Asian Journal of Crop Science

ISSN 1994-7879

OPEN ACCESS

Asian Journal of Crop Science

ISSN 1994-7879
DOI: 10.3923/ajcs.2024.1.5

Research Article

Cytotypic Diversity in Selected Taxa of Botanical Garden of Botanical Survey of India, Central Regional Center, Allahabad

Ashutosh Kumar Verma

Department of Botany, Siddharth University, Kapilvastu, Siddharthnagar, Uttar Pradesh 272202, India

Abstract

Background and Objective: Botanical gardens are conservatories where living plants are conserved for scientific, academic and awareness programs. Assessments of existing cytotypic diversity at inter and intraspecific levels provide a real pen picture of the genetic diversity of germplasm present in any *ex situ* conservatory like botanical garden. Therefore, the present investigation was undertaken for the assessment of cytotypic diversity in targeted taxa. **Materials and Methods:** A total number of 51 species of economically important angiosperms which are growing in the botanical garden of Botanical Survey of India, Central Regional Center and Allahabad were investigated for evaluation of existing cytotypic diversity. Meiotic preparations were made as per the standard squash preparation technique. **Results:** Among the worked-out species 47 species were represented by a single cytotype and the remaining four by two cytotypes. Besides, new cytotypes were recorded for 07 species of angiosperms which are possibly new to science. **Conclusion:** The findings of the present investigation are important in terms of the assessment of genetic diversity and conservational aspects of the aforesaid botanical garden. The identified unique germplasm of the concerned species will be utilized by the researchers who are working on genetic improvement and gene identification programs.

Key words: Botanical garden, conservation, cytotypes, germplasm, ploidy

Citation: Verma, A.K., 2024. Cytotypic diversity in selected taxa of botanical garden of botanical survey of India, central regional center, Allahabad. Asian J. Crop Sci., 16: 1-5.

Corresponding Author: Ashutosh Kumar Verma, Department of Botany, Siddharth University, Kapilvastu, Siddharthnagar, Uttar Pradesh 272202, India

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Knowledge of available cytotype diversity in any life form provides clues on ongoing evolutionary processes as well as provide information regarding unique germplasm viz., aneuploids, euploids, polyploids, etc. Such germplasm is very important and utilized by researchers in chromosome identification, gene identification, crop improvement programs, etc. Hence their identification, information about their availability and place of availability are very essential. Botanical gardens are sites where plants are gathered together for systematic studies. At present globally 2500 botanic gardens are existing which cumulatively conserve 6 million accessions of living plants, representing around 80000 taxa[1,2]. According to Dosman[3] botanical gardens are favourite sites for taxonomic and systematic studies as plants of different geographical and agroclimatic zones are available under one roof. Although, botanical gardens have great potential to contribute to different streams of biological sciences, inadequate knowledge of existing intraspecific and infraspecific genetic diversity limits their exploration[4].

The Botanical Garden of Botanical Survey of India, Central Regional Center, Allahabad (BSI, CRC, Allahabad) is situated at 181 m Altitude, 250 28'North and 810 51'Longitude and covers about 2.5 ha. It nurtures 663 species having medicinal, economically important, ornamental, rare and threatened plants belonging to 118 families[5]. The garden comprises many sections including aquatics, arboretum, bambusetum, gymnosperms, medicinal plants, net house, ornamental plants, plant introduction, RET species and rosary. Despite of vast gathering of unique germplasm of different species till the year 2019, no effort was made to explore the cytotypic diversity in available germplasm. Hence, in the light of above-mentioned facts, the present investigation was undertaken to explore the existing cytotypic diversity in targeted plant species.

MATERIALS AND METHODS

Study area: The present investigation was carried out between 2020-2021 at the botanical garden of Botanical Survey of India, Central Regional Center, Allahabad.

