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Unusual chromosome numbers in *Paspalum* L. (Poaceae: Paniceae) from Brazil

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ABSTRACT. Somatic chromosome numbers were determined for 20 new germplasm accessions of *Paspalum*, belonging to 17 species collected in Brazil. Chromosome number is reported for the first time for *P. reduncum* (2n = 18), *P. cinerascens* (2n = 20), *P. cordatum* (2n = 20), *P. filgueirasii* (2n = 24), *P. ammodes* (2n = 36), *P. bicilium* (2n = 40), *P. heterotrichon* (2n = 40), and *P. burmanii* (2n = 48). New cytotypes were confirmed for two germplasm accessions of *P. carinatum* (2n = 30) and *P. trachycoleon* (2n = 36), one of *P. clavuliferum* (2n = 40) and one of *P. lanciflorum* (2n = 40), indicating variability in these species. The remaining chromosome numbers reported here confirm previous counts. The unexpected chromosome numbers 2n = 18, 24, 36, and 48 in *Paspalum* species, which are usually shown to be multiples of 10, suggest that much more collection and cytogenetic characterization are necessary to assess the whole chromosomal and genomic multiplicity present in the genus, which seems to be much more diverse than currently thought to be.

Key words: Cytogenetics; Cytotaxonomy; Polyploidy; Morphology

INTRODUCTION

With about 330 species (Zuloaga and Morrone, 2005), *Paspalum* is one of the richest genera of Poaceae. Species of *Paspalum* are largely responsible for the biodiversity of grassland ecosystems in South America, and several of them are valuable forage grasses (Bennett, 1962; Allem and Valls, 1987; Filgueiras, 1992). According to Bennett and Bashaw (1966), “every desirable characteristic of a forage plant can be found in some *Paspalum* species”. A copious literature on the cytogenetics of *Paspalum* and its relationship to ploidy levels, reproductive systems, natural hybridization, genomic associations, and anatomical adaptations has accumulated during the last decades (Burson, 1983; Espinoza and Quarín, 1997, 1998; Pozzobon and Valls, 2000; Daurelio et al., 2004; Machado et al., 2005; and references therein), regarding especially some polyploid hybrid complexes that include highly valuable forage species, as in the case of *P. dilatatum* Poir. Unfortunately, collections and data on genetics and reproduction from non-foraging species are far scarcer. Nevertheless, a comprehensive understanding of the genus as a whole and of the evolutionary relationships among their species requires new collections with an emphasis on underrepresented groups and particularly on the diploid species on which the several complexes are based.

With very few exceptions, base chromosome number of *Paspalum* species is known to be x = 10, which is a general feature of the entire clade to which *Paspalum* belongs (Giussani et al., 2001). The reproductive system of *Paspalum* is generally complex. Many *Paspalum* ‘species’ consist of sexual-diploid and apomictic-polyploid cytotypes, and several of them arose through hybridization (Quarín and Norrmann, 1990). Ploidy levels reported include 2x, 3x, 4x, 5x, 6x, 7x, 8x, 10x, and 12x, and species consisting only of sexual-diploid cytotypes are relatively uncommon. Apparently, sexual-diploids are distributed in rather restricted areas, as well as certain hybrid combinations (Quarín and Lombardo, 1986; Urbani et al., 2002; Daurelio et al., 2004). Moreover, groups previously thought of as rather simple autopolyploid assemblages have turned out to be complex interspecific hybrid groups (Vaio et al., 2005). Therefore, a thorough cytogenetic characterization of each new material is necessary, prior to including it in a breeding program.

In the last few years, new collections have been carried out in southern South America, which considerably expanded the number of known diploid species and/or cytotypes (Hojsgaard et al., 2005; Pozzobon et al., 2008). New chromosome counts reported in this paper, mainly corresponding to materials from Central Brazil, show several unusual chromosome numbers, not previously reported for the genus.

MATERIAL AND METHODS

All the accessions analyzed are part of the germplasm collection of *Paspalum* at EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária), Brasília, DF, Brazil. The collections were made by Gabriel H. Rua (GHR) in several locations in the Brazilian States of Espírito Santo, Bahia, Distrito Federal, Goiás, Minas Gerais, Paraná, and Tocantins (Table 1). Vouchers were deposited at CEN and BAA.

