



CHEMICAL MUTAGENESIS IN THE CURRANT (*RIBES L.*) AND GOOSEBERRY (*GROSSULARIA MILL.*) SELECTIVE BREEDING

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Abstract: The optimum solution concentration for the treatment of mutagen varieties of black currants, red currants and gooseberries is defined within 12 hour exposure as: 0.005% nitrosoethylurea, 0.01% diethyl sulfate, 0.1% ethyleneimine, 0.05% dimethyl sulfate. When using higher concentration of mutagens (0.5 to 1%) along with an increase in the total number of mutants, the percentage of plants with economic traits is reduced. If the mutagen solution concentration is 1% the growth of browses from apical buds does not occur due to their dieback.

The great number of somatic mutations is induced by nitrosoethylurea and diethyl but less by ethyleneimine and dimethyl sulfate. Mutant forms of black currants, red currants and gooseberries with morphological lamina change and leaf chlorophyll distortion revealed a clear relation to bush yield and mien.

Keywords: currant, gooseberry, chemical mutagenesis

1. Introduction

The Food Program doesn't lose its actuality as the years go by. The root of this matter is in the discrepancy between an increased product demand of the population and performance capabilities of the agricultural industry, limited by land resources and its own development level. Due to this fact, there is a need of change-over to agricultural plant selection techniques providing their maximal compliance with the culture biological requirements to a new integrated utilization strategy of genetic, natural and man-induced factors providing stable growth of productivity, resource conservation and an environmental safety. The variety role will be increasingly rising in the integrated system of agricultural plant production as it is the most reliable and ecologically beneficial factor of productivity improvement and stability. In

perspective the increase in food products and other agricultural goods in the world will be primarily determined by the new technology development and implementation [1].

Working process in selecting initially various genotypes based on the hybridization technique precedes a new plant variety establishment. However, this fruit and berry shrub method of selective breeding requires 15-20 years to be implemented. One of the methods to obtain assorted in many features primary sources in the shortest possible time is the induced mutagenesis.

As compared with traditional methods of selection the induced mutagenesis main advantage is fast primary sources improvement for further selective purposes (by one or several agriculturally important characters) [2, 3].

However, early determination of dominant mutations and comparatively frequent var-

ious chromosomal aberrations caused by physical mutagens (high and cold temperatures, X-rays, α , β and γ -rays, UV radiation) create significant difficulties to more productive operation with the induced mutagenesis in selection process. To a great degree that can be limited by using chemical mutagens which can reduce drastically the amount of chromosomal aberrations and increase the percentage of dominant mutations [4, 5].

Among small fruits, cultivated in Belarus, the very important cultures are currants (*Ribes L.*) and gooseberries (*Grossularia Mill.*). Their berries enriched in complex of vitamins, minerals and enzymes play significant role in balanced nutrition, maintenance and effective treatment of many human diseases. In this regard, selective breeding of these cultures is of prime importance [6].

Large scale variability of such an important practical features as resistance to American powdery mildew, high productivity, berry size, taste, chemical composition, color etc. is typical to currants and gooseberries [6].

At this stage an extensive factual material has been accumulated about currant and gooseberry mutational variability.

Special sorts of black currant with high practical value (high growth, shortened internodes, elongated racemes, king-size berries, better taste, late ripening, anthracnose resistant) have been selected in Germany by γ -rays exposure. According to R. Bauer opinion, selection of new black currant variety by the method of radiation mutagenesis is more effective than intervarietal hybridization [7].

Mutant forms with different ripening periods, leaf form, growth rate have been selected in Switzerland [8].

The most effective mutagenic factors, doses, various sorts of black currant mutability and morphological characteristics variability have been studied in Latvia. It has been established that black currant sprigs γ -ray

exposure with the test doses cause dramatic rise in variability, whereas 0.7%-6.7% of all changes fall beyond the species features [9].

Grober K. from Germany has selected mutant species with high berry ascorbic acid content [10].

Yurtsev V.K. and Gorlanov N.A. have observed a positive effect of black currant sprigs γ -ray exposure on roots regeneration process, planted sprigs growth and development [11].

In experiments with black currant chronic γ -ray exposure during its vegetation period Ravkin A. S. has established the optimal dose to obtain radiomorphosis and highly resistant mutable varieties [12].

Experimental studies of a group of mutagenic effect chemical compounds on plants have been conducted concurrently with the effect of ionizing radiation. However, the first experiments on somatic mutations detection were ineffective. That was due to specific plants reaction on treatment with chemical compounds [13].

Further experimental study on black currant induced chemical mutagenesis was based on the culture specific features development, new particular characteristics, the obtained morphosis studies and detailed consideration of all hereditary changes frequency and range. At the same time black currant ability to vegetative reproduction provides stability of inherited somatic and bud mutations in the next vegetative generations [14, 15, 16].

