Cytological Observations on *Scirpus* Linn. from North India

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Scirpus Linn. of family Cyperaceae Juss. (members commonly known as sedges) is very well represented in the extant flora with 300 species in the world (Willis 1966) and 25 species in India (Santapau and Henri 1973). There have been a number of isolated reports on the chromosome numbers of this genus but works of Hicks (1928), Tanaka (1937a, b, 1938, 1939, 1940), Sharma and Bal (1956), Otzen (1962), Sharma (1962), Schyular (1963), Mehra and Sachdeva (1971) and Senyal and Sharma (1972) are significant. From India, so far cytology of only 14 species of *Scirpus* has been studied (cf. Kumar and Subramaniam 1987) while the majority of the taxa remained to be investigated. On population basis there are hardly any studies although sedges are now well known for chromosomal variations as revealed by the perusal of cumulative world-wide data.

As a part of our programme of chromosomal analysis of sedge flora of north India, the work on Punjab flora was started a few years ago and the present paper is in continuation of our earlier communication on *Scirpus tuberosus* Desf. from this region (cf. Bir *et al.* 1990). Presently, chromosome numbers of 5 species namely, *S. kyllingioides* Boeck., *S. litoralis* Schrad., *S. mucronatus* Linn., *S. roylei* (Nees) Parker, and *S. triqueter* Linn. are recorded and in each case different populations were analysed so as to notice the genetical variability, if any, at species level.

Materials and methods

Materials used in present investigation were collected from different parts of the Punjab State bordering Pakistan in north India (Fig. 1). Usual acetocarmine squashes of young floral buds were made after fixation in Carnoy's fluid (6:3:1 mixture of ethyl alcohol, chloroform and glacial acetic acid). Desirable slides were made permanent in euparal after dehydration in ethyl alcohol. Pollen fertility was determined by staining with glyco-acetocarmine (1:1 ratio) and scoring well filled and well stained pollen as fertile. For stomatal observations leaf epidermis peels were stained with glyco-safranin. Comparative data on morphology of different cytotypes and morphotypes are represented through polygraphs which give details on plant height, stem perimetre, leaf sheath length, spike length, spikelet length and breadth, pollen size and fertility, leaf lamina length and breadth, epidermal cell length, stomatal length and stomatal index. Voucher specimens have been deposited in the Herbarium of the Department of Botany, Punjabi University, Patiala (PUN).

Observations

To ascertain the correct chromosome numbers, each species has been studied from different populations and even in case of a population reliance is made on study of meiosis in several pollen mother cells (PMCs). Population-wise information for each species is provided in Table I which incorporates citation of voucher specimen for each of the recorded chromosome number. Critical analysis of meiotic course for each population has indicated that

Table 1. Chromosome Numbers in different species of *Scirpus* from Punjab state, North India

S. No.	Taxon	Locality	Chromosome number	Figure number	Ploidy level	PUN Accession number
<i>SCIRPUS</i> Linn. $x=5, 7, 8$						
1.	<i>Scirpus kyllingoides</i> Boeck. (= <i>Isolepis kyllingoides</i> A. Rich., = <i>Kyllinga microcephala</i> Steud.)			11a		
	Population i	Faridkot: Chail Village, 260 m.	$n=52$	2	14-ploid (aneuploid)	35257
	Population ii	Ferozepur: Headworks, 260 m.	$n=50$	3	14-ploid (aneu.)	35267
	Population iii	Ferozepur: Headworks, 260 m.	$n=51$	4	14-ploid (aneu.)	35266
	Population iv	Ferozepur: Headworks, 260 m.	$n=52$	—	14-ploid (aneu.)	35259
2.	<i>S. litoralis</i> Schrad. [= <i>Schoenoplectus litoralis</i> (Schrad.) Palla.]			11b		
	Population i	Ferozepur: Golewala Nala, 260 m.	$n=39$	5	10-ploid (aneu.)	35249
	Population ii	Faridkot: Chail Village, 260 m.	$n=42$	6	10-ploid (aneu.)	35250
3.	<i>S. mucronatus</i> Linn. [= <i>Schoenoplectus mucronatus</i> (Linn.) Palla.]			11d		
	Population i	Ropar: Headworks, 400 m.	$n=22$	7	6-ploid (aneu.) or 8-ploid (aneu.)	34975
	Population ii	Patiala: Nadampur 250 m.	$n=22$	—	6-ploid (aneu.) or 8-ploid (aneu.)	35252
	Population iii	Jalandhur-Amritsar: Beas, 260 m.	$n=22$	—	6-ploid (aneu.) or 8-ploid (aneu.)	35253
	Population iv	Ropar: Nangal, 600 m.	$n=22$	—	6-ploid (aneu.) or 8-ploid (aneu.)	35254
4.	<i>S. roylei</i> (Nees) Parker [= <i>Isolepis roylei</i> Nees = <i>S. quinquefarus</i> Buch. Ham. ex Boeck.]			11e		
	Population i	Patiala: Sheikhpura village, 251 m.	$n=11$	9	2-ploid	35369
	Population ii	Kapurthala; 260 m.	$n=44$	10	8-ploid	35408
5.	<i>S. triqueter</i> Linn. [= <i>S. triquetrus</i> L. syn. <i>Schoenoplectus triqueter</i> (Linn.) Palla.]			11c		
	Population i	Patiala: Nadampur 250 m.	$n=21$	8	6-ploid	35255
	Population ii	Ropar; Nangal 600 m.	$n=21$	—	6-ploid	35256

