COMPACT TYPE MUTANTS IN APPLE AND SOUR CHERRIES

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Abstract

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Induction of mutations in deciduous fruits is considered complementary to the conventional breeding methods. Several promissing mutants, particularly in apples, were described and some of them were introduced to commercial orchards.

Studies described herein are aimed at developing compact type mutants in apple cultivars, apple rootstocks and in sour cherry cultivars. Data obtained so far confirm the results of the other authors, who developed compact type mutants in apples and sweet cherries.

Physiological studies have shown that the leaves of spontanous apple mutants of compact type are more efficient in photosynthesis than the leaves of respective standards. In spite of this, using branch ringing techniques, it was found that the leaves of compacts and those of standards do not differ in their productivity.

There seem to be several advantages in employing tissue culture technique in mutation breeding. That is why a project was started to work out a method of growing apple shoots from adventitious buds developed on sections of roots.

INTRODUCTION

Within the last two decades several fruit breeders have engaged in mutation programs directed at developing bud sports through the use of ionizing radiation. As a result of their work several promissing mutants were described and some of them were introduced to commercial orchard, contributing either to productivity or to quality of fruit /2, 3/.

The project described in this paper was commenced in 1968. It originally was aimed at developing compact type mutants in commercially important apple cultivars. The results obtained in the course of the first four years of studies were published in 1973 /5/. As it was reported there dormant scions were subjected to acute irradiation, using gamma rays; the dose ranging from 2.5 kR to 5 kR. The methods of handling the irradiated material were similar to those described by Zwintscher /6/.

Starting in 1973 the project was expanded in two directions. Firstly, additional crops, namely sour cherries and vegetative apple were included. Secondly, sub-project was initiated to learn more about the nature of the compact type mutants. This last line

of work is expected to provide information which could be used in working out less time consuming techniques of selection as compared to the standard ones.

Mutation breeding, similary like conventional breeding, is a "number game", requiring a large number of plants. Additional difficulty in mutation breeding results from the fact that most of the mutants are of a chimerical structure. Because of this isolation of the mutated shoots or their parts takes considerable amount of time and requires sufficient spare for propagation of the "could be mutants".

Broertjes /1/ has shown that by employing the techniques of in vitro culture of plant organs it is possible to produce adventitious buds from single cells and by this to avoid the consequences of chimera formation in mutagene treated material. His works have given us an incentive to start in 1975 one more line of work, the purpose of which is to work out techniques of growing in vitro adventitious shoots from detached apple organs. It is expected that, if successful, this method could fasten and simplify the isolation procedures and lower the costs of the whole process.

PROGRESS

I. Compact type mutants in apple

The mutants selected from the buds irradiated in 1968, using gamma rays at 2.5 kR are grown since spring 1974 in a trial orchard in which they are being compared with the standards. The characteristics of these mutants are presented in table 1. As it can be seen from the data in that table the mutants, in comparison to the standards, differ considerably in their growth. They differ also among themselves, some of them being much less vigorous than the respective spontanous compacts.

The content of table 2 summarizes the results of selection work accomplished in the years 1973 to 1975. It should mentioned here that during the course of selection several clones lacking consistently stability were discarded. The clones listed in table 2 were planted into test orchard in autumn 1975.

Under preliminary screening there are additional over 50 clones of apples. It is worthy of mentioning here, that according to our experience, at least three repropagations are required to assess the stability of the new clones. This seems to be contrary to Lapin's finding /4/ according to whom most of the V_2 mutants are stable.

In 1975 a preliminary experiment was carried out in which the fast neutrons were used as a mutagenic agent, to irradiate dormant apple buds. The data presented in table 3 show the effect of different doses of fast neutrons on bud survival. This work is still in too preliminary stage to make any further comments.

In 1972 dormant rooted yearlings of vegetative apple rootstocks were irradiated with gamma rays. The promissing shoots were buded in 1973 to produce maidens, which were layered

in spring 1975. In autumn 1975 the data on vigour of growth were collected, which are presented in table 4. The results obtained are very encouraging as both the studied rootstock and particularly Alnarp 2, are known to be very winterhardy. Developing less vigour clones of those rootstocks would be a major contribution to apple industry in several parts of the world. It will take, however, some years of studies to assess fully those mutants.

II. Compact type mutants in sour cherry

In March 1973 dormant scions of three sour cherry cultivars, namely Schattenmorelle, Körözer and Nefris were treated with gamma rays, using doses 2.0; 3.0 and 4.0 kR. There were about 300 buds of each cultivar per treatment. Treated scions were grafted on 1-year-old P. mahaleb seedlings.