Study design: In the case of trees and shrubs, the cytological investigation was performed on an individual plant basis whereas in herbaceous it was on a population basis. For cytological investigations requisite plant materials were collected on each plant basis or population basis which depends on the habit of the species. The chromosomal count in each case was made through male meiotic preparation for which appropriate sized buds were fixed in Carnoy's fixative (6 Ethanol: 3 Chloroform: 1 Acetic acid v/v) for 24 hrs then the material was transferred into 70% ethanol and stored in the refrigerator at 4°C. The meiotic squash preparations were made in 2% acetocarmine adopting standard methodologies. Slides were observed under the Nikon Eclipse 200 microscope and chromosome counts were made.

RESULTS AND DISCUSSION

In the present investigation 51 species of angiosperms belonging to 37 genera and 20 families, conserved in the Botanical Garden of BSI, CRC, Allahabad were cytologically analyzed. In Table 1 the information on available cytotypes, their ploidy level, earlier reported chromosome count, etc. were summarized. Among them, 28 and 23 species were analyzed on a population and individual plant basis, respectively. As per Chromosome Counts Database(http://ccdb.tau.ac.il) and Chromosome Atlas of Flowering Plants of Indian Subcontinent[6] current findings showed close resemblance with the findings of earlier workers. Forty seven species were represented by a single cytotype, the remaining four viz., *Cassia fistula* (2n = 26, 28), *Rauvolfia tetraphylla* (2n = 44, 66), *Solanum nigrum* (2n = 24, 72) and *S. villosum* (2n = 24, 72) by two cytotypes. Review of the literature indicates that for *C. fistula* three cytotypes (2n = 24, 26, 28) were reported so far of which 2n = 28 is found most common. The cytotype 2n = 24 and 2n = 26 was found rare and reported by a few workers[6-8]. The observations on *Rauvolfia tetraphylla* support the findings of earlier workers[9-11]. For *S. nigrum* and *S. villosum* two cytotypes ($2X_i$, 6x) were observed which showed consonance with the findings of Melo *et al.*[12], Kumar and Pushpangdhan[13].

Bogunić *et al.*[14] opined that genomic and cytotypes diversity is possibly a major cause of reproductive isolation and finally leads to speciation. Discovery of new cytotypes is always challenging but it is desirable because they will be utilized as experimental material for a better understanding of ongoing evolutionary processes[15]. In the present investigation, new cytotypes were recorded for seven species viz. *Allium tuberosum* (2n = 28), *Chlorophytum nepalense* (2n = 26), *Chlorophytum tuberosum* (2n = 30), *Crotalaria spectabilis* (2n = 26), *Ocimum basilicum* (2n = 78), *Sansevieria cylindrica* (2n = 38) and *Sansevieria trifasciata*

