with a motorized mower equipped with a 50 cm cutting blade and a clipping (i.e, vegetal residues resulted from the mowing) collecting basket. From then on subsequent mowings (named “routine mowings”), were carried out on a fixed day of the week on plots whose

plants surpassed 7.5 cm height. The mowings were restricted to 2/3 (2 x 2 m) of the total area of each plot; this area was denominated “mowed fraction” (Figure 2). Clippings resulted from a 0.75 m² subarea localized in the center of this mowed fraction were collected, dried at 60 °C for 72 hours, weighed and discarded. The remaining area of the plot (1 x 2 m) was kept unmowed (“unmowed fraction”) for the purpose of the complementary evaluations described below. This fraction, however, was mowed in the first week of January/2012 in preparation for the evaluation of dry matter accumulated by the plants after 12 months of free growth.



Figure 2. General view of the experiment showing in the foreground one of the experimental plots composed of the unmowed and the mowed fractions of one of the accesses of native grass evaluated regarding their potential of use as lawns. April/2012.

The data collected before the first routine mowing were: time to total soil coverage (described by the number of days between planting and uniformization cut), regrowth period (evaluated by the number of days between the uniformization cut and the first routine mowing). The number of routine mowings was registered and the accumulated clipping dry mass (g m^{-2}) determined. On the unmowed fraction plant height was measured in the 12th month after the planting; inflorescences were removed on this occasion. Also in this occasion weed plants present in two subsamples of 0.25 m^2 of both fractions were cut at the soil level, classified by type (dicotyledonous, monocotyledonous), dried at 70 °C for 72 h, weighed and discarded; the dry mass of the access plants was evaluated in the same way and it the same occasion. The ornamental quality of the accesses was estimated in October/01/2012, coinciding with the beginning of recovery of the plants from the seasonal dry period, and again in December/20/2012 within a period of full vegetative development. The estimative was made by two independent evaluators with the aid of an arbitrary visual scale (index) ranging from 1 (very low quality) to 5 (excellent quality) one week after mowing; a mean was calculated from the data collected by the two evaluators.

The statistical design adopted was randomized blocks, with four replicates of each treatment (access); multiple

comparisons between means were made with the Tukey test. For this, the ANOVA, the regression and the correlation analyses, procedures of SAS®, version 8.0 (SAS Institute, Inc., Cary, N, USA) were used.

Results and Discussion

Accesses numbers 2, 6 (both *P. modestum*), 11 (*P. vaginatum*), 9 and 17 (both *P. indecorum*) did achieve plot surface coverage but did not survive the first experimental year, revealing their low potentials of use as lawns under the conditions to which they were submitted; for this reason their data were not considered in this report. All other accesses kept full coverage of the plots to the end of the evaluation period.

The average number of days elapsed between planting and the first routine mowing was (plus or minus one standard deviation), 185 ± 13 , having ranged from 97 to 337 days (Figure 3). This period can be taken as indicative of demand for mowing; the longer the period, the lower the demand. But it can be better interpreted if divided into two consecutive phases, viz., the number of days between planting and the uniformization cut (done at the achievement of total plot surface coverage) and between that cut and the first routine mowing.