there are no irregularities what-so-ever and anaphasic separations and resultant pollen formations are absolutely normal. Points of interest are as follows:

1. *Scirpus kyllingoides* Boeck.

Populations i and iv from Chail Village near Faridkot, 260 m and Ferozepur Head works, 260 m respectively show the presence of 52_{II} whereas in Pop. ii and iii, both from Ferozepur Head works 50_{II} and 51_{II} were countable. Thus there are three cytotypes with $n=50$, 51 and 52 for the species (Figs. 2-4). Pop. i and iv with $n=52$ but also Pop. ii and iii differ from each other in the number of spikelets per plant, two spikelets in Pop. i, ii and iii but four spikelets

Fig. 1. Map of Punjab state located in north India bordering Pakistan in north west with indication of cities and towns from where materials were obtained.

in Pop. iv. Morphological characters of four analysed populations are appreciably different as shown by data represented in Fig. 11a. Frequency of stomata per unit area is lesser in Pop. iv as compared to Pop. i, ii and iii (with 7-8 stomata/unit area). Perimeter of stem is similar in all the four populations studied presently. There is hardly any correlation between the number of spikelets and their size. Pollen fertility is the highest in Pop. iii (90%) and lowest in Pop. ii (50%) in comparison to Pop. i and iv (72% and 70% respectively).

2. *S. litoralis* Schrad.

Two populations from near Ferozepur and Faridkot i.e. Pop i with $n=39$ (Fig. 5) and Pop. ii with $n=42$ (Fig. 6), have been located. These cytotypes are morphologically very dis-

tinct. Plants of Pop. i are taller as compared to Pop. ii and these individuals are separable on several phenotypic characters as reflected in Fig. 11b. Pollen fertility is very high in both of the populations (96–100%).

3. *S. mucronatus* Linn.

All the populations i–iv from Ropar (Headworks), Patiala (Nadampur), Beas (in between Jalandhur and Amritsar) and Nangal (40 km north of Ropar) respectively, have the identical chromosome number $n=22$ (Fig. 7). However, morphologically these populations are distinct (Fig. 11d). Pollen fertility is higher in Pop. iii (96%) and Pop. iv (95%) with taller plants as compared to Pop. i (65%) and Pop. ii (76%).

Figs. 2–10. Meiosis in PMCs of different species of *Scirpus*. 2–4, *S. kyllingioides*-Pop. i with $n=52$, Pop. ii with $n=50$ and Pop. iii with $n=51$ respectively; 5–6, *S. litoralis*-Pop. i with $n=39$ and Pop. ii with $n=42$; 7, *S. mucronatus*-Pop. i with $n=22$; 8, *S. triqueter*-Pop. iii with $n=21$; 9–10, *S. roylei*-Pop. i with $n=11$ and Pop. ii with $n=44$ respectively.

4. *S. roylei* (Nees) Parker

Two populations investigated from Sheikhpura village near Patiala with $n=11$ (Fig. 9) and Kapurthala showing $n=44$ (Fig. 10) are interesting in the fact that diploid and tetraploid cytotypes are now known to exist for the species. The individuals of these populations vary markedly in size and various other characters as reflected in Fig. 11e.

5. *S. triqueter* Linn.