Somatic chromosome numbers were determined in root-tip cells, following the protocols of Pozzobon and Valls (1997), with minor modifications. At least five cells with good chromosome spreading and no overlapping were analyzed per plant. Semi-permanent slides were examined using a light microscope and recorded by photomicrography.

RESULTS

The chromosome numbers for 20 new germplasm accessions of *Paspalum*, belonging to 17 species, are listed in Table 1.

Table 1. *Paspalum* species and accessions analyzed, with somatic chromosome numbers and geographic origin.

Species	Accession	Origin	Latitude (S)	Longitude (W)
2n = 18				
*P. reduncum**	GHR 816	DF, Parque Nacional de Brasília	15°43'59''	47°56'12'
	GHR 822	DF, Parque Nacional de Brasília	15°43'59''	47°56'12'
2n = 20				
P. approximatum	GHR 667	TO, Mateiros	10°22'29''	46°36'28''
*P. cinerascens**	GHR 724	DF, Parque Nacional de Brasília	15°48'05''	47°47'20''
*P. cordatum**	GHR 750	PR, Balsa Nova	25°26'31''	49°44'50''
P. pumilum	GHR 716	ES, Conceição da Barra	18°35'17''	39°44'08''
2n = 24				
*P. filgueirasii**	GHR 619	GO, Alto Paraíso	14°09'39''	47°46'14''
2n = 30				
*P. carinatum***	GHR 773	BA, Formosa do Rio Preto	10°43'36''	46°12'48''
2n = 36				
*P. ammodes**	GHR 693	TO, Mateiros	10°21'16''	46°36'56''
	GHR 694	TO, Mateiros	10°21'16''	46°36'56''
*P. trachycoleon***	GHR 621	GO, Alto Paraíso	14°09'39''	47°46'14''
	GHR 634	GO, Niquelândia	14°20'22''	48°25'44''
2n = 40				
*P. bicilium**	GHR 645	DF, RA IV	15°34'39''	48°02'52''
*P. clavuliferum***	GHR 817	DF, Parque Nacional de Brasília	15°44'07''	47°55'37''
P. conjugatum	GHR 623	GO, Alto Paraíso	14°09'39''	47°46'14''
*P. heterotrichon**	GHR 644	GO, Alto Paraíso	14°09'39''	47°46'14''
*P. lanciflorum***	GHR 814	DF, Parque Nacional de Brasília	15°44'07''	47°55'37''
P. millegrana	GHR 713	ES, Guarapari	20°38'57''	40°28'44''
P. nutans	GHR 721	MG, Diamantina	18°14'21''	43°36'20''
2n = 48				
*P. burmanii**	GHR 635	GO, Niquelândia	14°20'36''	48°25'50''

*First chromosome number reported for the species.
**New chromosome number reported for the species.

From the 17 species studied, 12 showed chromosome number multiples of 10, as typical among *Paspalum* species. They include four diploids (2n = 20), one triploid (2n = 30), and seven tetraploids (2n = 40). The remaining five accessions were surprising, because of their unusual chromosome numbers: 2n = 18, 24, 36, and 48.

Chromosome numbers are reported for the first time for the following species: *P. reduncum* Ness (2n = 18), *P. cinerascens* (Döll) A.G. Burman and C.N. Bastos (2n = 20), *P. cordatum* Hack. (2n = 20), *P. filgueirasii* Morrone and Zuloaga (2n = 24), *P. ammodes* Trin. (2n = 36), *P. bicilium* Mez (2n = 40), *P. heterotrichon* Trin. (2n = 40), and *P. burmanii* Filg., Morrone and Zuloaga (2n = 48). The chromosome numbers 2n = 30 for *P. carinatum* Humb. and Bonpl. ex Flüggé, 2n = 36 for *P. trachycoleon* Steud., and 2n = 40 for *P. clavuliferum* Wright and *P. lanciflorum* Trin. had not yet been reported for these species (see Figure 1).