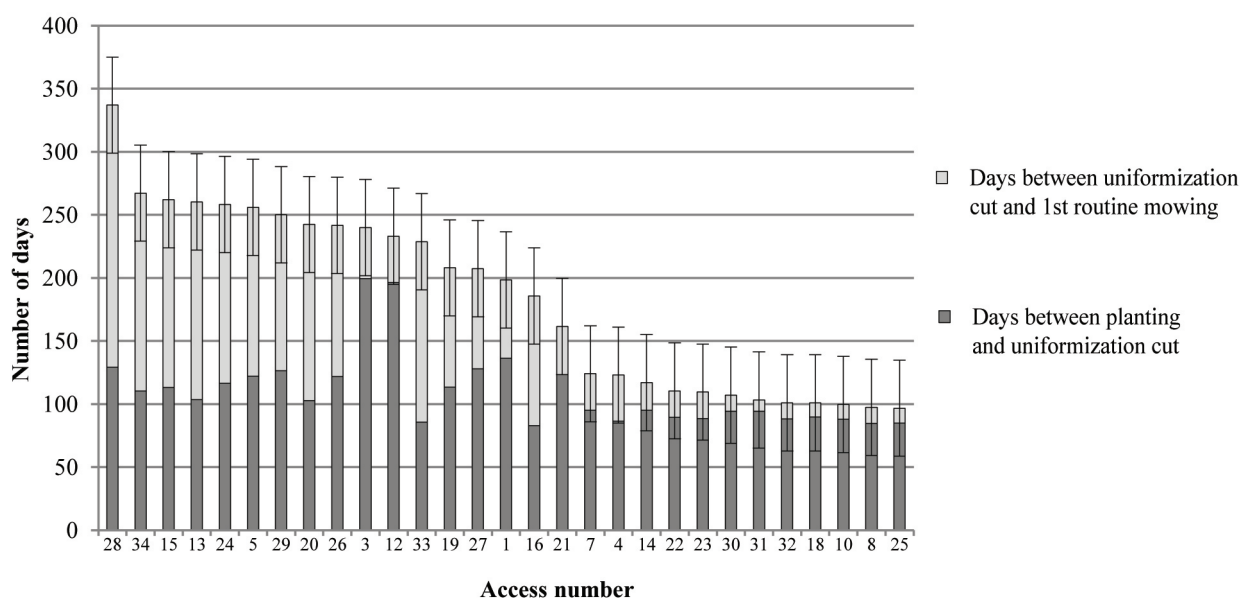


Figure 3. Number of days elapsed between planting and uniformization cut and between this cut and the first routine mowing performed in native grass accesses with potential use as lawns, in São Carlos, SP, Brazil, in 2011. The vertical bar at the top of the columns indicates the Minimum Significant Difference ($p < 0.05$) among the accessions.

Accessions 3 and 12 (both *P. notatum*) were characterized by its slowness of growth ($p < 0.01$) after planting (200 and 197 days until cutting, respectively); the others, on average, reached this stage 111 ± 10 days while the fastest 10 accessions did so in less than 90 days

(Figure 3). However, in commercial crops the rate of ground cover can to some extent be accelerated by high seeding rates or short inter-space vegetative propagules planting, as well by specific fertilization regimes, irrigation and associations of these techniques. Size and vigor of

seed and of vegetative propagules may also influence this parameter; this hypothesis remains to be tested. Thus, depending on the purpose of the selection program, the genetically determined horizontal growth potential may not be and excludent trait.

Ground covering (resulted from the horizontal growth of the sprigs after planting) and period of regrowth (resulted from the vertical growth after the uniformization cut) were not associated traits ($r = 0.22$, $p > 0.05$). In fact, 18 of the accesses took longer to regrowth than to cover the plot area as shown in Figure 3. In the period between the uniformization cut and the first routine mowing, here taken as indicative of the speed of regrowth, access 28 distinguished itself by its slow growth (208 days) when compared with seven others which demanded the first mowing less than 20 days after the uniformization cut; the mean of all accesses was 74 ± 10 days. Provided the plants sustain total surface coverage, slow regrowth might be a trait of interest for lawns since this represents lesser demand for mowing.

Plant dry mass productions accumulated over 12 months in the unmowed fraction of the experimental plots are shown in Figure 4. The productions of 13 accesses were below average ($603 \pm 117 \text{ g m}^{-2}$). Plant dry mass production and height were associated traits, that is, the higher the plant, the greater was the dry mass production ($r^2 = 0.70$, $p < 0.0001$). The highest growth reached by the unmowed plants was approximately 50 cm and the lowest, 17 cm (Figure 5). The growth of 15 accessions was below average ($37 \pm 6 \text{ cm}$). Although markedly influenced by the environment, these genetically determined characteristics are of particular importance for plants to be used as lawns. The height of interest depends on the function to be performed by the lawn. For example: on Class A highways (double lane) the current Brazilian legislation allows a maximum height of 20 cm for the vegetation cover in the lane side strips (BRASIL, 2009); along airport taxiways and runways, the legislation determines the maintenance of vegetation at a height equal to or less than 15 cm (BRASIL, 2018). Therefore, the longer the plants remain within the desired height range, the lower will be the demand for mowing and, consequently, the lower the maintenance costs.

