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RESEARCH ARTICLE

Somatic mutations in introduced garden rose cultivars in the collection of the M.M. Gryshko National Botanical Garden

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Abstract

The article analyzes the manifestations of somatic (bud) mutational variability of traits in garden roses (*Rosa* L.) under the conditions of the collection of the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine. The study is based on the results of long-term phenotypic observations of cultivars of different origin and garden groups. It was established that mutational variability in roses is not random but follows regular and largely predictable patterns determined by the genotype, origin, and breeding history of the initial cultivars. A relationship between the direction of mutational changes and the affinity of cultivars with particular garden groups was revealed: forms closer in origin to wild rose species more frequently produce mutants with enhanced expression of decorative traits, whereas cultivars of modern, evolutionarily advanced groups predominantly give rise to mutants with reduced expression of these traits. Both stable somatic mutants and cases of partial or complete reversion to the phenotype of the original cultivar were recorded. The practical significance of somatic mutations for cultivar assessment, cultivar identification, trait stability assessment, and mutation breeding in ornamental plants is substantiated.

Keywords: *Rosa*, garden roses, somatic mutations, bud mutations, mutational variability, cultivar study, trait stability, ornamental plants

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Introduction

Varietal studies of ornamental plants are an important component of the scientific support for breeding. For crops predominantly propagated vegetatively, particularly garden rose cultivars, the study of phenotypic variability in traits, their stability, and their origin is of special importance, since these characteristics form the basis for cultivar identification and for assessing compliance with the criteria of distinctness, uniformity, and stability.

Along with hybridization, somatic (bud) mutations play an important role in the formation of the modern assortment of roses. They have led to the emergence of numerous well-known cultivars that differ in flower color, degree of duplication, plant habit, and other morphological traits essential for cultivar identification. At the same time, mutational variability is often regarded as a random process, which complicates its practical application in breeding and varietal studies.

Studies by K.I. Zykov and Z.K. Klimenko (Rubtsova, 2003, 2005) have shown that the mutational process in garden roses follows certain regularities and is largely determined by the genotype and origin of the initial cultivars. These theoretical concepts are of great importance not only for breeding but also for varietal studies, as they enable the prediction of the nature of phenotypic changes and assessment of the potential of somatic mutants as new cultivars.

In this context, the analysis of mutational variability in botanical garden collections of roses is highly relevant due to its regularity, predictability, and significance for varietal studies. The integration of theoretical concepts of the mutational process with long-term phenotypic observations enables a deeper understanding of the nature of varietal variability. It substantiates the practical use of mutant forms in breeding.

The study aimed to identify the regularities of mutational variability of traits in garden rose cultivars and to assess their significance for varietal studies and cultivar identification. To achieve this aim, the following objectives were defined:

- to analyze the manifestation of somatic (bud) mutational variability of traits in rose cultivars of different origins and garden groups;
- to determine the dependence of the direction of mutational changes on the origin of the initial cultivars and on the inheritance patterns of quantitative and qualitative traits;
- to assess the stability of phenotypic expression of somatic mutants during long-term observations.

Material and methods

The study was carried out using a collection of garden rose cultivars from the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine (NBG), which is one of the largest and most representative rose collections in Ukraine and comprises more than 560 cultivars from various garden groups and origins. The collection is maintained under open-field conditions and is used for introduction, breeding, and varietal studies.

The study focused on rose cultivars, in which manifestations of somatic (bud) mutational variability were recorded during long-term observations, as well as on stable cultivar mutants preserved in the collection. The analysis included cultivars from different garden groups, in particular hybrid tea, floribunda, grandiflora, climbing, and old garden roses, which enabled comparison of mutational variability by origin and breeding development of the initial forms.

The research was conducted using long-term phenotypic observations (Boiko et al., 2015). Trait testing was performed throughout the growing season, accounting for trait expression repeatability across years. Special attention was paid to morphological traits of key importance for cultivar identification and for distinctness, uniformity, and stability testing, namely flower color and its intensity, degree of duplication, and plant habit.

