Morphological descriptions of some induced systematic mutants of grapes (Vitis vinifera L.)¹)

by

R. L. SHARMA and S. K. MUKHERJEE

Morphologische Beschreibung einiger experimentell ausgelöster systematischer Mutanten von Reben (Vitis vinifera L.)

Z us ammenfassung. — An Reben (Vitis vinifera L., Sorte Bhokri) wurden 1967—1969 Untersuchungen über die Auslösung von Mutationen angestellt. Nach Behandlung mit N-Nitroso-methyl-urethan (NMUt) und Gammastrahlen wurde eine große Zahl von systematischen Chlorophyll- und anderen somatischen Mutanten isoliert. Die morphologischen Eigenschaften von 18 systematischen Mutanten werden beschrieben und die Mutanten unter 12 Bezeichnungen in 6 Hauptgruppen eingeteilt. Einige von ihnen, und zwar die "siebenlappigen" und die "fiederspaltigen" Typen, die eine erhöhte Anzahl von Blattlappen aufweisen, dürften selten vorkommen. Eine große Anzahl systematischer Mutanten hatte Blätter mit tieferen Buchten und sehr spitzen und langen Zähnen. Im Gegensatz hierzu hatte eine durch NMUt ausgelöste Mutante (mit geschlossener Stielbucht) fein gesägte Blätter — fast ohne Nebenbuchten; außerdem waren sie dick und nach oben gewölbt. Andere Mutanten hatten glänzende Blätter oder waren zwergwüchsig mit kleinen schmalen Blättern.

Introduction

During a study to standardize methods for the induction of mutation in grapes a substantial number of somatic mutants were isolated from the material treated with N-nitroso-methyl urethane (NMUt) and gamma radiation. It is intended to describe here the morphological features of some of the systematic somatic mutants which may be found useful for genetic studies, establishing phylogenetic relationship and even commercial cultivation.

Materials and Methods

After various treatments (SHARMA and MUKHERIEE 1972) with NMUt and gamma radiation to the dormant cuttings or buds on the vines of Bhokri cultivar, every emerging shoot and its laterals were critically examined at frequent intervals for a period of about 3 years from 1967 to 1969. Almost all the variants were first noted in chimeral form and then encouraged to grow after suppressing the growth of the normal tissues. The morphological description is confined to only those characters for which mutants apparently differed from the parent cultivar. Minor plant to plant quantitative variations in leaf size have been ignored. In most cases the change involved was in the leaf and could be easily distinguished. The terminology used and the procedure were essentially the same as adopted by BIOLETTI (1938). The physical limits adopted for each category, whether same or slightly modified, are given below for each character:

¹) A part of the thesis submitted to the Post-Graduate School I.A.R.I. for the award of Ph.D. in 1970 by the first author.

(i) Nature of leaves (maximum width/length ratio):

Very narrow:	< 1.15	Narrow:	1.15-1.24
Medium:	1.25-1.34	Wide:	1.35—1.44
Very wide:	> 1.44		

Length of leaf being equal to the distance from distal end of petiole to the leaf tip and width being the maximum width perpendicular to the mid-rib.

(ii) Acuteness of teeth (length/breadth value):

Very acute:	> 1.20	acute:	0.88-1.20
Narrow:	0.59—0.87	wide:	0.49-0.58
Obtuse:	0.29-0.41		

A tooth may be pointed, blunt or rounded. At least 15 teeth of each of the first and second series were measured.

(iii) Lateral sinuses: The penetration was worked out as a ratio of depth (length) of sinus to the total distance from leaf margin to the petiole. In the case of an additional uppermost (third) pair of lateral sinuses, the penetration up to the central vein was worked out. On the basis of penetration the lateral sinuses were classified as:

None:	None except petiolar
Shallow:	extending to less than $\frac{1}{2}$
Medium:	extending to about $\frac{1}{2}$
Deep:	extending to ¾
Foliolate:	extending to petiole

A sinus may be narrow, wide, closed or perforated.

(iv) Petiolar sinus: It was categorised as closed when the inferior lateral lobes almost overlapped; narrow when the maximum width was less than the depth; medium when the width and depth were almost equal; wide when the width was greater; very wide when the sinus was almost flat.

All the measurements for comparison were made for 15 mature leaves on five shoots of the same plant on which a mutant occurred. The chlorophyll deficient variants were compared with horticultural colour charts (Royal Horticultural Society).