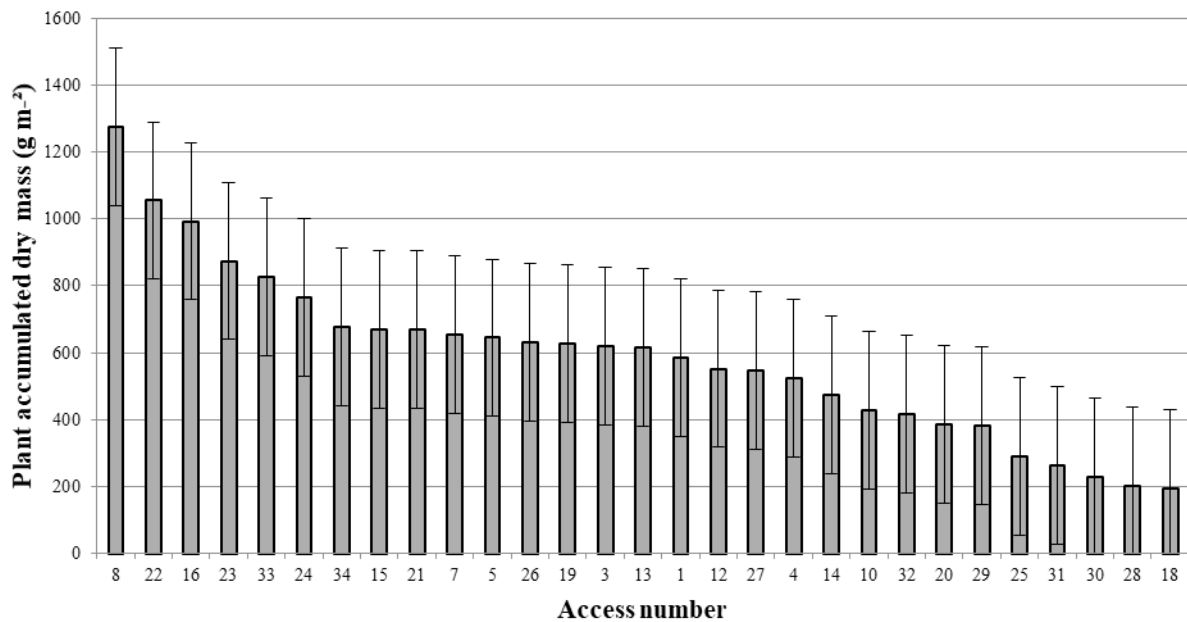


Figure 4. Dry mass (g m^{-2}) of native grass accesses with potential for use as lawns maintained under free growing conditions (unmowed) between January/2011 and December/2012, in São Carlos, SP, Brazil. The vertical bar at the top of the columns indicates the Minimum Significant Difference ($p < 0.05$) among the accesses.