Compact like shoots were collected in summer 1974 and were propagated by budding /10 buds per shoot/. Although originally 52 shoots were selected only 22 of them proved, following repropagation, to be compacts. Their characteristics are presented in table 5. In autumn 1975 the compacts were planted into a trial orchard.

In spring 1975 all the trees grown from irradiated scions were cut back, leaving only the irradiated parts of their stems. Shoots developed from adventitious buds were harvested in autumn 1975. The results of this line of work are presented in table 6.

III. Physiological and biometrical studies of apple mutants

Starkrimson Delicious and Golden Delicious spur were used in these studies. Starking Delicious and Golden Delicious served as their respective checks. All the trees were 6-years-old and are grown on seedling rootstocks. The following characteristics were measured:
/i/ rate of photosynthesis, using Shimshi's apparatus,
/ii/ rate of respiration using Wartburg apparatus, and
/iii/ the relationship of leaf area to the size of apple.
To study the relationship between leaf area and fruit size uniform branches of Starking and Starkrimson were selected. In the third decade of June the bases of the branches were ringed. Excess of either leaves or fruits was removed, so that each branch would hold 10 fruits and /i/ 25 or /ii/ 35 leaves per fruit. Each treatment was replicated 8 times.

The rate of photosynthesis was significantly lower in the leaves of standards as compared to their respective compacts, table 7. There were no differences, however, in the rate respiration, table 8.

The ringed branches with controlled number of leaves per 1 fruit enabled us to calculate the surface of foliage required to produce 100 g of fruit tissue on compacts, as compared to the standard trees, table 9. As it can be seen from the data in the table there were differences depending on the number of leaves per 1 fruit, but no differences between the compact trees and the standard ones. The results obtained seem to suggest that, although the leaves of compacts have a higher rate of photosybthesis this has no reflection in their productivity. It should

be added here, however, that this last experiment was conducted for one year only and the data cannot be considered as fully conclusive.

IV. Tissue culture

This line of work was started in the second part of 1975. As the personal assigned to these studies had only limited experience in tissue culture they started a series of pilot experiments using well worked out plant material and techniques. In the mean time, due to a generous help of the Agency the necessary equipment was completed. The pilot experiments gave positive results. Starting late in winter 1976, portions of apple roots were cultured on agar media using /i/ Muraschige's and Skoog's, /ii/ White's and /iii/ Street's and Bonner's solutions.

As it can be seen from fig. 1 the results obtained so far indicate on the possibility of growing shoots from adventitious buds developed on detached sections of apple roots.

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Table 1

Size of trees of apple mutants /at the end of their second season in the orchard/

Cultivar	Number of trees	Trunk diameter in mm	Total lenght of shoots in mm	Lenght of internodes in mm
McIntosh				
Standard	10	27	7348	23
E /spontaneous/	6	25	3863	17
M 20 /spontaneous/	6	24	6442	17
1 A	10	25	4400	18
2 A	7	24	3955	17
1 B	7	21	1907	16
2 B	8	27	5596	17
1 C	5	23	2610	17
Belle de Boscoop				
Standard	10	31	8844	24
S 1	10	22	3079	15
S 2	11	26	4849	17
Macoun				
Standard	8	28	6037	28
S 1	7	20	2225	16
S 2	1	25	3560	17

Table 2

Vigour of growth of apple mutants, in mm

Cultivars and clones	Dose of gamma rays kR	Year of selection	Hight of maidens	Lenght of internodes	Diameter at the base
1. Boiken control	-	-	1268	24	18
2. Boiken 68/72/XXIV/A V_4	2.5	1972	1100	22	16
3. Cox's Orange control	-	-	1451	27	20
4. Cox's Orange 14/ 9 V_3	2.5	1973	995	22	18
5. Cox's Orange 23/ 9 V_3	2.5	1973	1165	22	18
6. Cox's Orange 5/11 V_3	5	1973	1060	25	15
7. Cox's Orange 11/10 V_3	5	1973	520	13	18
8. Cox's Orange 72/72/XII/C V_4	5	1972	1383	25	19
9. McIntosh control	-	-	1334	27	17
10. McIntosh 8/XLII/74 V_4	2.5	1972	1178	23	17
11. McIntosh 11/XLII/74 V_4	2.5	1972	1155	24	15
12. Spartan control	-	-	1348	27	17
13. Spartan 1/5 V_3	2.5	1973	1236	24	17
14. Spartan 1/6 V_3	2.5	1973	785	17	16
15. Spartan 2/8 V_3	5	1972	935	22	16