Somatic mutation recording was performed in cases where shoots or inflorescences with phenotypic traits differing from those typical of the original cultivar appeared on plants. For each detected mutation, a description of morphological changes, a comparative characterization with the original form, and an assessment of the stability of trait expression in subsequent growing seasons were performed. In cases of repeated occurrence of altered traits or their persistence after vegetative propagation, mutant forms were regarded as potentially stable.

To analyze the directionality of mutational variability, a comparative morphological approach was used, accounting for the origin of cultivars, their affinity with particular garden groups, and the inheritance patterns of traits reported in the literature.

The stability of phenotypic traits was assessed through repeated observations over several growing seasons. Both cases of persistent maintenance of mutant traits and manifestations of reversion to the phenotype of the original cultivar were taken into account, which is important for varietal studies.

The obtained results were summarized using descriptive and analytical methods, which enabled the identification of regularities in the mutational variability of traits in garden roses and the evaluation of their practical significance for varietal studies and cultivar identification.

Results and discussion

Hybridization is the primary and traditional method for creating new plant cultivars; however, mutations also play a significant role in generating cultivar diversity, especially in vegetatively propagated crops. The use of natural (spontaneous) and induced mutations in the breeding process is known as mutation breeding. Its results can be applied to the development of new cultivars, the production of initial breeding material, overcoming crossing incompatibility, and fundamental research in plant genetics and biology.

An advantage of mutation breeding is the relatively rapid achievement of results compared to hybridization, particularly in crops with a long juvenile period, where the trials of hybrid progeny require many years of observation (Sarwar & Butt, 2015). Unlike hybridization, which combines traits from different genotypes within a single organism, the mutational process allows modification of one or several traits without significantly altering the genotype of the original cultivar. This is particularly important when it is necessary to adjust a specific characteristic of a high-quality cultivar while preserving its unique agronomically valuable properties.

During the mutational process, phenotypic expression of recessive genes controlling valuable traits is possible. In roses, these include remontancy, flower duplication, yellow, white, and dark red coloration, as well as the climbing growth habit (Datta, 2018). For this reason, somatic (bud) mutations play a key role in shaping the modern assortment of garden roses.

Among ornamental plants used for cut flowers and landscaping, roses take the leading place. The global assortment of roses has been formed over a long historical process of introduction, selection, and breeding, and currently comprises about 30,000 cultivars across various garden groups. Bud mutations have made a substantial contribution to enriching this assortment.

Some of the earliest examples of spontaneous mutations in roses include the emergence of remontant forms of *Rosa chinensis* Jacq., the cultivation of which in China began about a thousand years ago (Guoliang, 2003), as well as the appearance of characteristic glands on the sepals of moss roses – mutant forms of *R.* × *centifolia* L., first described in the 17th century (Hurst & Breeze, 1922). According to Fatih (2003), most thornless rose cultivars are also of mutant origin.

An analysis of the rose assortment presented on the world market in 1937–1976 showed that, out of 5,819 cultivars, 865 were obtained as a result of bud mutations (Haenchen & Geifert, 1978; Rout et al., 1999). Saakov (1976), analyzing the origin of 10,368 cultivars, concluded that 7.5 % arose from sport mutations. According to modern estimates, the number of such cultivars exceeds 1,600, accounting for about 10 % of the total global rose assortment (Haenchen & Geifert, 1978; Young & Schorr, 2007). Mutations contribute significantly to the formation of hybrid tea roses, with about 18 % of cultivars being of mutant origin (Datta, 2018). China, India, and Japan have made substantial contributions to the development of mutation breeding of ornamental plants. In India, a large number of ornamental crop mutants, including roses, have been obtained (Kharkwal & Shu, 2009), while in Japan, at least ten mutant rose cultivars have been developed (Nakagawa, 2009).

Studies of S. Saakov (Saakov, 1976), as well as Z.K. Klimenko and K.I. Zykov (Rubtsova, 2003, 2005) demonstrated that mutational variability in roses is not random but follows certain regularities and is largely determined by the origin of the initial cultivars. In particular, cultivars with a complex hybridogenic origin, as well as representatives of modern garden groups (hybrid tea, floribunda, and shrubs), exhibit an increased frequency of bud mutations. Most often, such mutations appear during the first years of a cultivar's existence (Rubtsova, 2003, 2005). Sarwar & Butt (2015) also noted that the introduction of new genotypes significantly increases the probability of mutational changes.