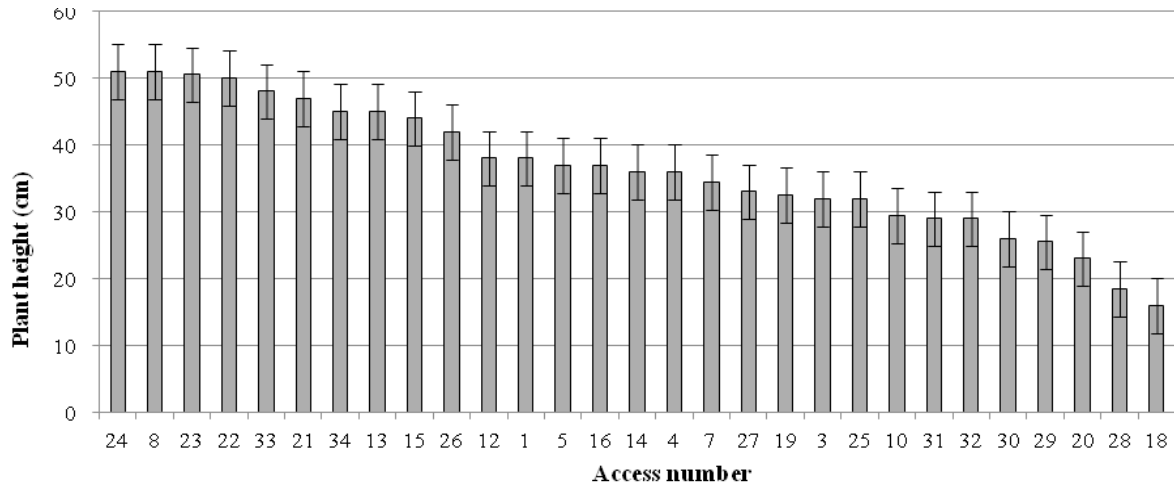


Figure 5. Plant height (cm) of native grasses accesses evaluated for potential use as lawns kept under free growing conditions for 12 months. São Carlos, SP, Brazil, December/2012. The vertical bar at the top of the columns indicates the Minimum Significant Difference ($p < 0.05$) among the accesses.

Mowing reduced weed encroachment (Figure 6) but within both experimental plots fractions no differences were found among accessions. Dicotyledonous weeds prevailed in both fractions ($p > 0,05$). An inverse correlation ($r^2 = -0.24$, $p < 0.0004$) was found between the dry mass accumulated by the accesses and by the weeds in the unmowed fractions. Thus, in the absence these plants, dry mass accumulated by at least some of the accessions may be higher than that observed in this work.

Moreover, mowing at heights greater than 5 cm may alter the competitive interactions among plant species and therefore, promote results different from those here reported. These hypotheses remain to be tested. Several agronomic techniques (*e.g.*, herbicide application) may attenuate weed problems, but the selection of accesses with certain traits, such as dense growth habit or allelopathic properties, may offer long-lasting, more economical and environmental-friendly solutions (Stier *et al.*, 2013).