Chemical mutagen implementation on black currant and gooseberry selection is at an initial stage of studying process in Belarus at present (including effective mutagens, doses, exposure time, variety mutability and features type of variation study). Starting from 1976 – 1980 mutant forms of black currant with changes in leaves and browse morphology, berry size, ripening period, yield, immunity, winter resistance, growth rate and self-fertility have been obtained by Bavituto G.A. [6].

In spite of visible success many aspects of black currant, red currant and gooseberry chemical mutagenesis remain unclear today.

2. Materials and methods

The buds treatment of black currants, red currants and gooseberries was conducted by supermutagens during the period 1998-2003.

The analysis on selection and study of mutant species was conducted during 1999-2009 at an agrobiological station of BSPU named after Maxim Tank, and 2009-2012 at a substation of Poles SU.

The objects of the study were such varieties as black currant (Pamyati Vavilova, Minay Shmiriyov, Kantata 50, Tserera, Katyusha), red currant (Nenaglyadnaya, Golandskaya krasnaya, Prygazhunya), gooseberry (Yarovoy, Belarussky krasny, Masheka).

Apical buds of varieties named above were treated by nitrosoethylurea (NEL), nitrosomethylurea (NML), ethyleneimin (EI), dimethyl sulfate (DMS) and diethyl sulfate (DES) in concentration 0.001; 0.005; 0.01; 0.05; 0.1; 0.5; 1% within 6, 12, 24 hours exposure. Being treated the apical buds of named above varieties were placed into gelatin capsule filled with mutagen aquatic

solution of appropriate concentration. In each capsule with different concentration were placed 160-180 buds. After certain exposure effect the buds were water-washed. Next year the grown browses from treated buds were cut and rooted.

The quantity indicator of transformed plants, grown from treated by chemical mutagen buds as the criteria of different currant and gooseberry variety test was used. The sensitivity of sprigs, grown from treated by mutagen buds was tested in a 2- year.

The field experiments and observations were made in line with Program and techniques of fruit, berry, and nut-fruited crop variety research [17].

3. Results and Discussion

During the research period 4808 buds were treated and 404 plants were grown. There were 81 selected with more than 20 various types of morphosis and mutation. It is stated that the frequency of mutative change depends on primary variety, mutagen and its concentration and exposure effect. On average, black currant – $2.07 \pm 0.28\%$; red currant – $1.94 \pm 0.15\%$; gooseberry – $1.07 \pm 0.08\%$ (see Figure 1).

Figure 1
Generalized average data of currant and gooseberry variety apical buds treatment

Crop	Treated buds, in pieces	Evolved apical buds		Rooted plants		Transformed plants		Selected varieties with economic traits	
		pieces	%	pieces	%	pieces	%	pieces	%
Black currant	1783	1041	58.38	154	8.64	37	2.07	4	0.22
Red currant	1341	921	68.68	152	11.33	26	1.94	2	0.15
Gooseberry	1684	1002	59.50	98	5.82	18	1.07	3	0.18

The research of chemical mutagen influence on black and red currant and gooseberry varieties showed the linear dependence of mutant plants development degree

on concentration and exposure of mutagen influence.

The analysis of the obtained results showed:

- 1) To get varieties with economic traits the optimum concentration of the solutions for the treatment of mutagens varieties of black currants, red currants and gooseberries is 0.005% NML, 0.01% DES, 0.1% EI, 0.05% DMS within 12 hours exposure.
- 2) With the use of higher concentration of mutagens (0.5 to 1%) along with an increase in the total number of mutants, the percentage of plants with economic traits is reduced.
- 3) If the mutagen solution concentration is 1% the growth of browses from apical buds does not occur due to their dieback.

It is stated that the most mutable sorts are Pamyati Vavilova (4.38%), Minay Shmiryov (4.26%), Kantata 50 (3.87%), Yarovoy (2.63%), Belarussky krasny (2.79%), Nenaglyadnaya (4.32%); less mutable Tserera (0.84%), Katyusha (0.78%), Masheka (0.63%), Golandskaya krasnaya (0.72%), Prygazhunya (0.71%). The study shows that chemical mutagens induce a great number of currant and gooseberry hereditary changes the most part of which is not relevant to economic traits (Figure 1).

Nearly all characteristics and properties change under mutagen influence: increase or reduction in berry size and shape; fruit flavor reversion; reduction in number of seeds; early or late ripening; improvement or reduction of disease resistance; deformation of the ability to self-pollination, dwarfness, mien change, size and form variation, leaf coloration and its parameter, change of phenophase occurrence period.

The study of the derived and selected forms according to their main economic traits made it possible to distinguish among revealed deviations macro- and micromutations. Mutant forms of the first group stand in marked contrast with parental forms in leaf structure, mien and branch growth status.

Mutant forms of the second group keep predominant of mother variety but there are some leaf morphology deviations.