The salient morphological features of the parent cultivar are:

Vines vigorous; leaves cuneiform, 5-lobed, medium sized, smooth, flat, thin glabrous; inferiour lateral sinus shallow, to almost absent; superior lateral sinus shallow, narrow; petiolar sinus medium wide; teeth in 3-series; teeth of first series narrow and pointed; petiole long; berries spherical, greenish yellow; seeded; average T.S.S. 17.2 percent; and acidity 0.5 to 0.6 per cent.

Results

Out of the 107 systematic, chlorophyll and other deleterious types of mutants observed during the study in Bhokri cultivar, 18 systematic mutants of six main groups are described below under 12 names.

A. Multilobed types

This group includes only two mutants in which the leaves, in addition to the usual two pairs of lateral sinuses, had one or two pairs of well marked secondary sinuses prominent enough to impart to them a multilobed appearance.



Fig. 1: 'Hepta-lobus' Bhokri Mutant. The mutated shoots (left and central) in early stages of their growth with fruit-bearing, normal parent shoot (right). The mutated shoot on the left is axillary to the chimeral shoot.

Fig. 2: Foliolate Bhokri. The whole axillary shoot turned into a complete mutant after two basal chimeral leaves.

1. 'Heptalobus' Bhokri

It originated as a full variant and also 50 per cent sectorial chimera from twin axillary buds in the NMUt treated material.

Distinguishing features: Leaves seven (rarely nine) lobed, in outline resembling those of water melon (*Citrullus vulgaris*), more elongated (very narrow), rougher than those of the parent; lateral sinuses six (rarely eight) very deep, imparting a palmatisect appearance to leaves (Fig. 1); second and third pairs more prominent

Character	Mutant	Parent type
1. Leaf:		
length (cm) width (cm) width/length	$\begin{array}{rrr} 7.43 & \pm \ 0.49 \\ 8.50 & \pm \ 0.43 \\ 1.148 \pm \ 0.113 \end{array}$	$\begin{array}{c} 8.03 \ \pm \ 0.40 \\ 10.33 \ \pm \ 0.35 \\ 1.286 \pm \ 0.031 \end{array}$
 Petiole length (cm) No. of lateral sinuses/leaf Inferior lateral sinuses: depth (cm) width (cm) penetration 	$\begin{array}{c} 5.26 \ \pm 0.26 \\ 6.37 \ \pm 0.26 \\ \end{array}$ $\begin{array}{c} 1.12 \ \pm 0.18 \\ 0.33 \ \pm 0.06 \\ 0.404 \ \pm 0.82 \end{array}$	$\begin{array}{rrrr} 4.93 & \pm & 0.16 \\ 4.0 & \pm & 0.0 \\ \end{array} \\ 0.73 & \pm & 0.24 \\ 0.11 & \pm & 0.04 \\ 0.189 & \pm & 0.42 \end{array}$
5. Middle lateral sinuses depth (cm) width (cm) penetration penetration in mid rib direction	$\begin{array}{ccc} 2.06 & \pm \ 0.13 \\ 0.93 & \pm \ 0.20 \\ 0.600 & \pm \ 0.939 \\ 0.803 & \pm \ 0.007 \end{array}$	$\begin{array}{rrrr} 1.52 & \pm \; 0.66 \\ 0.32 & \pm \; 0.26 \\ 0.225 & \pm \; 0.122 \\ 0.225 & \pm \; 0.122 \end{array}$
6. Top sinuses depth (cm) width (cm) penetration	$\begin{array}{ccc} 1.20 & \pm \ 0.26 \\ 0.37 & \pm \ 0.17 \\ 0.598 & \pm \ 0.104 \\ \end{array}$	
7. Internode length (cm)	4.00 ± 0.33	5.66 ± 0.54

Table 1 Features of 'Heptalobus' Bhokri

than first (or fourth) but all more prominent than any of the parent variety; primary lateral veins sometimes tending to fuse up to some distance instead of diverging from the petiolar joint; hairs on leaves slightly longer and more dense than in the parent type, conspicuous on the under surface and along the sinus margins. The contrast fascinating in the chimeral leaves; growth vigorous, internodes slightly shorter than in the parent. Viable and growing nicely. The data on some of these characters are given in Table 1.

2. 'Foliolate' Bhokri

This mutant arose as a sectorial chimera which after two chimeral leaves became a full variant (Fig. 2).

