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# A Study of the Cytomorphology of some Banana Hybrids

*by*

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The extensive investigations on breeding of bananas in Trinidad oriented towards development of disease resistant forms which yield export quality produce have already indicated the undesirability of using the diploid parental wild species, *Musa acuminata* Colla. in such programmes. The hybrids and derivatives were inferior in quality of produce as well as in productivity and resistance to diseases. Even the few edible diploids had undesirable qualities which did not permit their use in hybridisation. The synthesis of a male parent which would transmit the desirable qualities was considered necessary (Simmonds, 1959). This way of approach towards improvement was intended only for stepping up the desirable quality of the singular variety, 'Gros Michel' grown in monoculture. The advantages resulting from the improvement of more than one variety have been emphasised by Dodds (1958). The improvement of Indian bananas may be considered to be of a different nature. The varieties grown for commercial purposes are more than one and the ranges of productivity and quality characteristics are also very high. The extent of cultivation of each variety depends upon the local

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markets as well as the agro-climatic conditions deciding their cultivation in specific areas. The ravages due to diseases as experienced in other countries have not been significant and it is only now that the threat due to 'bunchy top' and 'Panama disease' is felt and even there the existing variation has guarded devastation by epidemics.

With the view of improving the varieties, hybridisation has been practised in this State between cultivated bananas and three species of *Musa*. The cytomorphological features of the progenies are presented in this paper.

**Material and Methods:** The plant materials were drawn from the collection of the Horticulturist, Coimbatore, maintained at the Banana Research Station, Aduthurai. The progenies were derived by hybridisation of 11 clones of cultivated bananas (triploids) with *M.balbisiana* Colla., *M.chiliocarpa* Baker. (a form of *M.acuminata*) and *M.coccinea* Andr. (since identified as *M.rosacea* Jacq ). The following progenies were examined for their morphology and cytological behaviour.

TABLE 1. *Parentage of progenies and their frequencies in different chromosome groups*

| S. No. | Parentage | Chromosome number (2n) | | | |
|---|---|---|---|---|---|
| | | 22 | 24 | 33 | 44 |
| I. | *Triploid* × *Diploid* | | | | |
| 1. | 'Govakkar' × *M.balbisiana* | — | — | — | 1 |
| 2. | 'Laden' × " | 2 | — | — | — |
| 3. | 'Peykunnan' × " | — | — | — | 4 |
| 4. | 'Poovan' × " | 1 | — | — | — |
| 5. | 'Vennettinmannan' × " | — | — | — | 2 |
| 6. | 'Rasthali' × " | 1 | — | — | — |
| 7. | 'Rajavazhai' × " | — | — | — | 1 |
| 8. | 'Thote' × " | — | — | — | 3 |
| 9. | 'Peyan' × " clone 'Elavazhai' | — | — | — | 1 |
| 10. | 'Peykunnan' × " " | — | — | — | 3 |
| 11. | 'Rajavazhai' × " " | — | — | — | 6 |
| 12. | 'Thote' × " clone 'Kadubale' | — | — | — | 3 |
| 13. | 'Neyvannan' × " clone 'Sawai' | — | — | 1* | 2 |
| 14. | 'Monthan' × " " | 1 | — | — | — |
| 15. | 'Monthan' × *M.coccinea* (since identified as *M.rosacea*) | *1 | 1 | — | — |
| 16. | 'Peykunnan' × " " | *1 | — | — | 2 |
| 17. | 'Poovan' × " " | — | — | — | 1 |
| II. | *Triploid* × *Triploid* | | | | |
| 18. | 'Peykunnan' × *M.chiliocarpa* | — | — | — | 5 |
| 19. | 'Thote' × " | — | — | — | 2 |

* Parthenogenetic derivatives

Eleven morphological characters *viz*, height of pseudostem, degree of suckering, girth of petiole, nature of petiole margin, length and width of lamina, hairiness of peduncle, length of pedicel and seed content were considered. The pictorialised scatter diagram was plotted by using the number of fruits per bunch and the girth of pseudostem as the ordinate and abcissa respectively. The metroglyph and index score analyses were adopted, giving scores for expression of characters.

The chromosomal status of the parents and hybrids was determined from temporary acetocarmine squashes of P.m. cells.

**Observations:** The hybrids were compared with the female parents in an attempt to assess the morphological changes brought in, as a result of tetraploidy arising from hybridisation in respect of the following characters.

*Pseudostem-girth:* Eighteen hybrids were found to have a greater circumference of the pseudostem than the corresponding female parents. In 16, the girth was less than that of the female while in two it was similar to that of the triploid parent.

*Pseudostem-height*: Out of 36 hybrids, 19 were found to be taller than their female parents while the 17 others were all shorter.

*Degree of suckering:* Nine hybrids had the same expression as the corresponding female parents; four of them were freely suckering while twenty three had poor suckering capacity.

*Petiole-girth:* The girth of petiole was less in 27 hybrids, while in three it was similar to that of the female parents. The values exceeded those of the parents in six of the hybrids.

