Cytological Studies in *Chlorophytum attenuatum* Complex and Cytotaxonomic Considerations

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Received November 22, 1973

Introduction

Conservative estimates place the number of species of *Chlorophytum* at over 100 (Dress 1961). In India, Hooker (1892) has recorded 12 species seven of which are apparently restricted to the subcontinent. He has opined that species of *Chlorophytum* are most difficult of circumscription owing to great variability in the leaves and the length and robustness of the scapes and racemes. Santapau and Fernandes (1955) have added one more species making the total number of species as 13 for the country. Cytological work on the genus in India is fragmentary when compared to the number of species occurring in the country and this situation appears to be due to the difficulty of accessibility to the remote areas where the species are reported to occur.

Cytological reports on the genus from different countries reveal the existence of two distinct basic chromosome numbers of 7 and 8 among the species investigated. It is also evident from these studies that under the 8-basic series, diploids with $2n=16$ are almost the rule as in *C. alismifolium* (Baldwin and Speese 1951); *C. tuberosum* (Kumar and Rao 1958, Sheriff 1967, Dutta and Mitra 1968); *C. laxum* (Boraiah 1966, Sheriff 1967, Dutta and Mitra 1968). In the case of 7-basic series, however, diploids with $2n=14$ are very few as in *C. heyneanum* (Thomas 1960, Sheriff 1967); *C. laxum* (Baldwin and Speese 1951), while polyploids at different levels constitute the great majority. Under the latter category, species exist either at the tetraploid level with $2n=28$ as in *C. elatum* (Matsuura and Sato 1935, Yamazaki 1936, Sharma and Chatterjee 1958, Sheriff 1957); *C. orchidastrum* and *C. viviparum* (Baldwin and Speese 1951); or at the hexaploid level with $2n=42$ as in *C. arundinaceum* (Sheriff 1967, Virendra Kumar and Pahuja 1967); *C. brevicapsum*, *C. malabaricum* and *C. orchidastrum* (Sheriff 1967). In *C. nepalense*, two cytotypes, one with $2n=42$ and another with $2n=56$ have been reported (Sharma and Chatterjee 1958).

The taxon *C. attenuatum* (Wight) Baker, under present investigation is apparently endemic to India. Dress (1961) has stated that *C. attenuatum* is the name that has been recognised and used for this species since Baker made this combination, it seems that the correct and the oldest available epithet for this species should be *C. indicum* (Willdenow in Schultes and Schultes f.) Dress comb. nov. Populationwise studies on the cytological aspects of this species collected from different regions of southern and central India are highly revealing. The taxon is found to exist at the hexaploid level with $2n=42$ as well as 12-ploid level with $2n=84$ under the 7-basic

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series thus forming a complex and showing an interesting geographical distribution. Each population is distinct from the other in respect of several features. The present contribution is the first account of the karyomorphological aspects of three populations under *C. attenuatum* and the taxonomic implications arising out of the cytological findings.

Materials and Methods

Living plants were collected from three different localities: Mahabaleshwar Hill Station (Maharashtra State), Londa plains (Northern Mysore State) and Nandi Hills (Southern Mysore State) and were grown at the departmental garden in Bangalore. Somatic chromosome number was determined from root tips pretreated either with colchicine or 8-hydroxyquinoline and stained with acetic orcein. Meiotic studies were made from acetic carmine squashes of pollen mother cells. For the study and comparison of karyotypes the chromosomes are classified on the basis of the position of the centric constriction and the presence or absence of secondary constriction, into four types: S-type (Chromosome with secondary constriction), V-type (metacentric), J-type (submetacentric) and I-type (subtelocentric).

Observations

1. *C. attenuatum* from Londa plains (Fig. 7)

The plants are comparatively the smallest among the three populations, with a rosette of short and oblong leaves and an erect unbranched scape with densely arranged flowers and fruits. The karyotype consists of $2n=42$ chromosomes (Figs. 1 and 8). The karyotype formula is $2n=42=6S+8V+12J+16I$. Fig. 2 is the idiogram of the haploid somatic complement. The length of the chromosomes ranges from $3.40\ \mu$ to $8.92\ \mu$. The computed absolute length of the chromosomes is $210.80\ \mu$. There are three pairs of satellited chromosomes, the satellites being interstitial in all. Meiosis is normal with the formation of 21 bivalents, three of them being associated with the nucleolus (Fig. 9). Anaphase I and II are normal.