Table 3

Survival of dormant apple buds as affected by different doses of fast neutrons

Cultivar	Dose in rads	No. of irradiated buds	Survived buds in per cent
Bancroft	2250	327	0
	1780	342	16,1
	1220	348	33,6
	940	191	55,1
	310	333	72,7
	250	223	71,3
	170	237	68,8
	130	222	67,6
Close	2250	315	0
	1780	322	2,4
	1220	314	18,8
	940	309	47,3
	310	212	43,4
	250	222	51,4
	170	216	66,2
	130	232	69,0

Table 4

Vigour of growth of vegetatively propagated rootstocks, in mm

Rootstocks and clones	Dose of gamma rays kR	Year of selection	Hight of shoots	Lenght of internodes	Diameter at the base
Alnarp 2 control	-	-	1038	19	14
Alnarp 2 - 3 V_2	2.5	1974	630	12	11
Alnarp 2 - 9 V_2	2.5	1974	658	15	13
Alnarp 2 - 10 V_2	3.5	1974	978	18	14
Alnarp 2 - 11 V_2	3.5	1974	390	11	9
Alnarp 2 - 12 V_2	3.5	1974	760	15	11
Alnarp 2 - 13 V_2	3.5	1974	865	16	12
Alnarp 2 - 16 V_2	3.5	1974	607	14	11
Alnarp 2 - 17 V_2	5	1974	650	16	12
Alnarp 2 - 18 V_2	5	1974	763	15	13
Alnarp 2 - 19 V_2	5	1974	687	16	12
M 26 control	-	-	1159	23	17
M 26 - 25 V_2	2.5	1974	570	13	14
M 26 - 26 V_2	3.5	1974	825	20	13
M 26 - 28 V_2	3.5	1974	813	20	16
M 26 - 29 V_2	3.5	1974	760	20	16

Table 5

Vigour of growth of sour cherry mutants, in mm

Cultivars and clones			Doze of gamma rays kR	Year of selec-tion	High of maidens	Lenght of inter-nodes	Diameter at the base
Körözer	control		-	-	1060	27	16
Körözer	6	V_3	2	1973	713	23	12
Körözer	7	V_3	2	1973	791	23	13
Körözer	8	V_3	2	1973	833	20	12
Körözer	54	V_2	3	1974	580	21	9
Körözer	50	V_2	4	1974	807	21	15
Schattenmorelle	control		-	-	1184	27	20
Schattenmorelle	18	V_3	2	1973	615	21	12
Schattenmorelle	35	V_3	2	1973	618	21	12
Schattenmorelle	56	V_2	2	1974	487	22	9
Schattenmorelle	59	V_2	2	1974	563	24	9
Schattenmorelle	64	V_2	2	1974	536	22	9
Schattenmorelle	67	V_2	2	1974	703	27	13
Schattenmorelle	68	V_2	2	1974	807	29	16
Schattenmorelle	70	V_2	3	1974	676	26	14
Schattenmorelle	73	V_2	3	1974	620	23	11
Schattenmorelle	75	V_2	3	1974	597	25	13
Schattenmorelle	80	V_2	3	1974	595	21	11
Schattenmorelle	81	V_2	3	1974	543	21	11
Schattenmorelle	82	V_2	3	1974	750	23	14
Schattenmorelle	100	V_2	3	1974	617	24	10
Schattenmorelle	46	V_3	4	1973	620	23	11
Schattenmorelle	85	V_2	4	1974	790	27	15
Nefris	control		-	-	1232	27	21
Nefris	92	V_2	3	1974	827	24	17

Table 6

The number of compact shoots developed from adventitions buds on sour cherry scions

Cultivar	Dose kR	Total number of shoots	Number of compact shoots
Körbzer	2	82	3
	3	54	1
	4	121	6
Schattenmorelle	2	202	4
	3	284	11
	4	456	9
Nefris	2	517	7
	3	500	11
	4	432	3

Table 7

The rate of photosynthesis expressed in mg $CO_2 dm^{-2} h^{-1}$ and classes calculated with the help of Duncan test

$\alpha = 0,05$

Cultivar	Combination	Photo-synthesis	Class
Starking Delicious	control	4.3	a
	spur	5.7	b
Golden Delicious	control	4.6	a
	spur	5.3	b