An analysis of the literature indicates that the most common manifestations of bud mutations in roses include changes in flower color, degree of doubleness, and transformation of plant habit, particularly the formation of climbing forms. Z.K. Klimenko and K.I. Zykov (Rubtsova, 2009) established that heterozygous cultivars, in which desirable traits are present in a recessive state in the genotype, are the most promising for obtaining mutants. Both spontaneous and induced mutations are often accompanied by changes in coloration from dominant (pink and red) to recessive (dark red, white, and yellow) variants.

Thus, the literature review confirms the important role of somatic mutations in the formation of cultivar diversity of garden roses and demonstrates their significant potential for introduction, varietal studies, and breeding of ornamental crops.

Patterns of mutational variability of traits in garden roses

The data presented in the table further demonstrate that somatic (bud) mutations are widespread and multidirectional within the NBG garden rose collection. Among the 560 cultivars maintained in the collection (Rubtsova, 2008), 27 cultivars (4.8 %) are of mutant origin.

The analysis of somatic mutation distribution among rose garden groups showed that frequency varied by group (Tables 1 & 2). The highest mutation frequency was observed in shrub roses (12.3 %) and climbing roses (9.6 %). In hybrid tea and floribunda cultivars, the frequency of detected mutations was lower (4.1% and 3.6 %, respectively). Such differences may be associated with the genetic characteristics of cultivars in different garden groups, as well as with the complex hybrid origin of many modern roses.

During long-term phenotypic observations of rose cultivars in the NBG collection, numerous manifestations of somatic (bud) mutational variability were recorded, affecting both qualitative and quantitative morphological traits important for cultivar identification. Most frequently, mutational changes involved perianth color, pigmentation intensity, degree of floral duplication, and plant growth habit.

Significance of varietal studies in roses

Somatic rose mutants exhibit distinct, morphologically fixed differences that can be used for variety identification, justification of the distinctness criterion, and testing of trait stability. Thus, the mutational variability in garden roses is not random but follows a consistent pattern. It confirms the important role of somatic mutations as both a source of new varieties and an object of scientific study of varieties. At the same time, the presence of mutants in old garden groups such as Gallica, Damask, Bourbon, and Moss (Rubtsova, 1982; Rubtsova & Chyzhankova, 2019; Rubtsova et al., 2025) indicates that the mutation process is a universal phenomenon and is not limited to modern breeding forms.

Direction of mutational changes

An analysis of the nature of phenotypic changes showed that the vast majority of mutations affect flower color. In contrast, mutations in plant habit (the transition from bush to climbing forms) occur much less frequently. This is consistent with the generally accepted view of the pigment system's high mutability in roses. In most cases, changes in flower color follow a direction from dominant to recessive forms, in particular:

- red or crimson-red → pink (e.g., in cultivars 'Akvarel Rose Park', 'Chicago Peace', 'Red Rugostar', 'Prodige Ecarlate');
- pink → white (e.g., in cultivars 'Leda', 'Nova Zembla', 'White Grootendorst', 'White Dorothy');
- yellow or apricot → lighter or modified shades.

At the same time, in some cases an intensification of anthocyanin pigmentation was observed, for example in the cultivar 'Black Beauty', which originated from the yellow cultivar 'Frisco', or in 'Red Leonardo da Vinci' with its deep red coloration. Such cases are particularly valuable for cultivar assessment and study.

Relationship between mutations, origin, and garden groups

Among mutant cultivars, representatives of modern garden groups, hybrid tea, floribunda, shrubs, and climbing roses predominate. This supports the view that a complex hybridogenic origin and a high level of heterozygosity contribute to an increased frequency of somatic mutations. Such mutations often manifest as stable qualitative changes that

Table 1. Comparative characteristics of somatic mutants and their original cultivars of introduced garden roses.

