Cytogenetical Investigations in Musaceae

I. Meiotic studies in South Indian bananas¹

P. K. Agarwal

Fruit Breeding Laboratory II
Indian Institute of Horticultural Research (I.C.A.R.)
Hessarghatta, Bangalore-560089, India

Received March 12, 1982

Banana is one of the most important fruit crops of the world. Banana cultivation in different parts of the world is threatened by the increased incidence of diseases like Panama disease, bunchy top, bacterial wilt and burrowing nematodes. Being, heterozygous and triploid in nature, improvement of cultivated banana can not be done by conventional breeding methods. Banana breeding essentially involves breeding male fertile diploids and crossing them with cultivated diploids or triploids which form restitution nuclei apart from having other desirable characters of commercial importance (to obtain primary triploids and tetraploids) (Rowe and Richardson 1975).

South India is one of the probable places of origin of bananas (Simmonds 1966), it represents diverse forms among cultivated varieties which are both diploids and triploids. Earlier studies on cytological behaviour of different Indian banana varieties were confined to determination of chromosome number (Roy and Sharma 1951, Govindaswami 1962, Raman *et al.* 1970). Present investigations were undertaken to study the meiotic behaviour of chromosomes, extent of restitution nucleus formation and male fertility in 17 banana varieties from South India to assess their value in breeding programme.

Material and methods

Banana varieties were collected from different locations in South India and planted at Indian Institute of Horticultural Research, Bangalore. For meiotic studies, young male inflorescence of banana were taken and flower buds were exposed by removing the bracts one by one. Flower buds were tested and those showing different stages of meiosis were fixed in Carnoy's fixative (6: 3: 1) for 24 hours at 15°C. Squash preparations were made using 2% acetocarmine solution. Photomicrographs were taken from temporary slides.

Observations

Out of seventeen varieties of Banana investigated cytologically, 6 were found to be diploid having $2n=22$ chromosomes and 11 were triploid having $2n=33$ chromo-

¹ Contribution No. 24/82 of Indian Institute of Horticultural Research, Bangalore.

somes (Table 1). Diploid varieties were characterized by the presence of a high frequency of bivalents at metaphase I of meiosis ranging from 7.94 to 11 bivalents per PMC. Univalents and trivalents were not frequently observed. Chromosomal distribution in varieties, Hoo bale and Ney poovan was found to be very regular, whereas, varieties Adakka kunnan, Kunnan and Then Kunnan showed unequal distribution of chromosomes at anaphase I. No laggards were observed in any of the diploid variety investigated except Then Kunnan where 50% of PMCs showed laggards ranging from 2–6 per cell. In variety Attikol meiosis was normal upto metaphase-I, at this stage eleven bivalents formed regularly. Later on during the course of movement to the two poles at anaphase-I, chromosomes disorganise in all the PMCs examined. Cytoplasm divides in 17.58% cells forming diads and 82.42%

Table 1. Table showing chromosomal association in PMCs of different *Musa* varieties

Musa varieties	2n chr. no.	Genomic grouping*	Univalents/PMC	Bivalents/PMC	Trivalents/PMC	Quadri-valents/PMC	Figs.
Diploid varieties:							
Adakka Kunnan	22	AB	0.29	10.00	0.57	—	—
Attikol	22	—	3.57	8.57	0.43	—	1, 2
Hoo bale	22	—	0.72	10.63	—	—	—
Kunnan	22	AB	—	11.00	—	—	—
Ney poovan	22	AB	6.11	7.94	—	—	3
Then Kunnan	22	AB	1.85	9.85	—	—	4, 13
Triploid varieties:							
Boothi bale	33	ABB	4.83	7.33	4.50	—	—
Chakkia	33	ABB	7.83	10.83	0.08	—	11
Kari bale	33	—	9.75	10.50	0.75	—	—
Karpura bale	33	—	3.14	7.00	5.29	—	5
Lacatan	33	AAA	12.50	3.50	4.50	—	6, 10
Lady's finger	33	—	5.00	12.33	1.11	—	7, 12
Nendra bale	33	—	4.89	10.67	2.67	—	—
Ney vannon	33	ABB	4.89	13.89	0.11	—	8
Poovan	33	AAB	6.00	11.79	2.86	—	—
Rasthali	33	AAB	4.43	7.57	4.29	0.14	—
Red Kali	33	—	6.25	7.00	4.25	—	9