Distinguishing characters: Leaves foliolate due to the extension of lateral sinuses upto petiole and central vein; lobes usually seven, sometimes nine; central lobe elongated; teeth short, inconspicuous, wide and rounded; lamina bumpy and uneven; foliage and shoot light green (lighter than 0960/3) later turning to pod green (061/1) as compared to the dark green (spinach green 0960/1) in the parental type; shoots faintly ribbed, devoid of purplish pigmentation and faintly pubescent. The data on the different features are given in Table 2.

The mutant growth was slow and stopped very early in the season followed by gradual defoliation and dying back of the shoot upto the point of origin of full mutant only.

B. Closed petiolar sinus type

Of this group only one mutant was isolated from the NMUt treated material. The salient features of the leaves are closed petiolar sinus and almost entire, finely serrated margin.

Table 2

Features of 'Foliolate' Bhokri				
Character	Mutant	Parent type		
1. Leaf:				
length (cm)	8.5 ± 0.20	7.7 ± 0.60		
width (cm)	$10.7 \pm \ 0.25$	9.6 \pm 0.63		
2. Distance (cm) between				
Superior lateral sinus and central vein (mid rib) Superior lateral sinus	0.0	2.10		
and petiolar joint Inferior lateral sinus	$0.35 \hspace{.1in} \pm \hspace{.1in} 0.34$	4.56 ± 0.22		
and central vein Inferior lateral sinus	0.6 ± 0.1	3.03 ± 0.13		
and petiolar joint	0.75 ± 0.20	3.18 ± 0.12		
3. Teeth (1st series):				
length (cm)	0.308 ± 0.082	0.672 ± 0.070		
breadth (cm)	0.580 ± 0.145	0.912 ± 0.055		
acuteness (length/breadth)	0.531 ± 0.007	0.739 ± 0.072		
4. Central lobe:				
length (cm)	10.6 ± 0.25	5.4 ± 0.25		
width (cm)	7.2 ± 0.30	5.4 ± 0.27		

		Та	ble 3		
Features	of	closed	petiolar	sinus	mutant

Character	Mutant	Parent type
1. Leaf:		
length (cm) width (cm)	$\begin{array}{rrr} 6.20 & \pm & 0.28 \\ 8.00 & \pm & 0.36 \end{array}$	$\begin{array}{rrr} 8.6 & \pm \ 0.46 \\ 11.7 & \pm \ 0.55 \end{array}$
2. Petiole: length (cm) leaf length/petiole length	$\begin{array}{r} 4.28 \pm 0.45 \\ 1.505 \end{array}$	$7.00 \pm 0.22 \\ 1.230$
3. Petiolar sinus: depth (cm) width (cm) width/depth	$\begin{array}{cc} 1.70 & \pm \ 0.04 \\ & 0.0 \\ & 0.0 \end{array}$	$\begin{array}{rrrr} 1.66 & \pm \; 0.048 \\ 1.80 & \pm \; 0.20 \\ 0.93 & \pm \; 0.13 \end{array}$
4. No. of teeth/cm ² area (length \times width)	0.842 ± 0.071	0.489 ± 0.012

3. Closed petiolar sinus type Bhokri

Distinguishing features: Leaves rough, thick, leathery, somewhat more pubescent, slightly smaller and darker, more or less devoid of lateral sinuses; petiolar sinus closed with overlapping inferior lateral lobes, in contrast to U- to V-shaped sinus of the parent variety; lateral sinuses, inconspicuous or altogether missing; teeth less narrow but more in number, difference between first and second series less than in parent cultivar; lamina reflexed; petiole shorter and thicker (Fig. 3). The comparative values of distinguishing characters are given in Table 3.



Fig. 3: Closed-petiolar sinus mutant. The mutated shoot (lower) with rough, somewhat smaller leaves.

Fig. 4: Deeply-lobed prominently serrated type I mutant (lower).

A pertinent point is that some characters of the first variant shoot modified and became stabilized in the subsequent secondary and tertiary shoots. For example, the superior lateral sinuses which on the first variant shoot were somewhat conspicuous, did not remain so in subsequent axillary shoots. The leaves also became tougher and thicker. This was the only variant where there was a reduction in the depth and prominence of the sinuses. The variant shoot had a small panicle having some 10—12 flowers, but no fruit was observed.

C. Deeply-lobed prominently-serrated mutants

This group had 11 members which were characterised by deeply lobed leaves with prominent teeth. On account of the similarity between many of these variants only four distinct types have been established.