*Petiole-margin:* In most of the hybrids (30 nos.) the petiole-margin was not winged, while six of them had slightly-winged margins.

*Lamina-length:* A longer lamina was noticed in 15 hybrids while in 21 others it was shorter than the triploid parents.

*Lamina-breadth:* Thirteen hybrids had broader lamina than the corresponding female parents; in 22 others lesser values were obtained. Only one hybrid had the same expression as that of its female parent.

*Peduncle-hairiness:* Most of the hybrids (32 nos.) had glabrous peduncles. Only four had slightly pubescent ones.

*Pedicel-length:* Sixteen hybrids had longer pedicels while in 19 others it was shorter than the female parent. Only one had the same value as its mother.

*Number of fruits per bunch:* Twenty nine hybrids had less number of fruits per bunch. Five had increased values over the female parents and two had similar values as their female counterparts.

*Seededness:* Ten hybrids had seedless fruits and in the rest, the fruits were either fully seeded or less-seeded.

It is evident that there is either a positive or negative deviation from the female parents in respect of the characters studied. The hybrids were unthrifty and not superior from the commercial point of view, excepting the hybrid, 'Neyvannan' × *M. balbisiana* (clone 'Sawai').

The frequency distribution of the parental clones and the hybrids with reference to the index scores, is furnished in the table below:

TABLE 2. *Index scores of parents and hybrids of banana*

| | Chromosome No. (2n) | Index scores | | | | | | | | | | | | | | | | Total No. of plants |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
| I. *Parents* | | | | | | | | | | | | | | | | | | |
| Female | 33 | — | — | — | — | 1 | 2 | — | 6 | 2 | — | — | — | — | — | — | — | 11 |
| Male | 22 | 1 | — | 1 | 2 | — | — | — | — | — | — | — | 1* | — | — | — | 1*** | 6 |
| | 33 | — | — | — | — | — | — | — | — | — | — | — | — | — | 1** | — | — | 1 |
| II. *Hybrids* | | | | | | | | | | | | | | | | | | |
| | 22 | — | — | — | 2 | 1 | 2 | — | — | — | — | — | — | — | — | — | — | 5 |
| | 24 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 1 | 1 |
| | 44 | — | — | — | 4 | 3 | 4 | 6 | 7 | 5 | 3 | 2 | 2 | — | — | — | — | 36 |
| III. *Parthenogenetic derivatives* | | | | | | | | | | | | | | | | | | |
| | 22 | — | — | — | — | — | — | — | — | 1 | — | 1 | — | — | — | — | — | 2 |
| | 33 | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | 1 |

* *M.rosacea* ** *M.chiliocarpa* *** *M acuminata*

A consideration of the index scores for the association of characters indicated a range of 4 to 8 scores for the female parents and 0 to 15 for the males. The index scores ranged from 3 to 8 in the case of hybrids between triploid clones and *M. balbisiana* depending upon the differences in the female parents. Hybrids of the same combination showed differences in total score values due to high deviation in the expression of certain characters. In the case of hybrids where *M. chiliocarpa* was the male parent, the former showed higher values (9 to 11 scores) than the female parent, while in hybrids between 'Peykunnan' and *M. coccinea*, lower values were obtained.

The diploid hybrids and the parthenogenetic derivatives are quite different in morphological features. The triploid parthenogenetic individual is almost similar to its progenitor. The aneuploid derivative showed a decrease in pseudostem girth as a consequence of hybridity well indicated in other traits. In case of diploid hybrids, the range of variation was similar to that seen in the tetraploid hybrids. The fruits were parthenocarpic, seed formation being sparse. There was significant dominant effect noticed in the diploid hybrids of the additional genome introduced from *M. balbisiana*.

Cytological examination of the hybrid, '*Monthan*' × *M. rosacea* indicated it to have resulted from the union of an unbalanced gamete (n=13) with a normal male (n=11) of the wild species. The chromosome number of the unbalanced gamete would suggest the functioning of such, in addition to the unreduced and haploid gametes in the triploid female. The hybrid exhibited a maximum chromosome association of $2_{III}+9_{II}$ and a minimum association of $7_{II}+10_{I}$. The trivalents indicated the duplication of two chromosomes in the gamete derived from the female parent. A good morphological description of this hybrid has been provided by Nair (1953).

In the diploid hybrids, usually $II_{II}$ were noticed at metaphase I. The maximum number of univalents noticed was 5. Laggards and irregular distribution of chromosomes at anaphase I were common. The percentage of good pollen was 48. The chromosome association and behaviour in the parthenogenetic triploid were similar to those observed in cultivated triploids. In the tetraploids, the chromosome association ranged from $11_{IV}$ to $22_{II}$. The average association noted was $9.6_{IV}+2.8_{II}$. Unequal distributions, laggards and their division were observed at anaphase I. Supernumerary spores and tetrads with micronuclei were also seen. Pollen fertility in the tetraploid hybrids was much higher (30–94 per cent) than in the triploid female parents (2–59 per cent). It is to be inferred that the increase in pollen fertility is concomitant of the balance in chromosomal behaviour and the genic influence in promoting fertility. A similar trend towards increase in seed formation was also noticed in the tetraploids.

