A New Basic Chromosome Number for *Amaranthus* (Amaranthaceae)

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Summary The chromosome number of *Amaranthus tenuifolius* Willd. has been found to be $2n=28$ which gives a new basic number ($x=14$) for the genus *Amaranthus*; previously characterized by $x=16$ or $x=17$. The karyotype of *A. tenuifolius* shows distinct features and is more symmetrical than that of other 14 grain and vegetable amaranth species studied.

Key words Basic number, Karyotype, *Amaranthus tenuifolius* Willd.

The genus *Amaranthus* is widely distributed in the tropics and subtropics and is comprised of 60–75 species (Aellen 1964, Sauer 1967) out of which 15 occur in the Indian subcontinent. Some species are grown as pot herbs while others as grain crops. Two groups represent section *Blitopsis* Dumort and section *Amaranthotypus* Dumort respectively (Aellen 1964).

Chromosome numbers of nearly 30 species have been studied which show that the genus is dibasic ($x=16, 17$) and is diploid except for a solitary tetraploid ($2n=64, x=16$) species, *A. dubius* Mart ex. Thell. (Pal 1971, Madhusoodanan and Nazeer 1983, Greizerstein and Poggio 1994, Greizerstein *et al.* 1997). The present study reports for the first time the chromosome number in *A. tenuifolius* Willd. which also gives a new basic number for the genus.

Materials and methods

A. tenuifolius, a wild delicate trailing herb with very small leaves and seeds, is distributed in the plains of North and South India (Fig. 1). The present study is based on the material collected from 'Katothital' a place 8 km from Lucknow. For karyotypic studies actively growing roots (1.0–1.5 cm long) were excised from germinated seeds and pretreated with 0.002 M aqueous solution of 8-hydroxyquinoline for 3 h at 15–17°C. After washing these were fixed in 1 : 3 acetic alcohol for 24 h. The root tips were washed and hydrolysed in 5 N HCl for 30 min and stained with Feulgen for 2 h then squashed in 1% iron acetocarmine to further intensify the stain. The centromeric nomenclature of Schlarbaum and Tsuchiya (1984) was followed and degree of symmetry/asymmetry of karyotypes has been estimated following Stebbins (1958). For meiosis young flower buds were fixed in Carnoy's fluid for 24 h and squashed in 1% acetocarmine.

Results and discussion

Somatic chromosome number of $2n=28$ has been observed in the present material (Fig. 2) which is a new basic number for the genus *Amaranthus*. Fourteen pairs of chromosomes have been arranged in decreasing order of total lengths (Figs. 2, 5) and the mean karyotype measurements from three good spreads are presented in Table 1. Based on the location of primary (centromere) constriction the karyotype formula of *A. tenuifolius* is $1M+2m+7msm+4sm$ according to the nomenclature system of Schlarbaum and Tsuchiya (1984) and it belongs to 1b class (Stebbins 1958) taking into account the ratio between the longest and shortest chromosome (2.17) and maxi-

mum r-index (2.30) (Table 1). The TF% is 38.95 which shows that the karyotype is moderately asymmetrical.

The diakinesis and metaphase I of meiosis also show 14II and at diakinesis one bivalent attaches to the nucleolus (Figs. 3, 4). The mean chiasma frequency per cell calculated from an analysis of 15 cells was 24.40 ± 0.54 . Further course of meiosis was regular with 14:14 distribution at anaphase I resulting in normal pollen and seed fertility.

The chromosome numbers on about 30 species reported so far show that $2n=28$ in *A. tenuifolius* is a new basic number and the genus is therefore tribasic $x=14, 16, 17$. Detailed karyotypic studies have been done on 14 grain and vegetable species representing $x=16$ or 17 (Madhusoodanan and Nazeer 1983, Greizerstein and Poggio 1994, Greizerstein *et al.* 1997). A comparison of the karyotypes shows that *A. tenuifolius* has the most symmetrical and primitive karyotype in the absence of any chromosome with arm ratio >2.5 (Table 1). In contrast to this the complements of other species studied have 7 to 18 chromosome pairs with arm ratio >3.0 and that of *A. lividus* L. is most asymmetrical and advanced with 10 pairs of telocentric chromosomes (Madhusoodanan and Nazeer 1983, Greizerstein and Poggio 1994, Greizerstein *et al.* 1997). However, the

Fig. 1. *A. tenuifolius* $\times 0.74$.

Table 1. Chromosome measurements and classification of *A. tenuifolius*

Chromosome pair number	Total length (μm) Mean $\pm$ S.D.	Length of long arm (μm) Mean $\pm$ S.D.	Length of short arm (μm) Mean $\pm$ S.D.	r-index Mean $\pm$ S.D.	Classification
1	2.22 ± 0.05	1.31 ± 0.02	0.91 ± 0.02	1.43 ± 0.05	msm
2	2.05 ± 0.04	1.17 ± 0.03	0.88 ± 0.03	1.32 ± 0.05	m
3	2.00 ± 0.04	1.20 ± 0.02	0.80 ± 0.01	1.50 ± 0.04	msm
4	1.99 ± 0.03	1.28 ± 0.01	0.71 ± 0.01	1.80 ± 0.03	sm
5	1.54 ± 0.01	0.97 ± 0.01	0.57 ± 0.01	1.70 ± 0.04	msm
6	1.52 ± 0.02	1.06 ± 0.02	0.46 ± 0.02	2.30 ± 0.02	sm
7	1.48 ± 0.02	0.74 ± 0.03	0.74 ± 0.01	1.00 ± 0.01	M
8	1.48 ± 0.03	0.77 ± 0.01	0.71 ± 0.02	1.08 ± 0.03	m
9	1.48 ± 0.01	0.91 ± 0.02	0.57 ± 0.03	1.59 ± 0.05	msm
10	1.45 ± 0.02	0.91 ± 0.01	0.54 ± 0.01	1.68 ± 0.02	msm
11	1.40 ± 0.03	0.86 ± 0.01	0.54 ± 0.02	1.59 ± 0.02	msm
12	1.36 ± 0.01	0.91 ± 0.01	0.45 ± 0.01	2.02 ± 0.01	sm
13	1.31 ± 0.03	0.83 ± 0.01	0.48 ± 0.01	1.72 ± 0.02	msm
14	1.02 ± 0.02	0.71 ± 0.01	0.31 ± 0.01	2.29 ± 0.03	sm

r-value- M: 1.0, m: 1.0–1.3, msm: 1.3–1.7, sm: 1.7–3.0.

Figs. 2–5. 2) Somatic metaphase ($2n=28$); 3) PMC at diakinesis, 14II; 4) Metaphase I, 14II, Scale= $5\text{ }\mu\text{m}$; 5) Karyotype ($2n=28$), Scale= $5\text{ }\mu\text{m}$.

present species is very specialized morphologically in having perianths subtending the utricle and the smallest seeds so far observed among all the species studied (Pal, observation).

It is not, however, possible to derive the origin and relationships between different basic numbers on the basis of gross karyotypic studies. A study of dibasic interspecific cross between white seeded *A. hypochondriacus* L. ($n=16$) and black seeded wild *A. hybridus* L. ($n=17$) showed that the latter number originated from the former by primary trisomy (Pal *et al.* 1982). A similar attempt to study the cross between *A. tenuifolius* and *A. lividus* ($n=17$) failed as the F_1 hybrids did not produce any inflorescence.

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