4. Deeply-lobed prominently-serrated type I

Distinguishing features: Leaves deeply lobed; teeth very long, very acute, pointed; veins and veinlets thick, prominently raised on the dorsal surface causing slight depression on the ventral surface; lateral sinuses deep, wide, open, tending to be perforated (Fig. 4); petiolar sinus less deep than in the parent variety; pubescence apparent on leaves and young shoots; purplish pigmentation almost lacking. Off-season flowers showed almost normal pollen fertility. The data on the above features are given together with data of types II and III.

5. Deeply-lobed prominently-serrated type II

Distinguishing features: Leaves deeply lobed, prominently serrated; teeth, fewer but longer than in parent type but not as long as those of the variants I and III; lateral sinuses very deep sometimes even touching the mid rib and petiolar joint; conspicuous pubescence on the younger leaves and growing shoots. Purple pigmentation almost negligible. Teeth of the two series differed in acuteness, those of lat being more acute and longer. Flowering in August showed normal pollen fertility.

6. Deeply-lobed prominently-serrated type III

It arose as a sectorial chimera on a part of axillary shoot with chimeral leaves occuring almost alternately with the normal ones. The full variant shoots were thus tertiary.

Distinguishing features: Leaves somewhat smaller; deeply lobed, prominently serrated sinuses deep and perforated as against shallow and open ones in the parent cultivar (Fig. 5); teeth longer, acute and numerous; veins prominent and appreciably raised on the dorsal surface. Purple pigmentation on veins and veinlets more intense and continuing over a longer distance; foliage dark green; pubescence (puberulent type) apparent.

The comparative data on some of the characters of types I, II and III are given in Table 4.

7. Deeply-lobed prominently-serrated type IV

This differed from the other three types of variants in having thin, sharply pointed, deeply-lobed, completely glabrous leaves; vein also not as prominent as in the other three mutants of this type.

D. 8. Narrow-lobed type

Distinguishing features: Leaves slightly smaller and deeply lobed, lobes elongated and conspicuously narrow; growth poor, resulting in death after about 2 months.

Ob any share	Mutants: Deepl	Depent type		
Character	Type I	Type II	Type III	Parent type
1. Leaf size (length $ imes$ width) (cm²)	9.40 $ imes$ 11.25	Normal	Normal	8.03 imes10.33
2. Petiole length (cm)	8.0 ± 1.00	Normal	Normal	4.93 ± 0.18
3. Leaf length/petiole length	1.18 ± 0.16	Normal	Normal	1.63 ± 0.09
4. Inferior lateral sinuses				
depth (cm)	2.02 ± 0.25	1.21 ± 0.28	1.45 ± 0.15	0.73 ± 0.24
width (cm)	0.52 \pm 0.08	$0.50 \hspace{0.2cm} \pm \hspace{0.2cm} 0.15 \hspace{0.2cm}$	$0.25 \hspace{0.2cm} \pm \hspace{0.2cm} 0.15 \hspace{0.2cm}$	0.11 \pm 0.04
penetration	0.446 ± 0.042	0.504 ± 0.041	0.487 ± 0.092	0.189 ± 0.042
5. Superior lateral sinuses				
depth (cm)	2.65 ± 0.57	2.13 ± 0.48	2.20 ± 0.70	1.25 ± 0.66
width (cm)	0.80 ± 0.10	0.75 ± 0.10	$0.45 \hspace{0.2cm} \pm \hspace{0.2cm} 0.15 \hspace{0.2cm}$	0.32 \pm 0.26
penetration	0.568 ± 0.065	0.541 ± 0.035	0.573 ± 0.043	0.225 ± 0.122
6. Teeth				
No./leaf	Normal	42.0 ± 3.2	Normal	58.0 ± 5.9
No./cm ² (length/width)	Normal	0.733	Normal	1.025
First series:				
length (cm)	1.117 ± 0.124	0.704 ± 0.089	0.93 ± 0.19	0.613 ± 0.075
breadth (cm)	0.823 ± 0.084	0.591 ± 0.052	0.67 ± 0.08	0.850 ± 0.050
acuteness (length/breadth)	1.363 ± 0.113	1.191 ± 0.007	1.388 ± 0.030	0.778 ± 0.074
Second series:				
length (cm)	0.948 ± 0.082	0.598 ± 0.056	_	0.580 ± 0.050
breath (cm)	0.747 ± 0.045	0.710 ± 0.108	—	0.771 ± 0.051
acuteness (length $ imes$ breadth)	1.276 ± 0.067	0.841 ± 0.030	—	0.768 ± 0.069

Table 4 Features of deeply-lobed prominently-serrated mutants, types I, II, III

E. Glossy types

These mutants had glossy dark-green leaves. In subsequent growth of original variant (normal glossy) other forms developed giving an instance of multiple mutations.