No.	Mutant cultivar	Perianth color, floral duplication or growth habit peculiarities of the derivative cultivar	Original cultivar	Garden group	Year of introduction	Perianth color, floral duplication or growth habit peculiarities of the original cultivar
1	'Abracadabra'	striped	'Hocus Pocus'	Floribunda	2001	striped
2	'Akvarel Rose Park'	pink	'Dame de Coeur'	Hybrid tea	1958	red
3	'Baron Girod de l'Ain'	red with white petal margins	'Eugene Furst'	Hybrid perpetual	1875	red
4	'Black Beauty'	dark red	'Frisco'	Floribunda	1986	yellow
5	'Chapeau de Napoleon'	more double	'Centifolia Muscosa Communis'	Moss	1696	less double
6	'Chicago Peace'	pink	'Gloria Dei'	Hybrid tea	1935	yellow
7	'Fantasia Mondiale'	light yellow	'Mondiale'	Hybrid tea	1993	yellow
8	'Flirt'	light pink	'Sommerwind'	Shrub	1985	pink
9	'Gloria Dei, Climbing'	climbing	'Gloria Dei'	Hybrid tea	1935	bush
10	'Iceberg, Climbing'	climbing	'Iceberg'	Floribunda	1958	bush
11	'Kakhovka'	pink	'Flammentanz'	Climber	1952	red
12	'Khersones'	crimson	'Décor Arlequin'	Shrub	1978	crimson pink with yellow reverse of petals
13	'Kronenbourg'	red with yellow reverse	'Gloria Dei'	Hybrid tea	1935	yellow with crimson-pink margins
14	'Leda'	white	'Pink Leda'	Damask	1949	pink
15	'Madam Pierre Oger'	light pink	'Reine Victoria'	Bourbon	1872	pink
16	'Margarita Hilling'	pink	'Nevada'	Shrub	1927	white
17	'New Dawn'	light pink	'Dr. W. van Fleet'	Climber	1899	pink
18	'Nova Zembla'	white	'C.F. Meyer'	Shrub	1893	pink
19	'Pestraya Fantasia'	crimson-red with golden streaks and petal reverse	'Kronenboug'	Hybrid tea	1966	red with yellow reverse
20	'Pink Grootendorst'	pink	'F.J. Grootendorst'	Shrub	1918	crimson
21	'Red Intuition'	red with stripes	'Belle Rouge'	Hybrid tea	1996	red
22	'Rote Dagmar Hastrup'	red	'Fru Dagmar Hastrup'	Shrub	1914	pink
23	'Versicolor'	light pink with crimson stripes	*Rosa gallica* L. var. *officinalis* (Andrews) Thory	Gallica	ca. 1160	pink
24	'White Dorothy'	white	'Dorothy Perkins'	Climber	1901	pink
25	'White Grootendorst'	white	'Pink Grootendorst'	Shrub	1923	pink
26	'Yellow Romantica'	yellow	'Colette'	Climber	1995	apricot
27	*Rosa roxburghii* var. *plena* Rehder	double-flowered	*Rosa roxburghii* Tratt.	Shrub	1825	single-flowered

Table 2. Frequency of somatic mutations in different garden groups of roses in the collection of the NBG.

Garden group	Number of cultivars in the collection	Cultivars with detected somatic mutations	Frequency of mutations (%)
Hybrid tea	146	6	4.1
Floribunda	84	3	3.6
Shrub	65	8	12.3
Climber	52	5	9.6
Old roses (Moss, Damask, Bourbon, Hybrid perpetual, Gallica)	75	5	6.7

are maintained over a long historical period (e.g., in cultivars 'Versicolor' and 'Chapeau de Napoleon').

Mutations of plant habit

A separate group consists of mutants with transformations of plant habit, in particular the transition from bush forms to climbing ones (e.g., in cultivars 'Gloria Dei Climbing', 'Iceberg Climbing', and 'Electron Climbing'). Such mutations have high practical value, as they significantly expand the possibilities for using a cultivar in landscaping without altering the cultivar's main decorative characteristics (Rakhmetov et al., 2019; Kolesnychenko et al., 2020).

