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Biotypic Differences in the Karyology of *Pennisetum pedicellatum* TRIN.

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Abstract. Detailed karyological analyses have been made of the five biotypes of *Pennisetum pedicellatum* TRIN. These biotypes not only differ in some morphological traits but also in their chromosomal characteristics. Biotype-B with 2n = 48 chromosomes shows constancy, while in the other four 2n = 36 and 54 are found to be "floating". Other numerical variations include 2n = 42 and 18 chromosomes. Minute karyological differences are not only noted amongst the biotypes, but also there are variations in the complements within a biotype. Such variations are presumed to be buffered through the apomictic mode of reproduction. From the morphological and cytological studies, the possibility of separation of biotype-B from the complex in future has been envisaged.

Pennisetum pedicellatum TRIN. is a promising forage grass and a good soil binder as well. It is a native of tropical Africa ("Kyasuwa grass") and is probably an introduction to India (BOR 1960, BOGDAN 1977), being locally known here as "Deenanath grass".

Cytological records of this valuable grass show different chromosome number reports of 2n = 30, 32, 35, 36, 48 and 54 (CARNAHAN and HILL 1961, CHATTERJI and PILLAI 1970, CHATTERJI and DAS 1979). Such numerical variations of chromosomes may be attributed to its well established apomictic mode of reproduction (WHYTE 1964, CHATTERJI and PILLAI 1970). CHATTERJI and DAS (1979) have characterized four biotypes within this species with chromosome numbers and behaviour. The present investigation is an attempt to assess the role of karyological changes in the differentiation of five such biotypes within the species, probably constituting a complex. Seed formation is solely apomictic in all and each produces homogeneous progenies.

MATERIAL AND METHODS

Five biotypes of the present investigation differ from each other in some morphological attributes with particular reference to inflorescence shape, size (Fig. 1) and colour and leaf characters. They grow wild in and around the institute campus and are prolific seeders. Somatic studies were made from the root tips of the germinating seeds of each biotype.

The root tips were pretreated for about 2.5 to 3.0 h at 4 °C in a mixture of saturated solution of Aesculin and paradichlorobenzene (pDB) and fixed

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in Clarke's fluid (mixture of isopropyl alcohol and propionic acid ratio of 3 : 1 v/v) for 24 h, stained in a mixture of 2% propiono-orce 5 M HCl in the ratio of 9 : 1 (v/v) for 15–20 min and squashed propiono-carmine. Karyological analyses were made from camera drawings at a magnification of approximately 1 000 ×.

RESULTS

The somatic chromosomes of *Pennisetum pedicellatum* Trin. are in medium to short in size ranging from 1.6 μm to 4.8 μm in length in d biotypes. The number of satellited chromosomes varies from four

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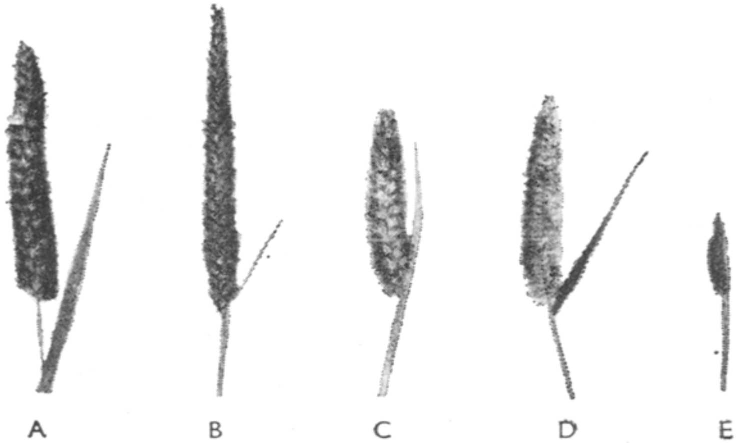

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Fig. 1. Photograph showing the types of inflorescence in the five biotypes of *Pennis latum* Trin.
Fig. 2. Camera-lucida drawings of the somatic chromosomes of *P. pedicellatum*.