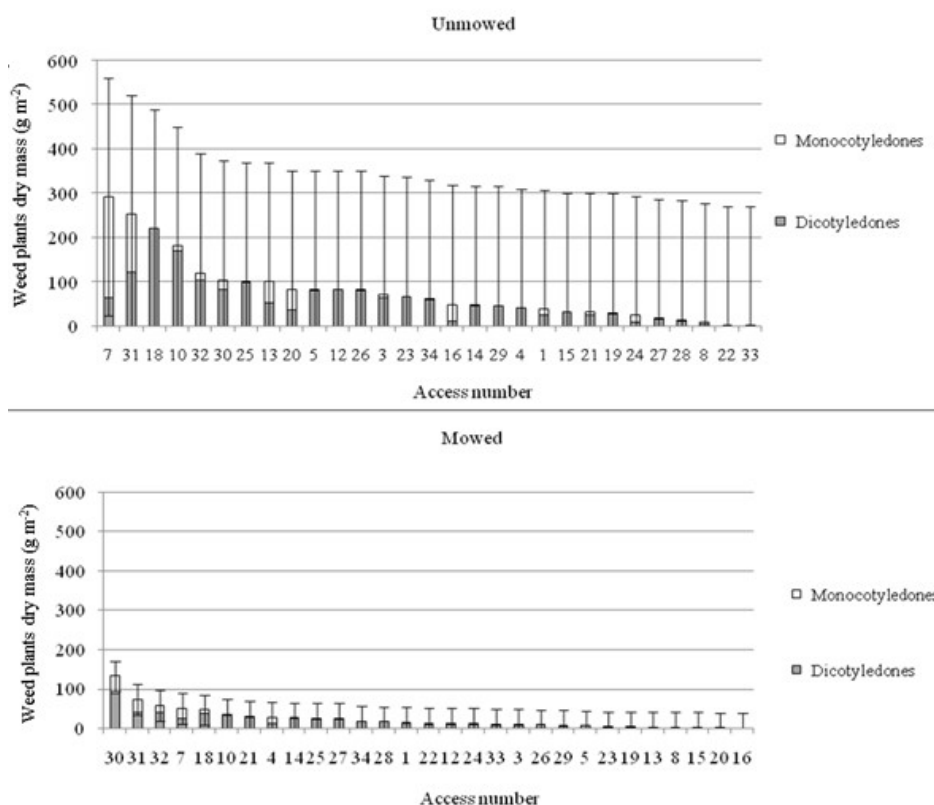


Figure 6. Dry mass (g m^{-2}) of monocotyledons and dicotyledons weed plants accumulated for 12 months in (a) unmowed and (b) frequently mowed fractions in plots of native grass accesses. December/2012, São Carlos, SP, Brazil. The vertical bar at the top of the columns indicates the Minimum Significant Difference ($p < 0.05$) among the accesses.

In the mowed fraction of the plots, the clipping dry mass accumulated during the experimental period varied from 215 g m^{-2} to 1973 g m^{-2} ; 13 accessions produced less than average ($1144 \pm 187 \text{ g m}^{-2}$) (Figure 7). With the exception of access 4 (*P. lividum*), clipping production in 2012 was higher ($p < 0.005$) possibly in consequence of the fact that 2011 included the plots establishment phase. Additionally, 2012 production was favored not only by the fact that the stands were already established but also by the greater distribution of rainfall verified that year as compared to the previous one (Figure 2). In this work, this trait was associated ($r^2 = 0.69$, $p < 0.001$) with the vertical growth of the accesses after 12 months of unrestricted growth; that is, those whose plants presented greater vertical growth were also more likely to produce greater amounts of clippings if subjected to mowing. High dry mass production by

lawns may be of interest in certain circumstances. When resulted from a high number of tillers and leaves, and not from vertical growth, this trait contributes to the increase of the lawn density (Morris, 2007). Dense lawns may inhibit weed encroachment and are particularly suitable for used as leisure and sports grounds (Carrow and Petrovic, 1992). This trait is, however, undesirable where mowing is scarce or infrequent, such as at railroad and highway margins, where it can increase fire hazards given the amount of fuel they may provide. Furthermore, in lawns maintained under intensive management as those with ornamental purposes, high clipping production may increase problems of disposal, of demand for mowing, and of soil nutrient replacement, increasing maintenance costs. Thus, the degree of importance of clipping production depends on the objective of the selection program.

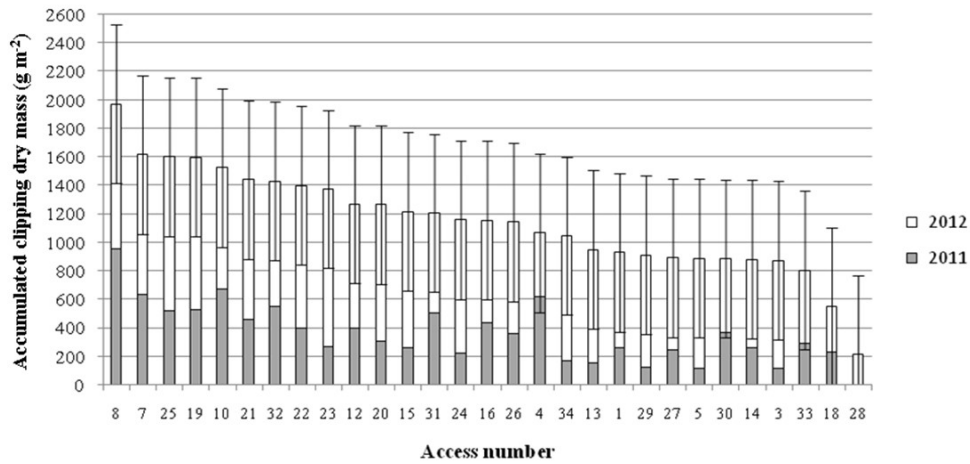


Figure 7. Accumulated clipping dry mass (g m^{-2}) from mowings at 5 cm of height of native grass accessions with potential for use as lawns, between January/2011 and December/2012, in São Carlos, SP, Brazil. The vertical bar at the top of the columns indicates the Minimum Significant Difference ($p < 0.05$) among the accesses.