Table 8

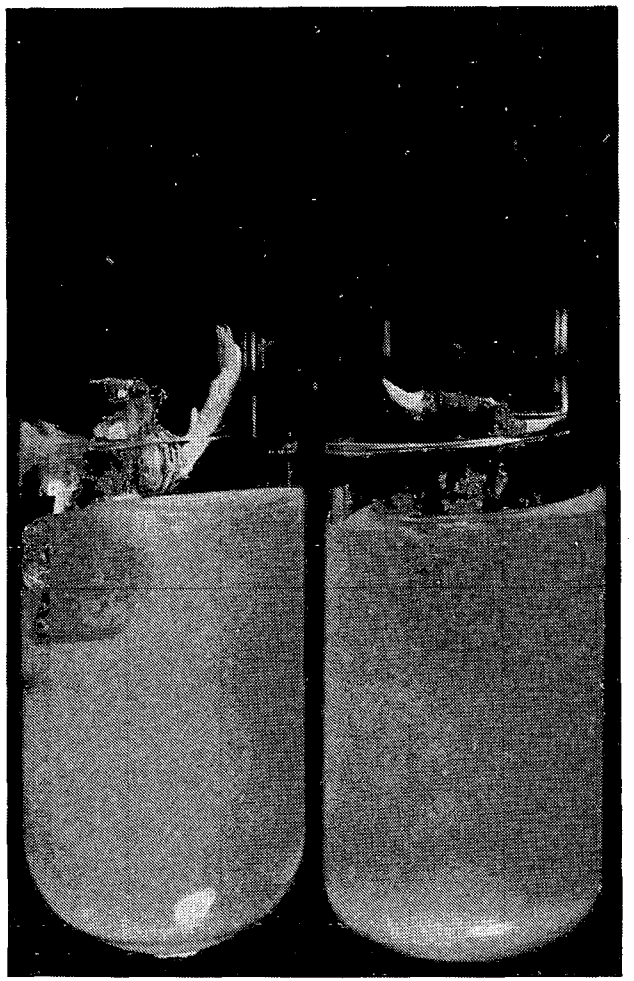
The rate of respiration of Starking Delicious leaves in $\mu l O_2/g$ of fresh weight /min and classes calculated with the help of Duncan test $\alpha = 0.05$

Cultivar	respiration	class
standard	22.0	a
Starkrimson	23.5	a

Table 9

The surface area of Starking Delicious foliage needed to produce 100 g fruit.

Cultivar	No of leaves per 1 fruit	Foliage in cm^2
Standard	25	304.6
	35	375.5
Starkrimson	25	291.6
	35	400.8



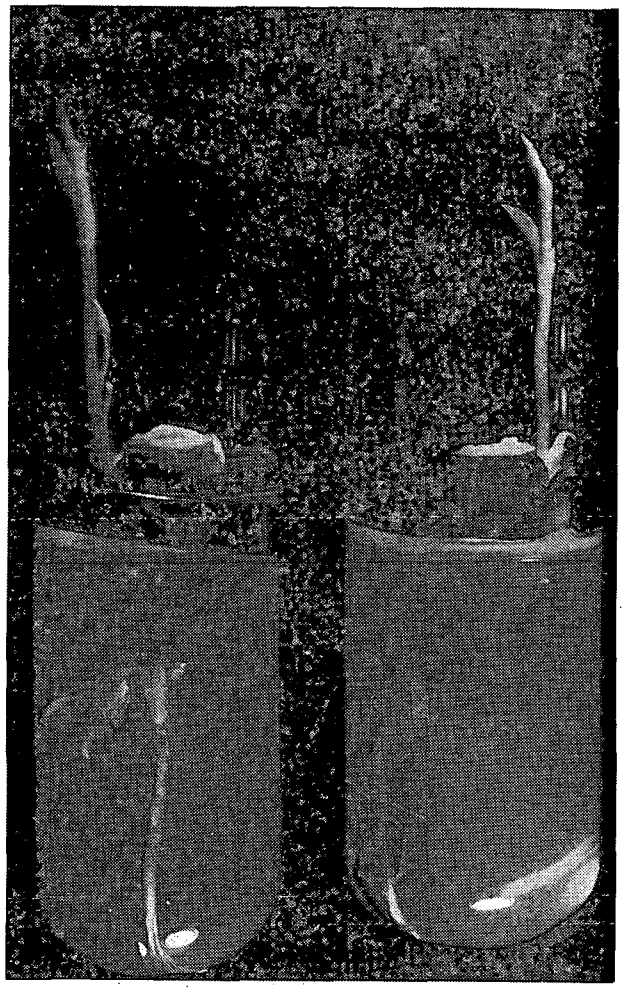


Fig. 1a and 1b. Sections of roots of MM 106 apple rootstock, grown for 2 weeks on Street's solution.