Table 1: Study pattern and cytological observations in different taxa

Species	Family	Study pattern	Observed chromosome No. (2n)	Ploidy	Reported chromosome number (By earlier workers)
Achyranthes aspera L. (x = 7)	Amaranthaceae	Population basis	28	4x	28, 42,48, 56, 96
Allium tuberosum Rottler ex Spreng. (x = 7)	Amaryllidaceae	Population basis	28*	4x	24,31,33,32,62
Aloe vera (L.) Burm. F. (x = 7)	Xanthorrhoeaceae	Population basis	14	2x	14, 21,38
Antigonon leptopus Hook. and Arn. (x = 7)	Polygonaceae	Population basis	42	6x	14,40, 42, 44,48
Asparagus racemosus Willd (x = 11)	Asparagaceae	Population basis	22	2x	20, 22, 40
Azadirachta indica A. Juss. (x = 14)	Meliaceae	Individual plant	28	2x	28, 30
Basella alba L. (Green) (x = 11,12)	Basellaceae	Individual plant	44	4x	44, 48
Bauhinia purpurea L. (x = 14)	Leguminosae	Individual plant	28	2x	28
Bauhinia variegata L. (x = 14)	Leguminosae	Individual plant	28	2x	28
Boerhavia diffusa L. (x = 13)	Nyctaginaceae	Population basis	56	Aneuploid	26, 52, 116
Caesalpinia pulcherrima (L.) Sw. (x = 11, 12)	Leguminosae	Individual plant	28	Aneuploid	22,24,28
Cassia fistula L. (x = 6, 7, 8; x_2 = 13)	Leguminosae	Individual plant	26, 28	2 x_2; 2x	24,26, 28
Chlorophytum comosum (Thunb.) Jacques (x = 7)	Asparagaceae	Population basis	28	4x	28
C. nepalense (Lindl.) Baker (x = 7, 8)	Asparagaceae	Population basis	26*	Aneuploid	28,40,42, 56
C. tuberosum (Roxb.) Baker (x = 7)	Asparagaceae	Population basis	30*	Aneuploid	16
Crotalaria spectabilis Roth (x = 8)	Leguminosae	Population basis	26*	Aneuploid	16,24
Datura stramonium L. (x = 12)	Solanaceae	Population basis	24	2x	24, 25,36, 48
Delphinium ajacis L. (x = 8)	Ranunculaceae	Individual Plant basis	16	2x	16, 24
Gymnema sylvestre (Retz.) R. Br. ex Sm. (x = 11)	Apocynaceae	Individual plant	22	2x	22
Haworthiopsis limifolia (Marloth) G. D. Rowley (x = 7)	Xanthorrhoeaceae	Population basis	28	4x	14,21,28
Helicteres isora L. (x = 9)	Malvaceae	Individual plant	18	2x	18,20,24,38
Justicia simplex D. Don (x = 9)	Acanthaceae	Individual plant	18	2x	18, 36
Justicia adhatoda L. (x = 7, 8, 9; x_2 = 17)	Acanthaceae	Population basis	34	2x	34,40,46, 50
Lantana camara L. (x = 11)	Verbenaceae	Population basis	44	4x	22, 32, 33,36, 44, 55, 66
Lantana montevidensis (Spreng.) Briq. (x = 11, 12)	Verbenaceae	Individual plant	48	4x	22, 36, 48
Ocimum basilicum L. (x = 8)	Lamiaceae	Population basis	78*	Aneuploid	30, 48, 52, 54, 56, 72,74
Oroxylum indicum (L.) Curz. (x = 14, 15)	Bignoniaceae	Individual plant	28	2*x*	28, 30, 38
Papaver rhoeas L. (x = 7)	Papaveraceae	Population basis	14	2x	14, 15,16,18, 21, 28,30, 42
Phlomoides superba (Royle) Kamelin & Makhm (x = 11)	Lamiaceae	Individual plant	22	2*x*	22
Physalis minima L. (x = 12)	Solanaceae	Population basis	48	4x	24, 48, 72
Pongamia pinnata (L.) Pierre (x = 10, 11)	Leguminosae	Individual plant basis	22	2x	20, 22
Rauvolfia serpentina (L.) Benth. ex Kurz (x = 10, 11)	Apocynaceae	Population basis	22	2x	20, 22, 44
Rauvolfia tetraphylla L. (x = 11)	Apocynaceae	Population basis	44, 66	4x, 6x	44, 55, 66, 68, 88
Sansevieria cylindrica Bojer ex Hook (x = 14*a)	Asparagaceae	Individual plant	38*	Aneuploid	28, 36, 42
Sansevieria trifasciata Prain (x = 9*a)	Asparagaceae	Individual plant	56*	Aneuploid	18, 40, 84, 92, 102, 103, 104, 112,119, 120
Sansevieria zeylanica (L.) Willd. (x = 20,21)	Asparagaceae	Individual plant	40	2x	40, 42
Santalum album L. (x = 10)	Santalaceae	Individual plant	20	2x	10,20,40
Saraca asoca (Roxb.) Willd.(x = 12)	Leguminosae	Individual plant	24	2x	24
Senna alata (L.) Roxb. (x = 6, 7, 8)	Leguminosae	Individual plant	28	4x	24, 28
Senna obtusifolia (L.) H.S. Irwin & Barneby (x = 6, 7, 8)	Leguminosae	Population basis	28	4x	24, 28, 52, 56
Senna tora L. (x = 6, 7, 8)	Leguminosae	Population basis	28	4x	26, 28, 52,56
Senna sulfurea (Collad.) H. S. Irwin & Barneby (x = 6, 7, 8)	Leguminosae	Individual plant (2)	28	4x	28, 56
Solanum diphyllum L. (x = 12)	Solanaceae	Population basis	24	2x	24
Solanum nigrum L. (x = 12)	Solanaceae	Population basis	24, 72	2x, 6x	24, 36, 48, 60, 64, 72, 96, 144
Solanum villosum L. (x = 12)	Solanaceae	Population basis	24,72	2x, 6x	24, 48, 50, 72
Solanum virginianum (x = 12)	Solanaceae	Population basis	24	2x	24
Tamarindus indica L. (x = 12)	Leguminosae	Individual plant	24	2x	24, 26, 28
Tinospora cordifolia (Willd.) Miers ex Hook.f. and *Thoms* (x = 12)	Menispermaceae	Population basis	26	Aneuploid	24, 26
Uraria picta (Jacq.) DC. (x = 8)	Leguminosae	Individual plant (2)	16	2x	16, 22
Urena lobata L. (x = 7)	Malvaceae	Population basis	28	4x	14,28, 56
Withania somnifera (L.) Dunal (x = 12)	Solanaceae	Population basis	48	4x	24, 48, 72