In 2011 the average number of routine mowings was eight; notably, access 28 (*A. parodii*) demanded a single mowing that year. In 2012 the average was 18 (Figure 8). The lesser mowing requirement verified in 2011 is a consequence of the establishment period during which dry matter production by the accesses was generally smaller as compared with that observed in 2012 (Figure 7). Among all accesses, the total number of mowings in the two-year experimental period varied between 10 and 37; average was 26. The five accessions of *P. lividum* were included

in the group that required the greatest number. Among the 17 accessions of *P. notatum*, the species best represented in this study (Table 1), there was great variation ($p < 0.05$) in the number of mowings, reflecting the wide intraspecific genetic variability characteristic of this species (Cidade *et al.*, 2009). Accessions 18 (*P. indecorum*) and 28 (*A. parodii*) presented low requirements associated with low dry mass production, while the low requirement of access 33 (*A. fissifolius*) was probably due to the low vertical growth of plants under the prevailing experimental conditions.

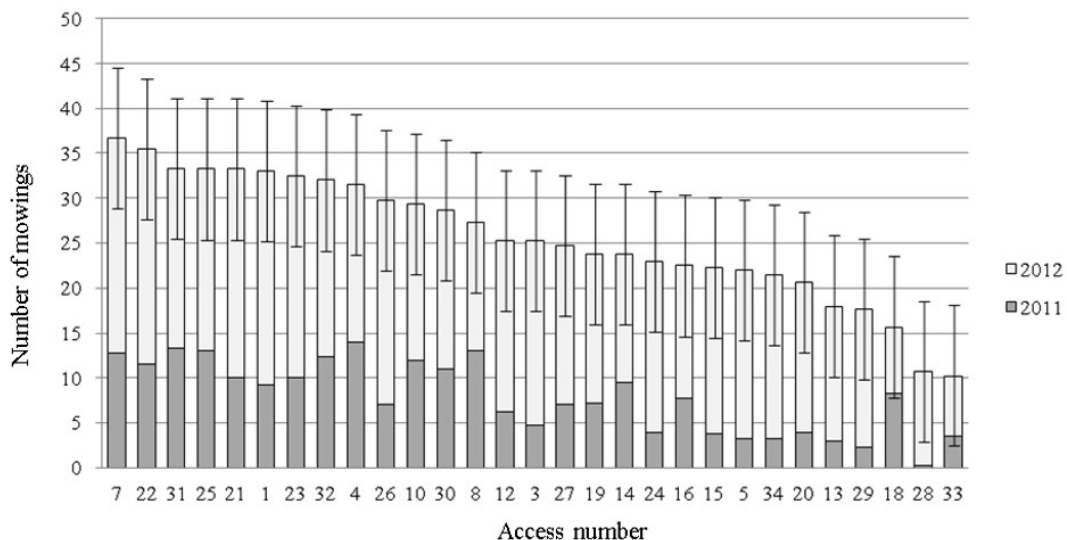


Figure 8. Number of mowings at 5 cm height carried out in plots covered by plants of native grass accessions between January/2011 and December/2012. São Carlos, SP, Brazil. The vertical bar at the top of the columns indicates the Minimum Significant Difference ($p < 0.05$) among the accesses.