The most valuable for selective breeding currant and gooseberry neoplasms are their much strong growth, shortened internodes, long racemes, tree-shaped shrub mien, fruit enlargement, fruit taste control, improvement of disease resistance. The frequency of desirable mutations for practical selective breeding, however, is rather small. The desirable features of derived forms combine with the impairment of fertility that phenotypically is presented by small in size berries, their quantity reduction, and fruit and germ drop.

In whole, there are only 9 forms selected that exceed primary varieties on the strength of all traits.

Somatic mutations of currant and gooseberry were also studied. Apparent phenomic changes reasoned by chlorophyll deficiency and leaf morphology (pattern of limb lamina laceration, its surface, pinnation, size and form) were used. The record was maintained at the end of browses growth.

The great number of somatic mutations is induced by nitrosoethylurea and diethyl but less by ethylenimine and dimethyl sulfate. In most cases NEL and DES facilitated chlorophyll mutation emergence, but EI and DMS caused accompanying each other chlorophyll and morphological mutations. The study of currant and gooseberry somatic mutations was conducted to ascertain mutant trait correlation evident at the early stage of growth (chlorophyll deficiency, leaf morphology) with economic traits (tree-shaped mien, large fruit and et cetera) evident at the late stage.

The studied mutant forms of morphological type were divided into three groups according to leaf change rate with:

- 1 – marked pinnation
- 2 – severe lamina surface strain
- 3 – lamina size change.

Originally selected modified forms underwent vegetative breeding.

Correlation of lamina size change rate with other traits is shown in the results of maintained records in the second and third vegetative voltine.

The first group of shrubs is characterized by slow growth up to dwarfing and late phenophase stage. The majority of shrubs in this group are characterized by chlorophyll deficiency.

The zone of transformed by colour tissue can be found lengthwise big ribs.

The second group is characterized by impairment of fertility and chlorophyll deficiency in the form of light green leaf colour.

The shrubs of this group are marked with low yield due to the reduction of inflorescence number, florets and berry size.

The third group does not differ from the original parental varieties (the power of growth, leaf colour), but is characterized by high pollen sterility, reduction of inflorescence number and small fruit size.

It is revealed that there is a clear connection of leaf lamina change to a complex of other traits such as shrub mien, yield and et cetera.

The chlorophyll mutant forms presented by shrubs with leaf colour change, having been observed during a year are investigated.

As opposed to morphological mutant forms with a slight amount of chlorophyll deficiency the named above forms are characterized by the colour change of the whole leaf lamina.

In whole, all educed forms with chlorophyll change can be unified into three groups:

1 – homochromous – yellow, light green, greenish-yellow

2 – bicolorous – a part of shrub leaves is light green or yellow-green, the rest one is habitual

3 – colour interchange – from green to inconspicuous yellowy-green during vegetation period.

The eduction of correlation between groups of chlorophyll mutants with other economic traits during three vegetative voltines showed that the first group is characterized by slow growth or tree-shaped shrub mien, the second group – tight shrub mien with elevated branch, the third – sprawling shrub and lagged phenophase development.

The educed regularity is inherent to black currants, red currants and gooseberries.

4. Conclusion

The possibility of currant and gooseberry selection induced by chemical mutagenesis has been shown in the following study results:

1. Optimum concentrations of mutagen solutions for agriculturally important species of black currant, red currant and gooseberry selection are: 0.005% NEU (Nitroso-N-ethylurea); 0.01% diethyl sulfate (DES); 0.1% ethyleneimin (EI) and 0.05% dimethyl sulfate (DMS) within 12 hours exposure. When using higher concentration of mutagens (0.5 to 1%) along with an increase in the total number of mutants, the percentage of plants with economic traits is reduced. If the mutagen solution concentration is 1% the growth of browses from apical buds does not occur due to their dieback.

2. The most mutable varieties are Pamyati Vavilova (4.38%), Minay Shmiryov (4.26%), Kantata 50 (3.87%), Yarovoy (2.63%), Belarussky krasny (2.79%), Nenaglyadnaya (4.32%); less mutable Tserera (0.84%), Katyusha (0.78%), Masheka (0.63%), Golandskaya krasnaya (0.72%), Prygazhunya (0.71%).

3. The great number of somatic mutations is induced by nitrosoethylurea and diethyl but less by ethylenimine and dimethyl sul-

fate. NEL and DMS in most cases enforce onset of chlorophyll mutations but EI and DMS usually cause concurrent chlorophyll and morphological mutations.

4. Mutant forms of black currants, red currants and gooseberries with morphological lamina change and leaf chlorophyll distortion revealed a clear relation to shrub yield and mien.

5. Four varieties of black currant, 2 – red currant and 3 – gooseberry exceeded the original parental variety in a complex of characteristics have been selected. The selected variety represents the original breeding material for further improvement.

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