*: New chromosome count (Cytotype) for particular species, x: Basic chromosome number, x_2: Secondary basic chromosome number and *a: Basic chromosome count assumed on the basis of lowest 2n number

(2n = 56) which are possibly new to science[6,7]. A total number of 26 species are identified as diploid, 15 as tetraploid, 04 as hexaploid and 09 as aneuploidy individual-containing species (Table 1). de Queiroz[16] and Meudt *et al.*[17] opined that ploidy change is very crucial for the speciation and diversification of plants. According to maximum workers change in the ploidy level of plants affects their qualitative and quantitative attributes and individuals having these changes are important for genetic improvement programs, the study of evolutionary trends, etc. In the case of *Boerhavia diffusa*, *Caesalpinia pulcherrima*, *Chlorophytum nepalense*, *C. tuberosum*, *Crotalaria spectabilis*, *Ocimum basilicum*, *Sansevieria cylindrica*, *S. trifasciata*, *Tinospora cordifolia* aneuploidy individuals were also observed (Table 1). Aneuploids generally formed by the gain or loss of chromosomes from the normal set of chromosomes, are very crucial for locating a linkage group and a gene in a particular chromosome[18]. Hence, there is a need to conserve these identified elite genotypes including aneuploids[18].

Lastly, cytological techniques have a number of limitations viz. time factor, requirement of advanced microscope facility and trend professions but the findings of present investigation prove the potential of the mentioned technique in assessment of existing genetic diversity in any germplasm and identification of the elite genotypes of particular species. The findings were also important in terms of research including genetic improvement program for economically important species, academics and formulation of conservation strategies. Keeping the mentioned facts and requirement of assessment of genetic diversity of any germplasm collection in mind similar types of investigations are recommended for the botanical gardens of India.

CONCLUSION

The findings of the present investigation on the one hand demonstrated the importance of cytological studies in the assessment of genetic variability in germplasm holdings of *ex situ* conservatories like botanical gardens on the other hand demonstrated the urgent need to start similar types of studies. Besides these, this type of studies will definitely provide help to the researchers who want to work on unique germplasm of economically or scientifically important plant species as search, identification and characterization of unique germplasm of any plant species is a tedious task.

SIGNIFICANCE STATEMENT

The present investigation was undertaken for the assessment of existing cytotypic diversity in germplasm collection of fifty-one targeted plant species. The key findings includes identification of rare cytotype for *C. fistula* (2n = 26) and new cytotype for *Allium tuberosum* (2n = 28), *Chlorophytum nepalense* (2n = 26), *Chlorophytum tuberosum* (2n = 30), *Crotalaria spectabilis* (2n = 26), *Ocimum basilicum* (2n = 78), *Sansevieria cylindrica* (2n = 38) and *Sansevieria trifasciata* (2n = 56) which are possibly new to science. Besides these polyploid and aneuploid individuals were identified for 19 and 09 species of angiosperms respectively which are very important in terms of gene identification and genetic improvement programs of economically important species.