The data showed that the higher the clipping dry mass production, the greater the number of mowings carried out in the plot ($r^2 = 0.35$; $p < 0.001$) but exceptions of interest were found (Figure 9). For example, in spite of having produced an amount of clipping similar to that produced by access 7, access 19 demanded fewer mowings (24 vs. 37). On the other hand, access 33 (*A. fissifolius*) demanded as many mowings (11) as access 28 (*A. parodii*) but produced four-fold as much clippings (Figure 10). This fact can be

explained by genotypic differences between the accessions, determinants of the dry mass allocation pattern among plant organs (roots, leaves, tillers, inflorescences, etc.). Such a pattern, however, may be altered by different mowing heights; in some accessions higher heights may reduce the contribution of lignified tissues such as stalks and stems to the clipping dry mass, altering the relation clipping production/mowing frequency. This hypothesis also is in need of testing.

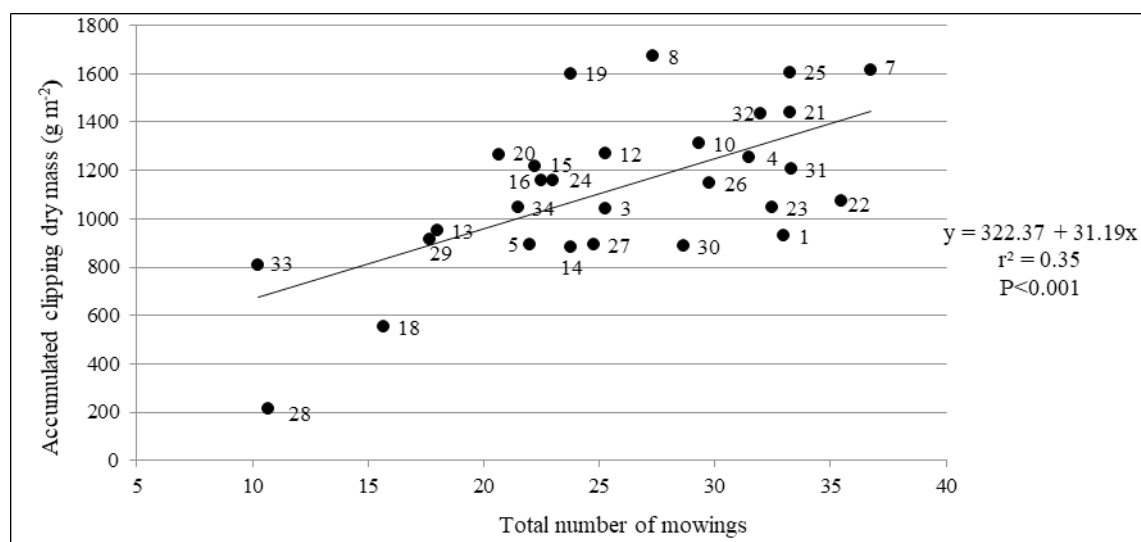


Figure 9. Relationship between accumulated clipping dry mass production (g m^{-2}) and total number of mowings made between January/2011 and December/2012 in plots covered by native grass accessions evaluated for potential use as lawns. São Carlos, SP, Brazil. Each dot is identified by its respective accession number.

High ornamental quality is a prerequisite for lawns intended for ornamental and landscaping functions. Visual estimation of this attribute is the consecrated method for its evaluation despite its potential inconsistencies (Bunderson et al., 2009). The average index of the two evaluations of the unmowed fraction (2.6 ± 0.4) was inferior to that of the mowed fraction (3.6 ± 0.4) (Figure 10). Mowing may have contributed to the higher quality index for having consistently eliminated inflorescences whose presence reduce ornamental quality (Zhang et al., 2007) and standardized the height of the plants. Accessions 27 (*P. notatum*) and 28 (*A. parodii*) stood out for having presented similar ornamental quality index for both fractions of the plots (mowed and unmowed). This characteristic may be

of special interest for use, for example, in areas where mowing predictably is to be scarce or infrequent. Overall, the accessions which presented above average quality when mowed also presented higher quality when unmowed ($r^2 = 0.72$, $p < 0.0001$). This can be taken as an indication of significant genetic effect. Ornamental quality results from the association of several characteristics of the plants, such as color, density, texture, and softness (Morris, 2007). All these traits are modulated by factors such as water and nutrient availability, photoperiod, temperature, light radiation, pests and disease attacks, besides management, hence the variations found among locations, regions and seasons (Johnson et al., 2003; Russi et al., 2004; Guertal and Frank, 2012).

