The genus *Sporobolus* R. Br. of tribe Sporoboleae in family Graminae consists of 150 species which are tropical and warm temperate in distribution (Airy Shaw 1973). Out of these, only 16 species are recorded from the Indian subcontinent (Bor 1960).

So far, chromosome numbers of 55 species have been recorded and these vary from $2n=12$ to $2n=126$ (see foot note to Table 1). From India, only 8 species have been studied (Mehra et al. 1968, Christopher and Abraham 1974, Mehra 1982, Christopher 1985), but taxa from different phytogeographic regions of the country have not been fully investigated so far. Therefore, as a part of our project of cytological studies on North Indian grasses and sedges, the present work was undertaken on the members of *Sporobolus* from Punjab plain from where only 6 species have been recorded (Sharma 1983 and the writers). Except for *S. fertilis* (Steud.) W. D. Clayton which is very rare in Punjab and could not be collected, all others have been presently chromosomally investigated.

**Materials and methods**

Details of localities from where the materials were collected are available in Table 1. Meiosis in young floral buds was studied following usual acetocarmine technique. Pollen fertility was ascertained by Mark's (1954) method. In order to reveal the existing cytological variability, if any, in each case, intensive analysis was done not only of several individuals but also of several populations.

**Observations**

Information about chromosome numbers recorded, ploidy level of taxa and the pollen fertility is given in Table 1. All the investigated taxa have normal meiosis except in case of *S. helvolus* and *S. indicus*. Three species, namely, *S. coromandelianus*, *S. helvolus* and *S. indicus* show the presence of 18II at diakinesis and M-I and $18+18$ or $(18+18)+(18+18)$ chromosomes at A-I and A-II (Figs. 1, 2, 3 respectively). For *S. diander* and *S. marginatus*, two cytotypes each with $n=12$ (Fig. 4) and $n=18$ (Fig. 5) for the former and $n=9$ (Fig. 6) and $n=18$ for the latter species are recorded (cf. Table 1).

In *S. helvolus* with $n=18$ (4x) phenomenon of cytomixis has been observed in 38.5% of observed pollen mother cells (PMCs) at different stages of meiosis. Actual passing of chromatin material is seen in 63.4% of the cytomictic cells (Fig. 7). As a result of transmigration of nuclear material PMCs with increased (not countable) and decreased ($n=8$, 10, 14, 15, 16), chromosome numbers have been located (Figs. 8, 9, 10). Due to these abnormalities, pollen fertility is reduced to 85.8%. In *S. indicus* nearly 72.7% of the observed PMCs show the presence of laggards and bridges at A-I which leads to highly decreased pollen viability (20.5%).

The tetraploid and hexaploid cytotypes of *S. diander* can be distinguished easily as the tetraploids are taller (52–57 cm) with bigger leaves (12–17 cm), large sized inflorescence (23–
26 cm) and large sized pollen (24×20–23×28 μm) as compared to hexaploid plants which are smaller in size (28–39 cm), possess smaller leaves (4.5–7.5 cm) and inflorescence (10–18 cm). The pollen are nearly of the same size (24×20–28×24 μm) as in case of tetraploids. It may be stated that both the cytotypes were growing under similar habitat conditions. However, in S. marginatus the tetraploid plants are more robust in appearance (55–60 cm) with bigger leaves (9.5–11.5 cm) and inflorescence (10.5–11 cm), but with small pollen (24×20–24×24 μm) as compared to the diploid plants which are 30–32 cm tall, possess smaller (7–10.5 cm) sized leaves and 8.5–10.5 cm long inflorescence and comparatively bigger sized (24×24–28×28 μm) pollen. Also pollen fertility is much reduced in tetraploids (30–48%) as compared to the diploids (98%).

Discussion

All the presently studied five species of Sporobolus are at polyploid level and are based on $x=6$ (S. diander) and $x=9$ (S. coromandelianus, S. helvolus, S. indicus and S. marginatus). Three well represented base numbers as $x=9, 10, 12$ have been suggested (cf. Darlington and Wylie 1955, Fedorov 1969, Moore 1973) for the genus. Tateoka (1965) reported $n=6$ in S. molleri from Uganda and another base number $x=6$. Later on, Christopher (1985) on the basis of record of $n=6$ for S. maderapatonous from South India supported the presence of $x=6$. Now with the recording of $n=12$ (4x) and $n=18$ (6x) for S. diander from North India, the existence of $x=6$ for Sporobolus is confirmed. This is a primary number for the genus and the other numbers $x=9, 10$ have evolved through aneuploidy from $x=6$. The existence of $x=12$ is ruled out because the species supporting $n=12$ and considered diploid as based on 12, are now scored as tetraploid as based on $x=6$. Eventually, the genus Sporobolus is tribasic with $x=6, 9$ and 10.

On world-wide basis the cumulative cytological data* for 89 investigated taxa show that 83.03% are polyploids and the following species* show intraspecific cytotypes (both eu- and aneuploids): S. airoides (2n=90, 108, 126), S. asper (2n=54, 88, 108), S. berteroanus (2n=36, 44), S. capensis (2n=18, 36), S. coromandelianus (2n=24, 36), S. cryptandrus (2n=18, 36, 38, 72), S. cubensis (2n=72, 80, 90), S. diander (2n=24, 36), S. fertilis (2n=24, 36, 48), S. festivus (2n=18, 24, 36, 40–45, 48, 54), S. marginatus (2n=18, 20, 36), S. piliferus (2n=20, 36), S. pyramidalis (2n=24, 30, 36), S. pyramidatus (2n=24, 30, 36, 54), S. stapfionus (2n=24, 36), S. tenuissimus (2n=12, 40), S. tremulus (2n=20, 48), S. virginiticus (2n=18, 20, 23–30, 30), S. wallichii (2n=24, 40).