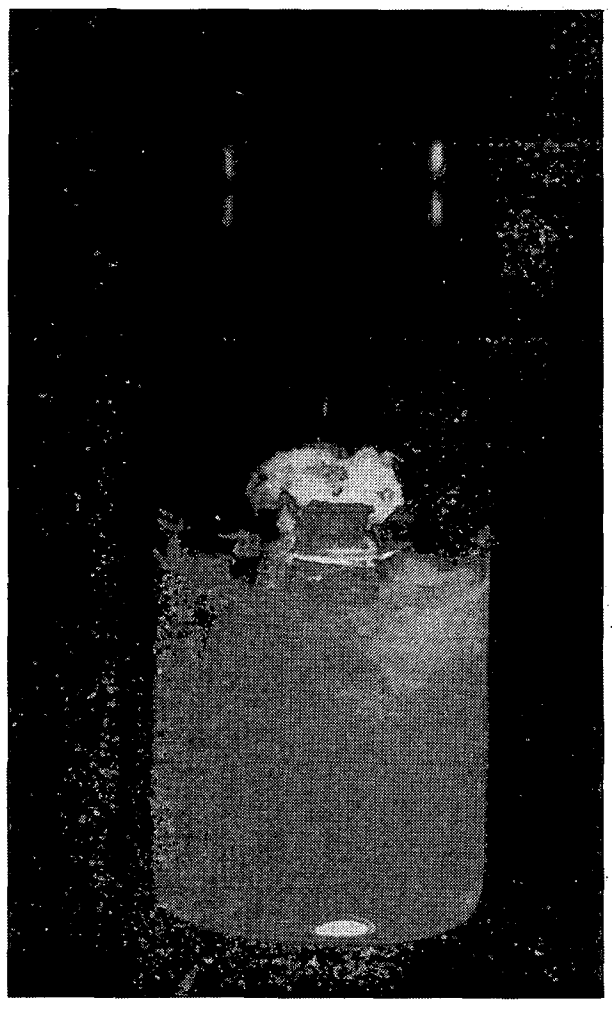


Fig. 1c Sections of roots of MM 106 apple rootstock grown for 2 weeks on Murashige's and Skoog's solution containing 2 ppm of NAA

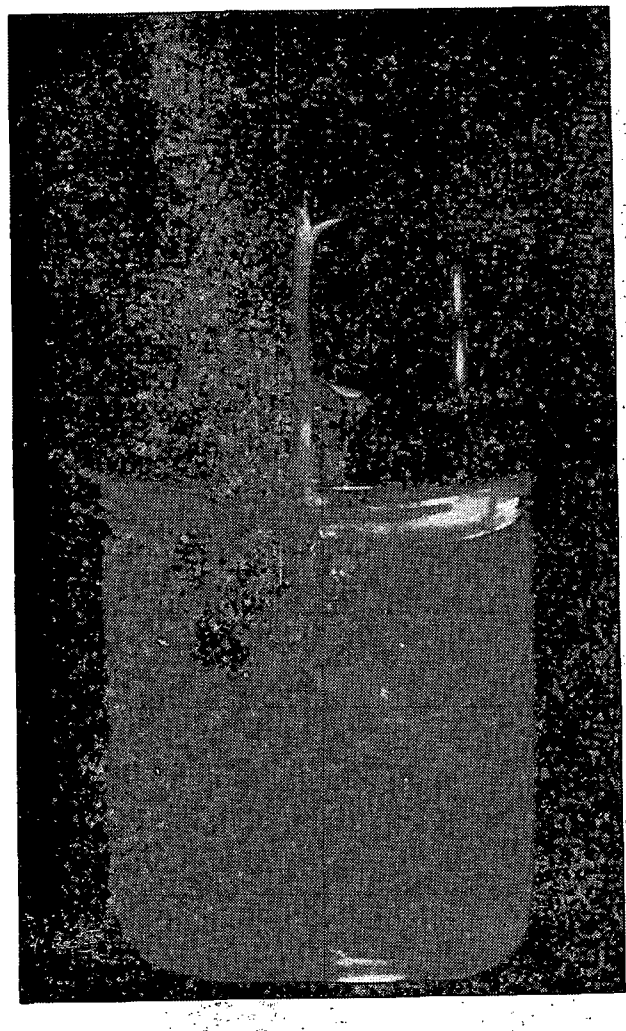


Fig. 1d Sections of roots of MM 106 apple rootstock grown for 2 weeks on Murashige's and Skoog's solution containing 0,2 ppm of kinetin