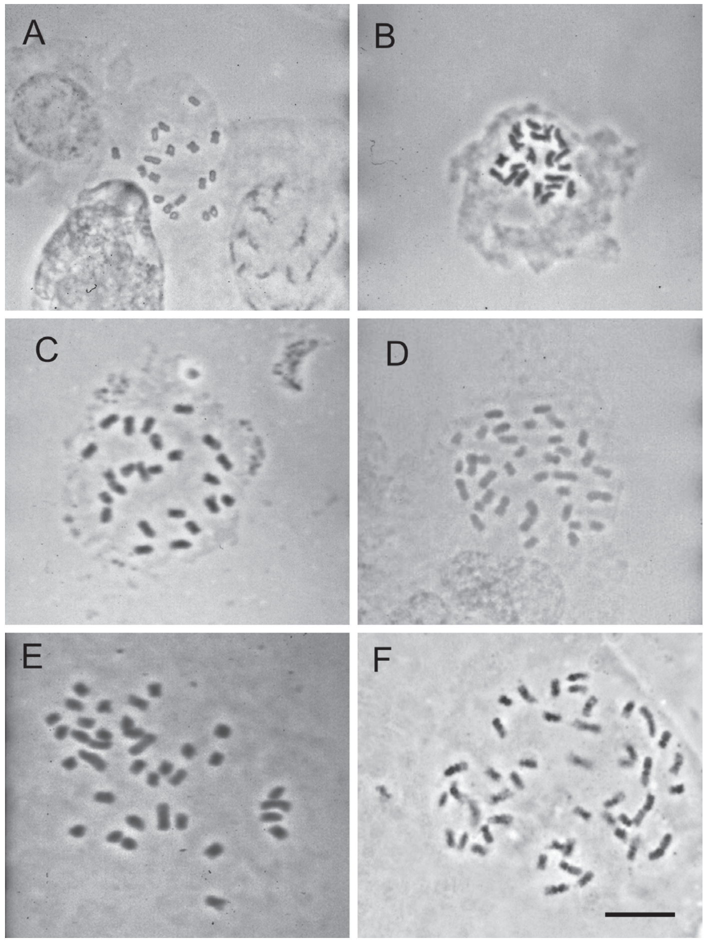

Figure 1. Mitotic metaphasic chromosomes in species of the genus *Paspalum*. **A.** *P. reduncum* GHR 822 (2n = 18). **B.** *P. cordatum* GHR 750 (2n = 20). **C.** *P. filguerasii* GHR 619 (2n = 24). **D.** *P. ammodes* GHR 693 (2n = 36). **E.** *P. trachycoleon* GHR 621 (2n = 36). **F.** *P. burmanii* GHR 635 (2n = 48). Bar = 10.0 µm.

Chromosome counts for *P. approximatum* Döll and *P. pumilum* Nees (2n = 20), *P. conjugatum* P.J. Bergius, *P. millegrana* Schrad. and *P. nutans* Lam. (2n = 40) confirmed previous counts for the respective species.

DISCUSSION

Base chromosome numbers other than x = 10 have been considered exceptional in *Paspalum*. The few disparate cases reported in the current literature from a broad area of distribution are a count of n = 9 for *P. lanciflorum* (Davidse and Pohl, 1974, *sub nom. P. contractum* Pilg.) and two counts of 2n = 32 for *P. convexum* Humb. and Bonpl. ex Flüggé (Selva, 1976; Reeder, 1984), as well as several counts of 2n = 32 (Honfi et al., 1990; Killeen, 1990;

Pozzobon et al., 2000), and one of 2n = 52 for *P. stellatum* Humb. and Bonpl. ex Flüggé (Honfi et al., 1990), and the repeatedly confirmed counts of 2n = 12 and 2n = 24 for *P. almum* Chase (Quarín, 1974; Quarín and Hanna, 1980; Dandin and Chennaveeraiah, 1983; Pozzobon and Valls, 1987; Norrmann et al., 1994; Hunziker et al., 1998; Pozzobon et al., 2008). For that reason, the discovery of several accessions of *Paspalum* having unusual chromosome numbers in a relatively small collection from a more limited geographical area is highly surprising, and reinforces the need of intensifying collection and characterization of new materials.

Paspalum reduncum is a member of the informal group Gardneriana (Renvoize, 1972), from which previous chromosome counts are not available. The two accessions reported here, both from the National Park of Brasília (Brasília, DF, Brazil), showed 2n = 18, suggesting a diploid level with a base chromosome number of x = 9, a condition only shared with an accession of *P. contractum* (= *P. lanciflorum*) reported by Davidse and Pohl (1974), as mentioned above.

Paspalum cinerascens (2n = 20) and *P. nutans* (2n = 40) belong to the subgenus *Harpostachys* (Trin.) S. Denham (Denham, 2005), a group scarcely studied from a cytogenetic point of view (Acuña et al., 2005).