* Simmonds 1966, Bhakthavatsalu *et al.* 1978.

cells remain as such (monads). Both in monads as well as in diads, cytoplasm shrinks and these shrivel later on. No further division takes place and the pollen do not form. Development of tapetal cell was found to be normal in this variety. In other diploid varieties the division proceeded upto telphase II but the pollen were sterile. However, 20% pollen fertility was observed in var. Hoo bale.

Triploid varieties showed various chromosomal configurations consisting of univalents ranging from 3.14 to 12.50/cell, bivalents ranging from 7.00 to 13.89/cell and trivalents ranging from 0.08 to 5.29/cell. Quadri-valents (0.14/cell) were observed in variety Rasthali only. Chromosomal distribution in all the triploid varieties was very irregular and varying number of laggards were observed ranging from 0 to 10 per PMC at anaphase I. Pollen fertility varied from 0% in variety

Figs. 1-9. 1, var. Attikol — PMC at M_1 showing 9 bivalents and 4 univalents. $\times 1200$. 2, var. Attikol — PMC at A_1 showing disorganization of chromosomes. $\times 1200$. 3, var. Ney Poovan — PMC at M_1 showing 1 trivalent, 3 bivalents and 13 univalents. $\times 1000$. 4, var. Then Kunnan — PMC at M_1 showing 11 bivalents. $\times 1250$. 5, var. Karpura bale — PMC at A_1 showing unequal distribution of chromosomes (15-18). $\times 1100$. 6, var. Lacatan — PMC at A_1 showing unequal distribution of chromosomes (16-17). $\times 800$. 7, var. Lady's finger — PMC at A_1 showing unequal distribution of chromosomes (16-17). $\times 1250$. 8, var. Ney Vannan — PMC at M_1 showing multivalents. $\times 1300$. 9, var. Red Kali — PMC at M_1 showing 4 trivalents, 7 bivalents and 7 univalents. $\times 1250$.

Poovan to 59.70% in variety Red Kali (Table 2). Restitution nuclei formation was not observed in any variety.

Figs. 10-13. 10, var. Lacatan — PMC at M_1 showing 13 bivalents and 7 univalents. $\times 1500$.
11, var. Chakkia — PMC at A_1 showing unequal distribution of chromosomes (14-19). $\times 1500$.
12, var. Lady's finger — PMC at M_1 showing 4 trivalents, 6 bivalents and 9 univalents. $\times 1500$.
13, var. Then Kunnan — PMC at A_1 showing unequal distribution of chromosomes. $\times 1500$.

Discussion

Bananas of commerce are mostly triploids and heterozygous in nature, except few varieties which are diploid. Triploid genome of the cultivated banana is the result of natural selection for years. Any crossing programme with these cultivated varieties will lead to the segregation of this highly selected genome and the product will be deficient in many desirable characters. The property of certain diploid and triploid varieties of banana to form restitution nuclei makes banana breeding possible (Rowe and Richardson 1975). Such clones if pollinated by a diploid resistant clone (producing haploid gametes) will produce triploid and tetraploid plants which will have all the desirable characters of cultivated banana plus the disease resistance from diploid male parent.

Table 2. PMCs showing chromosomal distribution at anaphase I in different varieties of *Musa* and their pollen fertility