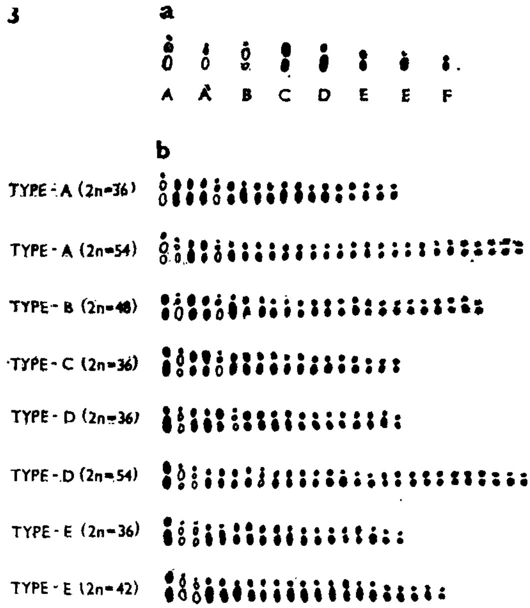

Fig. 3. Common chromosome types (a) and idiograms of the haploid complement (b) in the biotypes of *P. pedicellatum*.

The chromosomes are meta- or acrocentrics. According to their morphology and size, the chromosomes can be categorized into the following types (see Fig. 3a).

Type-A: The largest satellited chromosome in the set having two constrictions. One is nearly median in position and the second one is nearly terminal. The length of the chromosome is 4.8 μm.

Type-A′: Similar to type-A but comparatively smaller in structure. The size ranges from 2.8 μm to 3.6 μm in length.

Type-B: These chromosomes are also with secondary constrictions. Size ranges from 3.2 μm to 4.2 μm with larger middle piece than the other ones.

Type-C: Chromosomes are 3.0 μm to 4.0 μm in length and have median to nearly median primary constriction.

Type-D: Acrocentric chromosomes, ranging from 3.0 μm to 4.0 μm in length.

Type-E: Meta- and acrocentric chromosomes ranging from 2.0 μm to 2.8 μm in length.

Type-F: Smallest chromosomes in the set, 1.6 μm in length and generally acrocentric.

There is a good deal of similarity in the gross morphology of the chromosomes amongst these biotypes, although they differ from each other in the presence of the number of these chromosomal types. These biotypes, however, differ from each other numerically. Biotype-B shows mainly $2n = 48$ chromosomes, while others have mainly $2n = 36$ along with $2n = 54$ in biotype-A and biotype-D and $2n = 42$ in biotype-E. Again biotype-D and biotype-E have been found to contain $2n = ca.$ 70 and $2n = 18$, *ca.* 28 respectively in some of the cells. The chief chromosomal characteristics of the different biotypes is summarized in Table 1.

TABLE 1
Chromosome analyses in different biotypes of *Pennisetum pedicellatum* TRIN.

Biotypes	Comp-lements	2n No.	No. of satellited chromo-somes	Range of chromosome size [μm]	Total amount of chromatin length in haploid complement [μm]	Chromosome morphology (types and their numbers)
A	I	36	4	2.4–4.8	56.4	$A_2+A_2'+C_8+D_6+E_{18}$
	II	54	6	1.6–4.2	64.4	$A_4'+B_2+C_4+D_2+E_{32}++F_{10}$
B	–	48	4	1.6–4.0	63.8	$A_4'+C_6+D_4+E_{32}+F_2$
C	–	36	4	1.8–4.2	52.8	$A_2'+B_2+C_4+D_{10}+E_{16}+F_2$
D	I	36	4	2.0–3.6	50.0	$A_2'+B_2+C_2+D_6+E_{24}$
	II	54	6	1.6–3.6	63.8	$A_4'+B_2+C_8+D_2+E_{32}++F_6$
E	I	36	4	1.6–4.0	50.4	$A_4'+C_8+D_8+E_{14}+F_2$
	II	42	4	1.6–4.2	61.4	$A_4'+C_6+D_{14}+E_{16}+F_2$

Biotype–A

This biotype was shown to posses two chromosome complements differing from each other, both numerically and morphologically.

