Karyotype Polymorphism in *Trillium govanianum* Wall.

P. N. Mehra and S. K. Sachdeva

Department of Botany, Panjab University, Chandigarh, India

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Chromosome polymorphism in *Trillium govanianum* was first of all observed by us in an individual collected from Gulmarg (Kashmir) (Mehra and Sachdeva 1975a). Several chromosome pairs were found to be heteromorphic with respect to their length and number and position of secondary constrictions. Our study was then based on the observation of a single cell from a root-tip with clear and well spread out chromosomes.

This led us to make a critical study of the karyotype in this species. We have now investigated individuals of populations from four different areas, Khilanmarg, Sonamarg, Chandanwari and Lianmarg, all lying at an altitude of 3,000-3,500 m in the Kashmir hills of the N. W. part of the Himalayas. The species is quite common in this part and extends eastwards as far as Sikkim at nearly the same altitude. Its thick rhizome which grows deep in the soil and is fairly extensive, lies dormant during winter when the soil is covered with a thick sheet of snow, giving rise to aerial shoot as soon as the snow melts. The flowering season is in early May and the capsule ripens in July.

The rhizomes were dug out, wrapped with moss and kept in congenial environments in the laboratory. Root-tips, as soon as they emerged, were excised, pre-treated with 8-hydroxyquinoline and squashed. The technique followed was the same as described in our previous paper (Mehra and Sachdeva 1975a).

Observations

The species possesses exceptionally long chromosomes like other members of the genus. There are 10 pairs of chromosomes, 2 large pairs A and B with median-submedian centromere, 2 next large pairs C, D and 2 smallest pairs I, J, all the four with sub-median centromere, and 4 pairs E, F, G, H of moderate-sized pairs with sub-terminal centromere. Of these pairs A, B and I, J are marker being the largest and smallest pairs respectively. The F pair is also a marker because of its very characteristic appearance. It possesses a sub-terminal centromere but immediately below it in the long arm is a secondary constriction.

We are presenting here karyotypes of two cells from the same root-tip of an individual from each of the two populations from Khilanmarg and Sonamarg, and the karyotype from a single cell of an individual from each of the remaining two populations from Chandanwari and Lianmarg. In addition, the karyotype in a root-tip cell from an individual of Gulmarg population, worked out earlier, is re-drawn for the sake of comparison. In each case three figures are presented, a photographic illustration of the karyotype, its explanatory figure with the chromo-

somes labelled, and an idiogram of the same. In the last figure the heteromorphic pairs, where present, are shown together, connected with a line underneath.

Khilanmarg population: The karyotypes of two different cells of the same root-tip are presented in Figs. 1, 2. Both cells showed two pairs (A, B) of median-

Figs. 1a-c. a and b, Khilanmarg population. $\times 1500$. c, idiogram, Khilanmarg population.

submedian chromosomes, 4 pairs (C, D, I, J) of submedian, and 4 pairs (E, F, G, H) of sub-terminal chromosomes (Figs. 1C, 2C). In the first cell (Fig. 1C) chromosomes constituting the median-submedian pair B were dissimilar in length, while in the second cell (Fig. 2C) the pair C was heteromorphic in the sense that one chromosome of this pair was with median-submedian centromere and in the other the proximal arm was relatively much shorter than the distal, so that the centromere was distinctly submedian. The homologues, however, had the same length.

Sonamarg population: In this case also the karyotype was analysed from two different cells of the same root-tip. One of the cells showed a single accessory chromosome in its complement while in the other this was found to be absent.

Here in the cell with an accessory chromosome (Fig. 3C) the chromosome pairs C and I were found to be heteromorphic. The homologues varied in length. In the pair C the proximal arm of one homologue was found to be much smaller than the corresponding arm of its partner, suggesting deletion. The same was true of the I pair but the inequality between the two homologues was not so pronounced.

In the second cell (Fig. 4C) the chromosomes constituting the various pairs matched perfectly. The only difference noticed was in the occurrence of a secondary

constriction in one of the arms of each partner of the B pair—a feature not otherwise present in the karyotype.

Chandanwari population: In this case C pair was found to be heteromorphous (Fig. 5C). The two homologues were unequal and the larger partner possessed a secondary constriction in the long arm near the centromere which was absent in the other member.

Figs. 2a-c. Khilanmarg population. $\times 1500$. c, idiogram, Khilanmarg population.

Lianmarg population: The karyotype from this population exhibited very high degree of polymorphism. The pairs A, C, D, E, F, G, H were all heteromorphous differing either in length or in the number and position of secondary constriction or in both (Fig. 6C). The remaining pairs B, I, J matched perfectly. In addition to

Figs. 3a-c. Sonamarg population. Arrow indicates accessory chromosome. $\times 1500$. c, idiogram, Sonamarg population.