The cause for aneuploid numbers could be sought in the presence of cytomictic PMCs as recorded by us in S. helvolus for the first time in the genus Sporobolus as well as irregular divisions during sporogenesis as noticed in S. indicus. This ultimately leads to genetically imbalanced pollen and the resultant different biotypes which are easily perpetuated in nature through vegetative propagation so common in grasses.

It is very likely that cytomixis is prevalent in other species too, but this has not been noticed so far. The existence of polyploid cytotypes at intraspecific level, raises an important question as to the taxonomy of the concerned species. The taxonomic reflections of cytological differences well supported by morphological differences as brought out presently from S. diander

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* Based on information given in references mentioned in foot note (*) to Table 1 and present observations.
Table 1. Chromosomal data for species of genus *Sporobolus* from Punjab plains

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Name of taxon</th>
<th>Locality</th>
<th>Chromosome number</th>
<th>Ploidy level</th>
<th>Pollen fertility</th>
<th>PUN accession number/s</th>
<th>Previous reports from India*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>S. coromandelianus</em> (Retz.) Kunth</td>
<td>Univ. Campus Patiala 250 m</td>
<td>n=18</td>
<td>Tetraploid</td>
<td>97.0</td>
<td>28196</td>
<td>2n=24: Christopher and Abraham 1974</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>2n=36: Narayan and Muniyamma 1972, Bir and Sahni 1983</td>
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<tr>
<td>2</td>
<td><em>S. diander</em> (Retz.) P. Beauv. Population 1</td>
<td>Univ. Campus Patiala</td>
<td>n=12</td>
<td>Tetraploid</td>
<td>100.0</td>
<td>31300</td>
<td>2n=24: Gupta and Yashvir 1971, Christopher and Abraham 1974, Mehra 1982</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
<td>2n=54: Mehra <em>et al.</em> 1968</td>
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<td>2n=24, 36: Sahni and Bir 1985</td>
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<td>Population 2</td>
<td>Univ. Campus Patiala</td>
<td>n=18</td>
<td>Hexaploid</td>
<td>94.2</td>
<td>30082-84</td>
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<td>2n=36: Sahni and Bir 1985</td>
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<td></td>
<td>Population 3</td>
<td>V. Maharana Sangrur 240 m</td>
<td>n=18</td>
<td>Hexaploid</td>
<td>100.0</td>
<td>28973</td>
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<td>3</td>
<td><em>S. helvolus</em> (Trin.) Th. Dur et Schinz</td>
<td>Ferozepur Head work, 206 m</td>
<td>n=18</td>
<td>Tetraploid</td>
<td>85.8</td>
<td>32161</td>
<td>2n=36: Sahni and Bir 1985</td>
</tr>
<tr>
<td>4</td>
<td><em>S. indicus</em> (Linn.) R. Br.</td>
<td>Rajpura Road Patiala</td>
<td>n=18</td>
<td>Tetraploid</td>
<td>20.5</td>
<td>31274</td>
<td>2n=36: Sahni and Bir 1985</td>
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<td></td>
<td>Population 1</td>
<td>Sadhu Bela Patiala</td>
<td>n=9</td>
<td>Diploid</td>
<td>98.0</td>
<td>28201</td>
<td>2n=18: Mehra <em>et al.</em> 1968</td>
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<td>2n=36: Bir and Sahni 1984</td>
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<td></td>
<td>Population 2</td>
<td>NIS Patiala</td>
<td>n=18</td>
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<td>2n=48: Christopher and Abram 1974</td>
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<td>Population 3</td>
<td>V. Maharana Sangrur</td>
<td>n=18</td>
<td>Tetraploid</td>
<td>48.0</td>
<td>28997</td>
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</tbody>
</table>

* Previous reports compiled from Darlington and Wylie (1955), Löve and Löve (1961, '74, '75), Fedorov (1969), Index to plant chromosome number (1956 onwards) and IOPB chromosome number reports as published in Taxon 1965 onwards and SOCGI chromosome number reports I, II, III (1983, '84, '85). Irrespective of the fact whether n or 2n chromosome numbers are compiled by previous workers, we have invariably mentioned the '2n' numbers. References to workers mentioned under column 8 on previous reports are excluded at the end. Reader is referred to the above mentioned works.
and *S. marginatus*, has to wait till comparisons with the type materials are made. In any case, there is an urgent need for the taxonomic revision of the genus *Sporobolus*.

**Summary**

As a result of chromosomal analysis of various populations of five species of genus *Sporobolus* it has been found that (i) morphologically distinct tetraploid (n=12) and hexaploid (n=18) cytotypes for *S. diander* and diploid (n=9) and tetraploid (n=18) cytotypes for *S. marginatus* exist in nature, (ii) cytomixis leading to aneuploid numbers characterises *S. helvolus* and (iii) abnormal meiosis results in reduced pollen fertility in *S. indicus*.

All the five species are polyploids. On the basis of cumulative world wide data 83% of the species of genus *Sporobolus* are polyploids and intraspecific cytotypes exist in a large number of species. This calls for taxonomic revision of the genus in the light of cytomorphological evidence.

**Acknowledgements**

One of us (MS) is thankful to CSIR for financial assistance.

**References**