Complement-I ($2n = 36 = A_2 + A_2' + C_8 + D_6 + E_{18}$)

The normal somatic set of this biotype possesses thirty-six chromosomes (Fig. 2A). Size difference is seen within this complement ranging from 2.4 μm to 4.8 μm. The total amount of chromatin length in the haploid complement is 56.4 μm. The chromosomes are graded in size, one type merging into the other. Two pairs are satellited (Fig. 3b).

Complement-II ($2n = 54 = A_4' + B_2 + C_4 + D_2 + E_{32} + F_{10}$)

Fifty-four somatic chromosomes are present in this complement (Fig. 2B). Frequency of cells having this chromosome number is less than cells having complement-I.

There is a size difference of chromosomes ranging from 1.6 μm to 4.2 μm. The total chromatin length of haploid complement is 64.4 μm. Secondary constrictions are present on three pairs of chromosomes (Fig. 3b).

Biotype–B

$$(2n = 48 = A_4' + C_6 + D_4 + E_{32} + F_2)$$

Forty-eight chromosomes are present in the somatic cells (Fig. 2C). The size difference of chromosomes is well marked ranging from 1.6 μm to 4.0 μm. Two pairs of chromosomes are satellited (Fig. 3b). This biotype is characterized by constancy in number which is not found in any other type. The length of haploid complement is 63.8 μm.

Biotype–C

$$(2n = 36 = A_2' + B_2 + C_4 + D_{10} + E_{16} + F_2)$$

Thirty-six chromosomes are present in the somatic cells (Fig. 2D). No variation in chromosome number has been noted in this biotype. The chromosomes form a graded series, ranging from 1.8 μm to 4.2 μm. The total chromatin length of the haploid complement is 52.8 μm. Secondary constrictions are present in two pairs of chromosomes (Fig. 3b).

Biotype–D

This biotype possesses two different complements.

Complement-I ($2n = 36 = A_2' + B_2 + C_2 + D_6 + E_{24}$)

Thirty-six chromosomes are found in the somatic cells (Fig. 2E). The frequency is high. The chromosomes are present in graded series ranging

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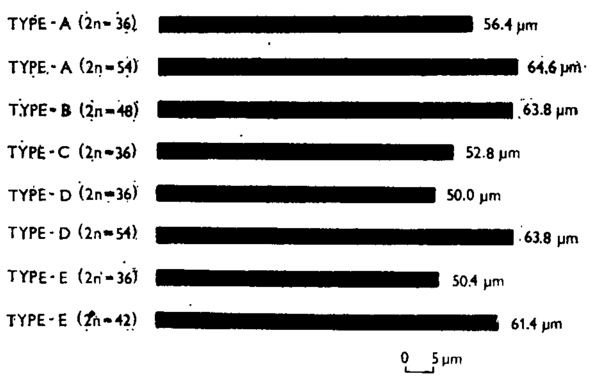

Fig. 4. Histograms of the haploid chromatin matter in the biotypes of *P. pedicellatum*.

from 2.0 μm to 3.6 μm. The total amount of chromatin length of the haploid complement is 50.0 μm. Two pairs of satellited chromosomes are present (Fig. 3b).

Complement-II ($2n = 54 = A_4' + B_2 + C_8 + D_2 + E_{32} + F_6$)

Fifty-four chromosomes are present in this complement, whose frequency is much less (Fig. 2F). Chromosomes are present in a graded series ranging from 1.6 μm to 3.6 μm. The total amount of chromatin length of the haploid complement is 63.8 μm. Three pairs of satellited chromosomes are noted to occur (Fig. 3b).