9. Normal glossy

Leaves shiny, rather glossy, of usual thickness and size; lateral sinuses prominent.

10. Small-leaved glossy

Originated as an axillary shoot from the distal nodes on the mutated shoot. Distinguishing features: Leaves small and glossy; inferior lateral sinuses deep and



Fig. 5: Deeply-lobed prominently serrated type III mutant growing as an axillary from a chimeral shoot.

Fig. 6: Small, narrow-leaved dwarf Bhokri (left part). The leaves have a conspicuous, superior lateral sinus and elongated central lobe.

Features of normal and sman-leaved glossy type mutants			
Character	Normal glossy	Small- leaved glossy	Parent type
1. Leaf:			
length (cm) width (cm)	$\begin{array}{rrr} 7.25 & \pm \ 0.10 \\ 8.95 & \pm \ 0.50 \end{array}$	$\begin{array}{rrr} 5.20 & \pm \ 0.15 \\ 6.36 & \pm \ 0.40 \end{array}$	$\begin{array}{rrr} 8.03 & \pm \ 0.43 \\ 10.33 & \pm \ 0.35 \end{array}$
2. Petiole length (cm)	5.20 ± 0.00	4.63 ± 0.15	$4.93 \hspace{0.2cm} \pm \hspace{0.2cm} 0.16$
3. Inferior lateral sinuses:			
depth (cm) width (cm) penetration	$\begin{array}{rrr} 0.82 & \pm \ 0.28 \\ 0.32 & \pm \ 0.03 \\ 0.365 & \pm \ 0.073 \end{array}$	$\begin{array}{rrr} 0.95 & \pm \ 0.23 \\ 0.35 & \pm \ 0.15 \\ 0.370 & \pm \ 0.89 \end{array}$	$\begin{array}{rrr} 0.73 & \pm \ 0.24 \\ 0.11 & \pm \ 0.04 \\ 0.189 \pm \ 0.42 \end{array}$
4. Superior lateral sinuses:			
depth (cm) width (cm) penetration	$\begin{array}{rrr} 1.45 & \pm \; 0.05 \\ 0.40 & \pm \; 0.10 \\ 0.425 \pm \; 0.037 \end{array}$	$\begin{array}{rrr} 1.35 & \pm \ 0.08 \\ 0.30 & \pm \ 0.11 \\ 0.403 & \pm \ 0.016 \end{array}$	$\begin{array}{rrrr} 1.52 & \pm \; 0.66 \\ 0.32 & \pm \; 0.26 \\ 0.225 & \pm \; 0.122 \end{array}$

Table 5

Features of normal and small-leaved glossy type mutants

prominent; internodes small. The comparative data on leaf size, sinus etc. of this and the preceeding variant are given in Table 5.

11. Chlorina sectored glossy

Another axillary shoot on the main variant arose from one of the distal nodes which, instead of having uniformly glossy dark-green leaves, had chlorina sectored leaves. The size of the chlorina sector varied from $^{3}/_{6}$ to $^{4}/_{6}$ of the leaf. It proved non-viable and the axillary buds did not yield uniformly glossy chlorina shoots.

F. 12. Small, narrow-leaved dwarf Bhokri

Distinguishing features: Leaves small, very narrow with wide open petiolar sinus resembling more or less those of St. George cultivar (*Vitis rupestris*); superior lateral sinuses deep, wide and elongated imparting a spatulated shape to the central lobe (Fig. 6); inferior lateral sinuses inconspicuous, making the leaf more or less trilobed; veins considerably depressed on ventral surface and tending to converge; purple pigmentation on veins not extending beyond the first joints as compared to second or third joints in the parent variety. Emerging leaves invariably more green, unlike purplish in the parent variety. Growth slow; viable.

The data on different characters of the variant have been compared with those of the parent in Table 6.