Paspalum filgueirasii (2n = 24) is a little-known species, endemic to the Brazilian Central Plateau (Morrone and Zuloaga, 2003), probably related to *P. ellipticum* Döll and to the Venezuelan *P. atabapense* Davidse and Zuloaga. Chromosome numbers reported for *P. ellipticum* are 2n = 40 (Morrone et al., 2006) and 2n = 80 (Fernandes et al., 1974). Chromosome number multiples of 6, as reported for *P. almum* (see above) are very rare among Panicoid grasses. Since no data on meiotic behavior are currently available for *P. filgueirasii*, the base chromosome number x = 6 for this species is conjectural.

Paspalum ammodes (2n = 36) is a species currently ascribed to the informal group Eriantha (Morrone et al., 2004), which seems to be a largely polyphyletic assemblage (Speranza P and Rua GH, unpublished results). The unusual chromosome number of both accessions studied points to a base chromosome number of either x = 6 or x = 9. Both accessions differ in the pigmentation of the anthers. Whereas anthers of GHR 693 are purple, as typical for this species, those of GHR 694 are yellow. Interestingly, anther pigmentation is associated with ploidy level and mode of reproduction, with a few exceptions in *P. dilatatum* Poir. (Burson, 1983; Pozzobon et al., 2000). In this species, yellow-anthered biotypes are mostly tetraploid and sexual, while purple-anthered biotypes are penta- and hexaploid apomictics. This is not the case with *P. ammodes*, in which yellow- and purple-anthered plants collected in contiguous populations have the same chromosome number, a feature also documented for distinct individuals of a single accession of *P. dasypleurum* Kunze ex Desv. by Quarín and Caponio (1995). Since *P. ammodes* is a widespread species in South America (Morrone et al., 2004), it would be interesting to know if additional populations have the same chromosome number.

Paspalum cordatum (2n = 20), *P. carinatum* (2n = 30), *P. trachycoleon* (2n = 36), *P. bicilium* (2n = 40), *P. heterotrichon* (2n = 40), *P. lanciflorum* (2n = 40), and *P. burmanii* (2n = 48) are all members of the subgenus *Ceresia* (Pers.) Rchb. (Denham et al., 2002), which is, however, likely to be a polyphyletic assemblage (Rua and Aliscioni, 2002; Speranza P and Rua GH, unpublished results).

Previous chromosome counts of n = 10 and 2n = 40 exist for *P. carinatum* (Davidse and Pohl, 1972, 1978), now found in the triploid level.

Paspalum bicilium is narrowly related to *P. polyphyllum* Nees, where some authors consider it to be a synonym (Denham et al., 2002; Zuloaga and Morrone, 2005). Although available counts for *P. polyphyllum* also showed 2n = 40 (Burson, 1997), we prefer to maintain it tentatively as a separate species, based on morphological and ecological evidence. *Paspalum polyphyllum* and *P. bicilium*, together with *P. humboldtianum* Flüggé and a few other species, are probably unrelated to the rest of the subgenus *Ceresia* (Rua and Aliscioni, 2002; Speranza P and Rua GH, unpublished results).

Previous counts are available for *P. trachycoleon* (n = 20) and *P. lanciflorum* (n = 18, *sub nom. P. contractum*) (Davidse and Pohl, 1974), which differ, however, from these reported in this paper. In both cases, regular and unusual chromosome numbers co-exist in the same species, a case also known from another member of the subgenus *Ceresia*, *P. stellatum* Humb. and Bonpl. ex Flüggé, in which regular diploids (2n = 20) occur as well as an unusual polyploid series, comprising 2n = 32 and 52 (Honfi et al., 1990; Killeen, 1990). This fact poses a challenging question about a possible hybrid origin of the polyploid cytotypes, perhaps involving quite unrelated species.

Finally, the chromosome number 2n = 48 of *P. burmanii* was also unexpected for the genus. It is a poorly known species, endemic to the serpentinic region of Niquelândia, in the State of Goiás (Filgueiras et al., 2001), where several new species of *Paspalum* were unveiled in recent years (Davidse and Filgueiras, 1993; Filgueiras and Davidse, 1994; Filgueiras, 1995).

The finding of a set of new, unexpected chromosome numbers in *Paspalum* species suggests that much more collection and cytogenetic characterization are necessary to assess the whole chromosomal and genomic multiplicity present in the genus, which seems to be much more diverse than currently thought to be.

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