Varieties	Distribution					Other dist. %	Laggards/PMC		Pollen fertility
	10-12 %	11-11 %	16-17 %	15-18 %	14-19 %		Range %	Showing PMC laggards	
Diploid varieties:									
Adakka Kunnan	67.00	33.00	—	—	—	—	—	0	0
Attikol	—	100	—	—	—	—	—	0	Absent
Hoo bale	—	100	—	—	—	—	—	0	20
Kunnan	34.00	66.00	—	—	—	—	—	0	0
Ney poovan	—	100	—	—	—	—	—	0	Absent
Then Kunnan	25.00	25.00	—	—	—	50.00	2-6	50.00	0
Triploid varieties:									
Boothi bale	—	—	25.00	25.00	25.00	25.00	0-2	12.50	55.00
Chakkia	—	—	18.18	18.18	—	63.64	0-10	72.72	38.91
Kari Bale	—	—	40.00	20.00	—	40.00	0-5	20.00	46.45
Karpura bale	—	—	12.5	12.5	—	75.00	0-4	75.00	0.00
Lacatan	—	—	62.5	25.00	—	13.5	0-8	12.5	53.16
Lady's finger	—	—	—	—	—	—	—	—	Absent
Nendra bale	—	—	33.33	—	—	66.34	0-3	58.33	Absent
Ney vannon	—	—	33.33	—	—	66.34	0-7	67.00	26.47
Poovan	—	—	—	71.42	14.28	14.30	1-2	28.5	0.00
Rasthali	—	—	20.00	20.00	40.00	20.00	—	0.00	1.75
Red Kali	—	—	77.77	11.11	11.11	—	—	0.00	59.70

Present studies were undertaken to isolate the commercial diploid and triploid varieties which show restitution nuclei formation and diploid varieties which have high pollen fertility so that these can be used for developing resistant lines for later crossing with these restitution nuclei forming cultivars. In 17 varieties examined (including diploids and triploids) various chromosomal configurations were observed. Diploid varieties showed a high frequency of bivalent formation at M_1 and regular separation of chromosomes at A_1 and A_2 but pollen fertility was nil, this indicates that sterility in banana is genic and not chromosomal which operate to bring about disorganization of chromosomes and microspores at different stages of development as observed in variety Attikol.

Based on the morphological characters and somatic chromosome count (Simmonds and Shepherd 1955) different banana varieties have been classified as comprising of AA, AB, AAA, AAB or ABB genomes (Simmonds 1966, Bhakthavatsalu *et al.* 1978). The absence of high frequency of a bivalents corresponding to BB and AA genome in Boothi bale and Rasthali respectively and absence of high frequency of trivalents corresponding to three A genome in Lacatan indicates that the genomes A or A & B are not present as complete genomes. There may be present some chromosomes of one genome and some of the other.

No restitution nuclei formation was observed in any of the varieties investigated, this makes impossible the use of these varieties in banana breeding programme.

Summary

Meiotic studies were conducted in 17 South Indian banana varieties. Different cytological abnormalities were observed. Sterility in diploid varieties of banana was found to be genic which operates to bring about disorganization of chromosomes and microspores at different stages of development. None of the variety showed restitution nuclei formation.

Acknowledgement

Thanks are due to Director, Indian Institute of Horticultural Research (ICAR), Bangalore for providing necessary facilities.

References

- Bhakthavatsalu, C. M., Sathiamoorthy, S. and Azhakiyamanavalan, R. S. 1978. Banana clonal situation in India. All India Co-ordinated Fruit Improvement Project Fruit Research Workshop, Bangalore.
- Dodds, K. S. and Simmonds, N. W. 1948. Sterility and parthenocarpy in diploid hybrids of *Musa*. *Heredity* 2: 101-117.
- Govindaswami, S. 1962. Cytogenetical studies on a non parthenocarpic wild diploid *Eumusa* variety Kadubalai. *Ind. J. Genet.* 22: 145-153.
- Raman, V. S., Sree Rangaswamy, S. R., Alikhan, W. M. and Manimekalai, G. 1970. A comparative cytomorphological analysis of diploid bananas. *Madras Agric. Jour.* 57: 604-611.
- Rowe, P. R. and Richardson, D. L. 1975. Breeding bananas for disease resistance, fruit quality and yield. *Bull. Trop. Agric. Res. Ser. La Lima Honduras*. pp. 41.
- Roy, R. S. and Sharma, C. 1951. Chromosome studies of Bihar bananas. *Ind. J. Genet. Pl. Breed.* 11: 210-214.
- Simmonds, N. W. 1966. Bananas. Longmans, pp. 512.
- and Shepherd, K. 1955. The taxonomy and origin of the cultivated bananas. *J. Linn. Soc. Bot. Lond.* 55: 302-312.
-