2. *C. attenuatum* from Mahabaleshwar Hills (Fig. 10)

The plants are of medium size with linear leaves. The karyotype consists of $2n=42$ chromosomes (Figs. 3 and 12) and the formula is $2n=42=4S+8V+20J+10I$. Fig. 4 is the idiogram. The length of the chromosomes ranges between $3.20\ \mu$ and $10.60\ \mu$ and the absolute length is $259.76\ \mu$. There are two pairs of chromosomes with interstitial satellites. 21 bivalents were counted at metaphase I (Fig. 13). Anaphase I and II are normal.

In this collection, a few plants were isolated in which the somatic chromosome number was found to be $2n=84$ (Figs. 5 and 11). These were phenotypically indistinguishable from the others with $2n=42$.

3. *C. attenuatum* from Nandi Hills (Fig. 14)

The plants are the largest among the collections. The leaves are linear and

reach a length of upto 26 cm and a breadth of upto 3 cm and the inflorescence reaching a height of upto 30 cm. It is possible to distinguish two varieties within this population differing in respect of certain phenotypic characters like narrower and longer leaves and bracts and less dense distribution of flowers on the scape in one of these varieties.

Figs. 1-4. Camera lucida drawings. 1, karyotype of *C. attenuatum* ($2n=42$) from Londa area. $\times 1455$. 2, its idiogram. 3, karyotype of *C. attenuatum* ($2n=42$) from Mahabaleshwar area. $\times 1455$. 4, its idiogram.

Figs. 5-6. Camera lucida drawings. 5, karyotype of *C. attenuatum* ($2n=84$) from Mahabaleshwar area. $\times 1455$. 6, karyotype of *C. attenuatum* ($2n=84$) from Nandi Hills. $\times 1455$.

Figs. 7-16. 7, photograph of *C. attenuatum* from Londa. 8, its karyotype. 9, its PMC at diakinesis. 10, *C. attenuatum* from Mahabaleshwar. 11, its karyotype with $2n=84$. 12, its karyotype with $2n=42$. 13, its PMC at M I. 14, *C. attenuatum* from Nandi Hills. 15, its karyotype ($2n=84$). 16, its PMC at M I.

The karyotypes in both consist of $2n=84$ chromosomes (Figs. 6 and 15). Although only two pairs of chromosomes with interstitial satellites were observed there could presumably be others, the detection of which might not have been possible on account of the large number, overcrowding and contracted nature of the chromosomes. Nonetheless, the somatic chromosomes conform to the general pattern of $2n=42$ types. Meiosis was studied in considerable detail as the plants flower profusely during July and August. In almost all pollen mother cells examined, 42 clear bivalents could be easily counted (Fig. 16). Occasionally, however, one or two quadrivalents were observed. Anaphase I and II were found to be normal.

Since this population is at a very high level of polyploidy a search was made on the hill station to find out if individuals with either $2n=42$ or some other number existed. No such plants have been found so far. Another feature worth recording in this connection is that the population on the isolated hill is progressively dwindling, the plants are becoming more and more scarce year after year and are also becoming more and more restricted to the summit regions.

Discussion and conclusions

The data emerging from the foregoing observations on the three populations under *C. attenuatum* from different regions reveal several interesting features which provide useful information for an understanding of the cytological, regional and ecological pattern of evolution within the taxon. The chromosome number of $2n=42$ and $2n=84$ in the populations fits the species very well in the 7-basic euploid series in the genus. If $2n=14$ is taken as representing the diploid number then the species *attenuatum* exists either at the hexaploid level with $2n=42$ or at the 12-ploid level with $2n=84$, the highest recorded chromosome number in the genus so far. While populations with $2n=42$ fall in line with the hexaploid species already investigated (*C. arundinaceum*, *C. brevicapsum*, *C. malabaricum*, *C. orchidastrum*, and *C. nepalense*) the 12-ploids with $2n=84$ are unique in existing at the highest level of ploidy. This is indicative of the extent to which polyploidy has proceeded in the evolutionary history of the genus.