ACKNOWLEDGMENTS

Present work carried out under Annual Action Plan Project of Botanical Survey of India. The author is grateful to Director, BSI, Kolkata, and HoO BSI, CRC, Allahabad for providing all necessary facilities and support for executing the present research work.

REFERENCES

1. Golding, J., S. Güsewell, H. Kreft, V.Y. Kuzevanov, S. Lehvävirta, I. Parmentier and M. Pautasso, 2010. Species-richness patterns of the living collections of the world's botanic gardens: A matter of socio-economics? Ann. Bot., 105: 689-696.
2. O'Donnell, K. and S. Sharrock, 2017. The contribution of botanic gardens to *ex situ* conservation through seed banking. Plant Divers., 39: 373-378.
3. Dosmann, M.S., 2006. Research in the garden: Averting the collections crisis. Bot. Rev., 72: 207-234.
4. Blackmore, S., M. Gibby and D. Rae, 2011. Strengthening the scientific contribution of botanic gardens to the second phase of the global strategy for plant conservation. Bot. J. Linn. Soc., 166: 267-281.
5. Singh, R.K., 2016. Plants of associated botanic garden, botanical survey of India, Central Regional Centre, Allahabad. J. Non-Timber For. Prod., 23: 37-54.
6. Irwin, H.S. and B.L. Turner, 1960. Chromosomal relationships and taxonomic considerations in the genus cassia. Am. J. Bot., 47: 309-318.
7. Dutta, A. and B. De, 2002. *Cassia fistula*: A source of sennoside b (chromosome morphology and sennoside content). Acta Hortic., 576: 45-48.
8. Mohanty, S. and A.B. Das, 2006. Interspecific genetic diversity in 15 species of *Cassia* L. evident by chromosome and 4C nuclear DNA analysis. J. Biol. Sci., 6: 664-670.
9. Harun Ar Rashid, M., C.K. Dash, S. S. Alam and S.S. Sultana, 2019. Differential chromosome banding of three *Rauvolfia* species. Cytologia, 84: 143-146.
10. Tapadar, N.N.R., 1964. Cytotaxonomic studies in apocynaceae and delineation of the different evolutionary tendencies operating within the family. Caryologia, 17: 103-138.

11. Raghavan, R.S., 1957. Chromosome numbers in Indian medicinal plants. Proc. Indian Acad. Sci., 45: 294-298.
12. Melo, C.A.F., M.I.G. Martins, M.B.M. Oliveira, A.M. Benko-Iseppon and R. Carvalho, 2011. Karyotype analysis for diploid and polyploid species of the *Solanum* L. Plant Syst. Evol., 293: 227-235.
13. Kumar, A. and P. Pushpangadan, 2005. Molecular systematic study of variants of *Solanum nigrum* L. in India. Cytologia, 70: 33-38.
14. Bogunić, F., S. Iljak-Yakovlev, I. Mahmutović-Dizdarević, A. Hajrudinović-Bogunić, M. Bourge, S.C. Brown and E. Muratović, 2021. Genome size, cytotype diversity and reproductive mode variation of *Cotoneaster integerrimus* (Rosaceae) from the Balkans. Plants, Vol. 10. 10.3390/plants10122798.
15. Peirson, J.A., A.A. Reznicek and J.C. Semple, 2012. Polyploidy, infraspecific cytotype variation, and speciation in Goldenrods: The cytogeography of *Solidago* subsect. *Humiles* (Asteraceae) in North America. Taxon, 61: 197-210.
16. de Queiroz, K., 2007. Species concepts and species delimitation. Syst. Biol., 56: 879-886.
17. Meudt, H.M., D.C. Albach, A.J. Tanentzap, J. Igea and S.C. Newmarch *et al*., 2021. Polyploidy on Islands: Its emergence and importance for diversification. Front. Plant Sci., Vol. 12. 10.3389/fpls.2021.637214.
18. Huettel, B., D.P. Kreil, M. Matzke and A.J.M. Matzke, 2008. Effects of aneuploidy on genome structure, expression, and interphase organization in *Arabidopsis thaliana*. PLoS Genet., Vol. 4. 10.1371/journal.pgen.1000226.