Both the populations from Patiala (Nadampur) and Nangal (Near Ropar) show invariably the same number $n=21$ as indicated by presence of 21_{II} at M–I (Fig. 8). However, the plants vary markedly in morphological characters (Fig. 11c). Pop. ii is with taller plants, bigger pollen, higher pollen fertility but smaller spikes in contrast to Pop. i.

Figs. 11, a–e. Polygraphs representing the differentiating characters in various populations of a. *Scirpus kyllingioides*, b. *S. litoralis*, c. *S. triqueter*, d. *S. mucronatus*, e. *S. roylei*. A=Height, B=Stem perimeter, C=Leaf sheath length, D=Spikelet length, E=Spikelet breadth, F=Spike length, G=pollen size, H=pollen fertility %age, I=Average leaf lamina length, J=Average leaf lamina breadth, K=Length of epidermal cell, L=Stomata length, M=Stomata breadth, N=Stomatal Index.

Discussion

S. kyllingioides with $n=50, 51, 52$ is investigated for the first time while chromosome numbers $n=39, 42$ for *S. litoralis* are at variance with earlier records of $2n=10$ (Sarkar *et al.* 1976) and $2n=80$ (Nijalingappa *et al.* 1978). For *S. mucronatus*, the recorded number $n=22$ corroborates the earlier report of Bir *et al.* (1988) but Sanyal and Sharma (1972) and Mehra and Sachdeva (1975) reported $2n=42$ from India. *S. triqueter* with $n=21$ is a stable species as also indicated by earlier reports of Bir *et al.* (1988). *S. roylei* is the only species showing euploid cytotypes at diploid ($n=11$) and octaploid ($n=44$) levels, the cytotypes are morphologically distinguishable in the field as indicated earlier. Both the recorded numbers confirm the earlier reports of Mandeep (1985). It is also clear that the diploid and octaploid plants are well established in the region.

As noted earlier aneuploidy is operative in differentiation of different taxa in *S. kyllingioides* and *S. litoralis* whereas *S. mucronatus* and *S. triqueter* are both stable species with $n=22$ and 21 respectively, both at hexaploid level with base number $x=7$. With a high divergence of aneuploid number in *S. kyllingioides* ($n=50, 51, 52$) and *S. litoralis* ($n=39, 42$), it is practically impossible to determine the polyploidy level, because the genus *Scirpus* is known to have $x=5, 7, 8$, and any guess on this account is hazardous.

It will be of interest to note that *S. tuberosus* in Punjab is highly variable with $n=47, 48, 52, 56, 57$ and 58 and different biotypes are easily distinguishable on morphological characters (Bir *et al.* 1990).

The frequent incidence of euploid and aneuploid chromosome numbers in sedges indicate the high evolutionary rate of these plants. Richardson (1933), MacMohan (1936), Sachdeva (1972) and Bir *et al.* (1988, 1989) pointed out the possibility of fragmentation of chromosomes as the main cause for high aneuploidy incidence in sedges. This explains remarked chromosomal size differences amongst various taxa. Earlier, Stebbins (1950) attributed high frequency of polyploidy to vegetative propagation which helps in spreading of polyploids in Cyperaceae, Gramineae and Juncaceae. On the basis of cumulative chromosomal data, it is clear that sedges show a very high incidence of polyploidy, above 70% although earlier Stebbins (1950) mentioned polyploidy incidence in the family to the order of about 95%. The main reason being conservation of polyploid taxa through vegetative propagation so rampant in sedges and grasses too, which is normally not the case with other groups of flowering plants where seeds play vital role in propagation. Chromosomal variations presently noted in different populations of investigated species have stressed the importance of population analysis of different floras so as to unearth the genetical variabilities.

Summary

Population studies on five species of *Scirpus* namely, *S. kyllingioides*, *S. litoralis*, *S. mucronatus*, *S. roylei* and *S. triqueter* show fixed chromosome numbers in *S. mucronatus* ($n=22$) and *S. triqueter* ($n=21$) while *S. kyllingioides* and *S. litoralis* show high incidence of aneuploidy. Both diploid ($n=11$) and octaploid ($n=44$) cytotypes are recorded for *S. roylei*. On the basis of recorded base numbers ($X=5, 7, 8$) in *Scirpus*, it is very difficult to guess correctly the ploidy level for *S. kyllingioides* and *S. litoralis* cytotypes.

Sedges show a high incidence of euploid and aneuploid numbers which is due to vegetative propagation so common in the group because this mechanism of race perpetuation helps in conservation of all the evolved cytotypes which is normally not the case with other groups of flowering plants not exhibiting vegetative propagation.

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