Attempts at cross-pollination of the diploid hybrid, 'Laden' × *M. balbisiana* were made with pollen from a diploid clone of the male parent. The seedling derived from this cross was found to be a triploid possessing the characteristics of *M. balbisiana* to a noticeable extent indicating its hybridity. The diploid hybrid and the triploid one had many morphological features in common. This points to the possibility of deriving new triploids with varying combinations of genomes by a careful analysis of the progenies. It would not be out of place to suggest here that such a scheme would help in the production of triploid hybrids combining *M. balbisiana* and any of the edible diploids

which are pollen fertile. By this procedure, it would seem possible to mitigate the ill-effects noticeable in the primary hybrids involving *M. balbisiana*.

The diploid species, *M. chiliocarpa* represents an edible form of *M. acuminata* (Sundararaj, *et al*, 1959). The clone used as the male parent in the present investigation was found to be a triploid. In spite of triploidy there was about 48 percent good pollen. The possibility of using triploids in breeding programmes surveying the available variability is indicated thereby.

The somatic chromosome number of the wild species of *Musa*, hitherto classified as *M. coccinea* and employed in hybridisation was determined to be 22 from root tip squashes. This is in conformity with the observations from meiosis (Raman, *et al*, 1963). Thus, since *M. coccinea* belongs to the 2n : 20 group, the type under consideration can more reasonably be identified as *M. rosacea* of the section Rhodochlamys.

**Discussion:** The existence of high morphological variability in South Indian bananas is attributable to varying degrees of introgression of gene complex of *M. balbisiana*. This variability appears to be distributed in both triploid and diploid forms (Raman *et al*, 1968). Attempts at improvement through hybridisation of edible bananas with a restricted number of male parents were not encouraging (Krishnamurthi and Madhava Rao, 1964). The situation, therefore, warrants an alternative approach in the choice of parents. The high female sterility, expression of parthenocarpy and availability of viable pollen in sufficient quantities in the edible diploid varieties point to their high potentialities in use as male parents for hybridisation (Raman *et al*, 1970). These characteristics and in addition their agro-botanical features which have contributed to their continuation in culture, enable their direct use as male parents in breeding projects without expectations of any hazards of introduction of undesirable commercial characteristics into the derivatives.

The tetraploid hybrids in general, have been found to be not superior to the triploid in commercial characteristics. Hence, development of new triploid varieties would be a more satisfactory proposition. In building up new triploids, it is necessary to keep in view the dwarf habit, upright leaves, lesser suckering and desirable features of the bunch and fruit should be combined to meet the requirements for the internal market and for export (Raman, 1968; Raman and Madhava Rao, 1969).

The production of new triploids is easy by crossing between the existing edible diploids. The potentialities of new tetraploids that could be derived by hybridisation between the commercially valuable triploids and the edible diploids have to be tested on a large scale. The high degree of pollen production

noticed in some of the triploid clones may be taken advantage of, for hybridisation with other highly female-fertile triploids in commercial cultivation. The prospects of isolation of superior types by an intensive study of the progenies from the crosses suggested above are to be considered high, in view of the recombinations that are possible. The step-wise development of hybrids, will no doubt, entail a long term project. In the meantime, it would be of value to study the performance of different triploid and diploid varieties in varied tracts, so that clones with higher adaptability may be chosen for cultivation over larger areas (Raman, 1970). The necessity for synthesis of an ideal male parent for evolving a superior commercial type of banana by hybridisation appears to be not imminent. From the experience gained as a result of this analysis it could also be said that the utilisation of the wild diploid species like *M balbisiana* in hybridisation programmes, will not be rewarding.

**Summary:** Progenies derived from hybridisation of edible bananas with three species of *Musa* were analysed for their morphological features and cytological behaviour. It was observed that in most of the combinations the hybrids obtained were tetraploids. The introduction of the genome of the diploid species into the existing triploids upsets the commereial value of the latter and induces seed formation to a greater degree interfering with the full expression of parthenocarpy in the hybrids. Variation between hybrids of the same parents was evident. The high homology of the genomes observed in the diploids and triploids was also evidenced in the tetraploids.

Apart from tetraploids, hybrids with 22 and 24 chromosomes (2n) were obtained in the progenies of the cross, triploid × diploid. The 24 chromosome progeny was, however, realised in a cross between a triploid cultivated variety and *M. rosacea*. This male parent was previously designated *M. coccinea* erroneously. In addition, parthenogenetic diploids were also derived from crosses between triploid × diploid bananas. Both the hybrids as well as the parthenogenetic diploids showed variation from the female parent characteristics. The possibility of obtaining new recombinant forms at diploid and higher levels both by hybridisation and through parthenogenesis is thereby, evident. By crossing the diploid hybrid with pollen from another diploid plant, a triploid seedling could be derived which also points to the means of obtaining new triploid forms.

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