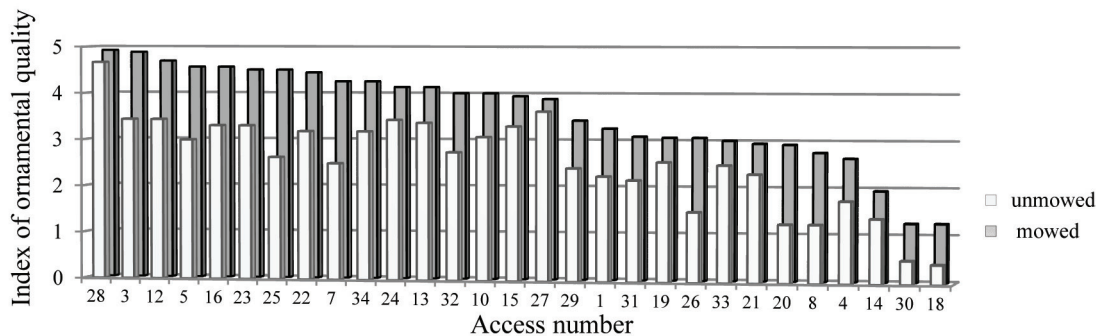


Figure 10. Visual indexes of ornamental quality (1 to 5) presented by native grass accesses with potential for use as lawns under mowed and unmowed conditions. Each bar represents the mean of visual estimations made in two occasions (October and December/2012). São Carlos, SP, Brazil.

In turfgrass selection programs it is necessary to assign a degree of relative importance to traits indicative of adaptation of the genotype to the desired conditions of use as lawn (Souza et al., 2016). The traits evaluated in this work, albeit important for a range of breeding programs, do not suffice to allow conclusive selection. To this aim, in subsequent stages, accessions eventually chosen among those here evaluated should be submitted also to other complementary evaluations, such as degrees of tolerance to shading, to frost, to salinity, to pests and diseases as well as others. Then the identification of genotypes presenting the greatest potential to meet specific environmental and management requirements should be possible for each region and functions to be performed by them when cultivated as lawns.

Conclusions

Based on several agronomic attributes of particular interest for genotypes intended for use as turfgrasses, a broad genetic variability was characterized among the components of a collection of Brazilian native accesses of grass species. The results here reported are valuable to the development of new cultivars of *Paspalum* and *Axonopus* for use as lawns. The degree of importance of each attribute evaluated in this work depends on the objectives of the program of development of turfgrass cultivars to which the accesses will eventually participate. Such a development inevitably requires submitting the chosen accesses to the evaluation of complementary attributes, specific to each situation of use anticipated for the cultivar. Additionally, the results highlight the potential of the Brazilian flora in providing genotypes valuable for use as tropical turfgrasses. Until presently, this fact had not been experimentally

characterized in Brazil where there prevails a scarcity of turfgrass cultivars notwithstanding the richness of its native flora. Also, this work reinforces the importance of native genetic resources, contributes to the continuity of research aimed at the development of this type of cultivars in Brazil for which there is a persistent demand.

Author Contribution

F.H.D.S. ⁰⁰⁰⁰⁻⁰⁰⁰²⁻⁵⁸³⁸⁻⁰⁰¹³: original conception of the work, composition of the text first draft; data analyses and interpretations; field evaluations. **M.R.G.** ⁰⁰⁰⁰⁻⁰⁰⁰³⁻⁴⁰⁵³⁻⁸⁹²⁴: data analyses and interpretations; field evaluations. **M.M.C.** ^{0000-0002-1446-328X}: data analyses and interpretations. **W.B.Jr.** ⁰⁰⁰⁰⁻⁰⁰⁰¹⁻⁵⁹⁷⁰⁻⁶⁵⁹¹: data analyses and interpretations; construction of graphics.

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