Equally interesting is the pattern of regional distribution of the polyploids. In the Londa area, only hexaploids are found while in the Mahabaleshwar hill station hexaploids and 12-ploids are found to occur together. On the Nandi hills only 12-ploids are to be found. Such regional intraspecific variations within the species are of considerable biosystematic importance and are receiving much attention of late. With regard to the nature of polyploidy in the three populations, the situation is different in each. Karyotypic evidence coupled with meiotic studies is indicative of the incidence of allopolyploidy in all the three populations but the karyotype of each is distinct from the other thus revealing genotypic differences. As for the 12-ploids occurring side by side with the hexaploids in the Mahabaleshwar area and which are phenotypically indistinguishable, a comparison of their karyotypes shows that the chromosomes in the former are in duplicate sets of the latter thus indicating their autotetraploid origin.

The situation in the Nandi Hills population is unique in several respects which

are highly significant and deserve special treatment. The population is small and restricted to the isolated hill station. The plants exist exclusively at the 12-ploid level. Individuals at any other level of ploidy have not been found so far. Conceivably, they may not exist. A careful analysis of the karyotype, formation of 42 clear bivalents at diakinesis, normal fertility as evidenced by profuse fruit and seed-set is indicative of the allopolyploid origin of this population. The occasional formation of one to two quadrivalents could, however, be attributed to either translocation or segmental polyploidy. Another noteworthy feature is the progressive dwindling of the population (as observed by the authors during the past 25 years) for reasons unknown. Perhaps, the population is in a process of eventual disappearance! Heslop-Harrison (1960) writing on regional variation at the level of species has discussed the possibility of the operation of genetic drift in small populations leading to the fixation of non-adaptive genotypes and has made pointed references to the existence of highly anomalous minor populations of plants often occurring confined to remote islands and isolated mountain summits owing their distinctive features to this process. The Nandi Hills population, perhaps represents a population of this kind!

With regard to the phenotypic correlations among the three populations each is phenotypically distinct in characters like the size of the plant, leaf size and shape, height of the inflorescence, bracts etc. although they are found growing under more or less similar conditions. They have also been found to retain their distinctive phenotype when grown together in the garden. The plants from the Londa area are comparatively the smallest with short and elliptic leaves arranged in a rosette form and look very much different from the others either on Mahabaleshwar or Nandi Hills. The Mahabaleshwar plants are medium sized with linear but shorter leaves thus forming a class by themselves in their phenotype. The Nandi Hill plants are the largest with linear and broad leaves. Even for a casual observer plants of the three populations looklike three distinct species!

The data presented above clearly reveal the regionwise superimposition of phenotypic variation over cytological variation in the three populations investigated in the present work. They not only establish the phenotypic and cytological distinctiveness of each population but also provide a basis and present a strong case warranting the break-up of the species *attenuatum* and accord of independent taxonomic status to each of the three populations on biosystematic considerations. With regard to the question of operation of isolation mechanisms among the populations many cytogeneticists argue that all observations of differences in chromosome number, karyotypes etc. should be accepted as indicative of specific distinctions because of their implications of sterility. Viewed in these contexts, the Nandi Hill population with its karyotypic, phenotypic and regional uniqueness would present the strongest case warranting its removal from *attenuatum* and its elevation to the rank of a new species in the genus *Chlorophytum*. The next in order to claim a similar taxonomic status is the Londa population with its own distinct phenotype and genotype.

Summary

Three populations under *Chlorophytum attenuatum* collected from three different geographical regions in India have been subjected to cytological and cytotaxonomic studies. Cytological studies have revealed that the species exists at different levels of polyploidy under the 7-basic chromosome number series in the genus, exhibiting a very interesting regional distribution pattern. The population from the Londa area consists of hexaploids ($2n=42$). The Mahabaleshwar population is a mixture of hexaploids ($2n=42$) and 12-ploids ($2n=84$) which are morphologically indistinguishable. The Nandi Hill population is unique both phenotypically and cytologically in consisting of only 12-ploids ($2n=84$). The chromosome number of $2n=84$ as a stabilised condition is the highest recorded so far in the genus. While the karyotypic features of all the three populations conform to the general karyotype pattern in the genus, the karyotype of each population is distinct from the other. Meiotic behaviour is indicative of the allopolyploid nature of the three populations. The superimposition of phenotypic variation over cytological variation in each population makes them so distinct that it provides a basis for the breaking up of the species *attenuatum* on cytotaxonomic and biosystematic considerations, removal of Nandi Hill and Londa populations from *attenuatum* and their elevation to the rank of new species under *Chlorophytum*.

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