Biotype–E

This biotype also possesses two different complements.

Complement-I ($2n = 36 = A_4' + C_8 + D_8 + E_{14} + F_2$)

Thirty-six chromosomes are present in the normal somatic cells (Fig. 2G), whose frequency is high. The chromosomes are graded ranging from 1.6 μm to 4.0 μm. The total length of chromatin in the haploid complement is 50.4 μm. Two pairs of satellited chromosomes are present (Fig. 3b).

Complement-II ($2n = 42 = A_4' + C_6 + D_{14} + E_{16} + F_2$)

Forty-two chromosomes are present in this complement (Fig. 2 H). The chromosomes are in a graded series ranging from 1.6 μm to 4.2 μm in length.

The total chromatin length of the haploid complement is 61.4 μm. Two pairs of chromosomes are satellited (Fig. 3b).

Besides the above two distinct complements, sometimes cells with 2n = 18 chromosomes were also noted.

DISCUSSION

The genus *Pennisetum* is a complex one and is badly in need of revision (HARLAN 1969). This is evident from the existence of different synonyms for a particular species (CHASE and NILES 1962) probably based on minor morphological variations at the intraspecific level. The diversity is also reflected in the chromosomal situation showing a polybasic nature with x = 5, 7, 8 and 9 (NARAYAN 1951, HRISHI 1952, NATH and SWAMINATHAN 1957, JOSHI *et al.* 1959, CARNAHAN and HILL 1961).

Pennisetum pedicellatum TRIN. of the present study shows the existence of three distinct chromosomal races with 2n = 36, 54 and 48 (NATH and SWAMINATHAN 1957, JOSHI *et al.* 1959, CHATTERJI and REDDY 1975, CHATTERJI and DAS 1979). The former two are probably built upon a basic of x = 9 and the latter one a basic of x = 8. The basic of x = 9 is prevalent in the genus, while x = 8 is rather infrequent having been only reported in *P. massaicum* and *P. subangustum* (SWAMINATHAN and NATH 1956, JOSHI *et al.* 1959).

The present study shows that the biotype-B is characterized by 2n = 48, while 2n = 36 and 54 chromosomes are "floating" among the other four biotypes. In the latter group 2n = 42 and even 18 (confirming the basic of x = 9) are noted in different frequencies. The occurrence of two base numbers (x = 9 and 8) within a single species is a characteristic one probably arising as "polyploid drop" and indicates that the evolution is in an active state. The possibility of such a situation can be visualised in a species like this, whose chief mode of reproduction is apomictic with a highly irregular meiosis. A similar condition has also been pointed out by GILLDENHUYS and BRIX (1961) in the anomalous apomictic species, *P. dubium*.

Besides the role of numerical changes in speciation, the role of structural alteration has been little assessed in the genus *Pennisetum*, excepting *P. typhoides*, *P. purpureum* and *P. orientale* (SHARMA and DE 1956, PANTULU 1958, AL-FAKHRY *et al.* 1964). In *P. typhoides* karyological analysis has been done at the varietal level too, showing their differentiation (GILL and GUPTA 1966, POWELL and BURTON 1969, CHANDOLA and JAIN 1970). In *P. pedicellatum* no such work has yet been done.

It appears from the present observation that in the differentiation of the biotypes within this species, both numerical and structural alterations have played significant roles. Moreover, as the species is a well established apomict and the progeny is developed from diploid tissues (nucellar), new complements numerically and structurally altered are favoured to generate variation similar to those in vegetatively reproducing plants (SHARMA 1956). Chromosomally altered clones are being successfully buffered through apomixis and perpetuated in nature. Thus the species probably constitutes an agamic aneuploid complex, within which some biotypes like biotype-B with comparatively larger chromosomes, different base number and more cytological stability, warrant separation pending further investigation.

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