Figs. 4a-c. Sonamarg population. $\times 1500$. c, idiogram, Sonamarg population.

the usual complement of 20 chromosomes, an accessory chromosome with submedian centromere was also observed.

Gulmarg population: The karyotype of this population was described earlier (Mehra and Sachdeva 1975a) and the reader may refer to it for details. However, the karyotype is illustrated in Fig. 7C for the sake of comparison.

Figs. 5a-c. Chandanwari population. $\times 1500$. c, idiogram, Chandanwari population.

Figs. 6a-c. Lianmarg population. Arrow indicates accessory chromosome. $\times 1500$. c, idiogram, Lianmarg population.

Discussion

An appraisal of the above situation leaves us no doubt that chromosomal alterations do occur in the somatic tissues of root-tips in *Trillium govanianum*. Also it becomes apparent that the pair C was highly variable, whereas all the other pairs showed variability to a greater or lesser extent.

Figs. 7a-c. Gulmarg population. $\times 1500$. c, idiogram, Gulmarg population. The chromosome A on the left represents a break at the arrow due to pressure during squashing.

Heteromorphic pairs have also been observed by us in two other species with long chromosomes, i.e. in *Paris polyphylla* and *Allium victorialis* (Mehra and Sachdeva 1975a, b). This may well be a general phenomenon in species with long chromosomes. It is conceivable that congestion within the limited volume of the nuclear membrane during the nuclear division cycle, when the chromosomes appear in the form of elongated threads, may be responsible for such a phenomenon. If it does occur in the somatic tissue of the root-tips, it will not be ill-logical to assume their occurrence in other somatic tissues too, in the rhizome, stem tips and even in the somatic tissue in the floral reproductive organs. In fact the latter probably is the case, as suggested by us, in *Saccharum spontaneum* where in the C cytotype variable number of bivalents are manifested during sporogenesis (Mehra and Sood 1974). In Monocots where the vegetative reproduction is from the rhizomes, bulbs, tubers and bulbils, the altered karyotype could enter into the constitution of offsprings

under favourable circumstances, provided the alteration is not of a lethal type. This is the thesis of Sharma (1956). But while it is perfectly a logical deduction, no experimental or any other unequivocal proof in this direction has come forth.

In *Polygonatum multiflorum* chromosomal races with very different karyotypes are known which may differ also in chromosome numbers. The reports in the literature depict $2n=18, 20, 22, 24, 28$ and 30 . Likewise in *P. verticillatum* cytological races with $2n=27, 28, 30, 60, 66, 84, 86-91$ have been recorded. The same is true of *P. sibiricum* with $2n=20, 21, 26, 36$ (cf. Mehra and Pathania 1960). All these species possess long chromosomes. In *Disporum cantoniense*, also with long chromosomes, whereas the Himalayan and the Japanese taxa exhibit the same somatic chromosome number $2n=16$, there are differences in the details of the karyotype. It is also pertinent to emphasize that these species do reproduce vegetatively in nature, apart from reproduction by seeds. One thing, however, is certain. If the alteration in karyotype is brought about via the sex cells during seed formation, the zygote, which is a single cell, will be the starting point, whereas if it is via the somatic tissue, the same alteration shall have to occur in all the cells of the multicellular apical dome of the offspring unless the latter takes its origin from a single cell.

Taking an overall view of the situation there seem to be 4 systems operative in nature in respect of karyotypic stability in the vegetative tissue as discerned from the root-tips.

1. Karyotype is perfectly stable and does not exhibit alteration of any type, either in number, or in the morphology of chromosomes. Species with relatively small chromosomes like *Pterotheca falconeri* belong to this category (personal observations).

2. Karyotype is stable but there are numerical changes in the complement which may take the form of deletion or addition of whole chromosome/s, or duplication of the entire set of chromosomes which are otherwise unaltered in their morphology. The latter is frequently a prelude to differentiation of tissues such as xylem.

3. Karyotype is broadly stable in respect of the number of chromosomes as well the location of centromere which may be median, submedian or sub-terminal but the chromosome pairs show heteromorphism and there is alteration in the number and position of secondary constrictions (cf. *Trillium govanianum*). Species with long chromosomes which, therefore, lie congested in the restricted volume of the nucleus during the earlier phases of nuclear division, like the species of *Trillium*, *Allium*, *Polygonatum*, *Disporum* and others seem to be specially prone to it.

4. There are species which combine features 2 and 3 mentioned above.

Literature cited

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