Discussion

The systematic somatic mutants having an increased number (7 or 9) of lobes may be rare in the genome. The 'hepta-lobed' mutant found in the NMUt treated material does not resemble any of the known *Vitis* species. Three or sometimes four pairs of very deep lateral sinuses and a number of symmetrical sub-sinuses, as compared to 2 pairs of sinuses in the parent cultivar, very narrow lamina and long central lobe, are features of taxonomic importance imparting to the leaves the

Т	а	b	1	е	6
---	---	---	---	---	---

Character	Mutant	Parent variety
Leaf:		
length (cm)	6.5 ± 0.36	8.03 ± 0.40
width (cm)	6.8 ± 0.40	10.33 ± 0.35
width/length	1.046 ± 0.01	1.28 ± 0.03
Petiolar sinus:		
depth (cm)	0.6 ± 0.3	1.50 ± 0.16
width (cm)	3.2 ± 0.9	1.86 ± 0.05
depth/width	0.177 ± 0.042	0.805 ± 0.107
Superior lateral sinuses:		
depth (cm)	1.31 ± 0.19	1.52 ± 0.66
width (cm)	0.51 ± 0.29	0.32 ± 0.26
penetration	$0.33 \hspace{0.2cm} \pm \hspace{0.2cm} 0.01 \hspace{0.2cm}$	0.325 ± 0.122
Central lobe:		
length	3.9 ± 0.20	5.40 ± 0.25
max. width	3.1 ± 0.20	5.40 ± 0.27
length/width	1.26	1.00

Features of small, narrow-leaved dwarf Bhokri

outline of water melon (*Citrullus vulgaris*) leaves. The increased pubescence in the mutant may also be important from the breeding view point.

The 'foliolate' Bhokri having originated from the gamma irradiated material resembled to some extent only the foliage characters of the cultivar Chasselas Cioutat described by CONSTANTINESCU *et al.* (1959). The mutant, however, did not possess the long, acute teeth typical of Chasselas Cioutat. Probably due to drastic genetic disturbances, the mutant did not grow further.

The third mutant having thick leaves with closed petiolar sinus, and inconspicuous lateral sinuses may be of economic interest, particularly due to its sparse pubescence and thick, dark green leaves. This was the only variant which finally came to possess leaves with finely serrated margins and devoid of lateral sinuses. These characters being opposite to the deep lobing and prominent serrations of many mutants.

The next group of 11 mutants of four sub-groups had leaves with very acute and long teeth. Most of them exhibited vigorous, vegetative growth. There seems to be a greater tendency on the part of the Bhokri cultivar to exhibit this change after treatment with both the mutagens in general and NMUt in particular.

In the glossy types either only a shine appeared or it was in combination with other changes such as deeper lobing, smallness of leaves and chlorophyll variation.

The isolation of widely dissimilar type of systematic somatic mutations, some of which are rare, from the gamma and NMUt treated grape material indicates the possibility of creating enormous genetic variability. These mutants, besides being sometimes of economic use, can be effectively utilized for genetic studies and establishing phylogenetic relationship.

Summary

During mutation induction studies on grapes (*Vitis vinifera* L.) conducted from 1967 to 1969 a large number of systematic, chlorophyll and other types of somatic mutants were isolated in Bhokri cultivar after N-nitroso-methyl urethane and gamma radiation treatments. The vegetative characters of 18 systematic mutants have been described under 6 main groups and 12 names. Some of these, viz. 'hepta-lobed' and 'foliolate' types, which have an increased number of lobes may be rare ones. A large number of systematic mutants had leaves with deeper sinuses and very acute and long teeth. On the contrary, there was one mutant (closed-petiolar sinus type), induced by NMUt, whose leaves were finely serrated and almost devoid of lateral sinuses, besides being thick and reflexed. Other mutants had glossy foliage or were dwarf with small, narrow leaves.

Acknowledgements

The authors are grateful to Prof. R. SINGH, Professor of Horticulture, Division of Horticulture, I.A.R.I. for kindly going through the original manuscript and giving valuable suggestions. The first author is also grateful to the I.C.A.R. for granting him a Senior Research Fellowship during the course of these studies.

References

- BIOLETTI, F. T., 1938: Outline of ampelography for vinifera grapes in California. Hilgardia 11, 227-293.
- CONSTANTINESCU, GH., NEGREANU, E., LAZARESCU, V., POENARU, I., ALEXEI, O. and MIHALCA, G., 1959: Ampelografia Republicii Populare Romine. Vol. 4, 225–235.
- SHARMA, R. L. and MUKHERJEE, S. K., 1972: Studies on mutation in grapes. I. Relative mutagenicity of different mutagens. Proc. 3rd Internat. Symp. Sub-tropical and Tropical Horticulture, Bangalore, India (in press).

Eingegangen am 24. 4. 1972

Assoc. Prof. Dr. R. L. SHARMA Himachal Pradesh Univ. College of Agriculture Palampur, Dist. Kangra, H. P. India

Dir. Dr. S. K. MUKHERIEE Bot. Survey of India Calcutta 13 India