Stability of mutational expression and trait reversion

An assessment of phenotypic stability in somatic mutants showed that, alongside stable forms that retained altered traits over several growing seasons, the collection also included cases of partial or complete reversion to the phenotype of the original cultivar. Such phenomena were particularly observed in mutants with altered flower color, in which shoots with different types of pigmentation appeared simultaneously on the same plant. This is especially characteristic of mutants with modified flower color (e.g., in cultivars 'White Grootendorst' and 'Versicolor'), underscoring the need for long-term testing of such forms during cultivar trials and stability assessment. In particular, in the cultivar 'White Grootendorst' (Fig. 1A), pink flowers frequently appear, as in the original cultivar 'Pink Grootendorst'. In the striped cultivar 'Versicolor' (Fig. 1B), a mass reversion to the original pink coloration of *Rosa gallica* var. *officinalis* was observed.

The fact of reversion is of great importance for cultivar assessment and stability testing, as it indicates the need for long-term observations of mutant forms before they can be considered as potential new cultivars. At the same time, stable somatic mutants that retain their phenotypic traits over a long period may be regarded as full-fledged objects of cultivar trials. Particularly active spontaneous mutational variability was recorded by us in 2020: six spontaneous mutations were identified based on phenotypic changes (flower color), and one mutation concerned plant habit:

- 'Charlotte Wheatcroft' (red) → pink (Fig. 1C);
- 'Prodige Ecarlate' (crimson-red) → pink;
- 'Red Leonardo da Vinci' (red) → dark red;
- 'Red Rugostar' (red) → pink (Fig. 1D);
- 'Vintazh' (yellow) → pink;
- 'Weg der Sinne' (purple) → white;
- 'Electron' → 'Electron' climbing.

Such intensive mutational variability may be associated with specific environmental physical factors in Kyiv in 2020 – a warm winter with almost no snow, and extreme weather conditions in May, when the mean monthly temperature was 2.8 °C below the climatic norm. In addition, 122 mm of precipitation fell in May, which amounted to 230 % of the climatic norm.

We also selected a spontaneous bud mutation with pink flower color from the red-flowered cultivar 'Dame de Coeur' (Fig. 2 A). This mutant cultivar was named 'Akvarel Rose Park' (Fig. 2 B) and successfully passed the official state cultivar testing. An authorship certificate and a patent were obtained for this cultivar.

Figure 1. Reversion to the phenotype of the original cultivar in the garden roses: **A** – 'Pink Grootendorst'; **B** – 'Versicolor'; **C** – 'Charlotte Wheatcroft'; **D** – 'Red Rugostar'.

Analysis of the obtained data showed that mutational variability in roses is not random in nature, but exhibits regular patterns associated with the origin of the source cultivars and their affinity with particular garden groups. It was established that cultivars whose origin is closer to primitive wild rose species (acyanous, single-flowered, small-flowered forms) more frequently produce somatic mutants with an increased expression of traits such as anthocyanin pigmentation intensity, doubleness, and flower size. In contrast, cultivars of modern, evolutionarily advanced garden groups, primarily hybrid tea, floribunda, and grandiflora, which are products of long-term intragroup and close-related hybridizations, are characterized by the predominance of mutants with reduced expression of these traits.

The results obtained are consistent with the concepts of K.I. Zykov (Rubtsova, 2005) concerning the regular nature of mutational variability in garden roses. The results confirm that the direction of the mutational process depends on the genotype and breeding history of the original cultivars. Within the collection, a trend is observed in which cultivars of modern garden groups are dominated by mutations that reduce flower color intensity or other quantitative traits. In contrast, in less selective 'advanced' forms, mutants with enhanced phenotypic traits arise more frequently.

Other types of mutations

In addition to somatic mutations that serve as a source of material for selecting new cultivars, roses also display a range of mutations that appear as developmental abnormalities. Although such changes are not of practical interest for breeding, they have important theoretical significance. These include fasciation, flower proliferation, petalization, heteromorphism, chorisis, and several other forms of teratomorphosis.

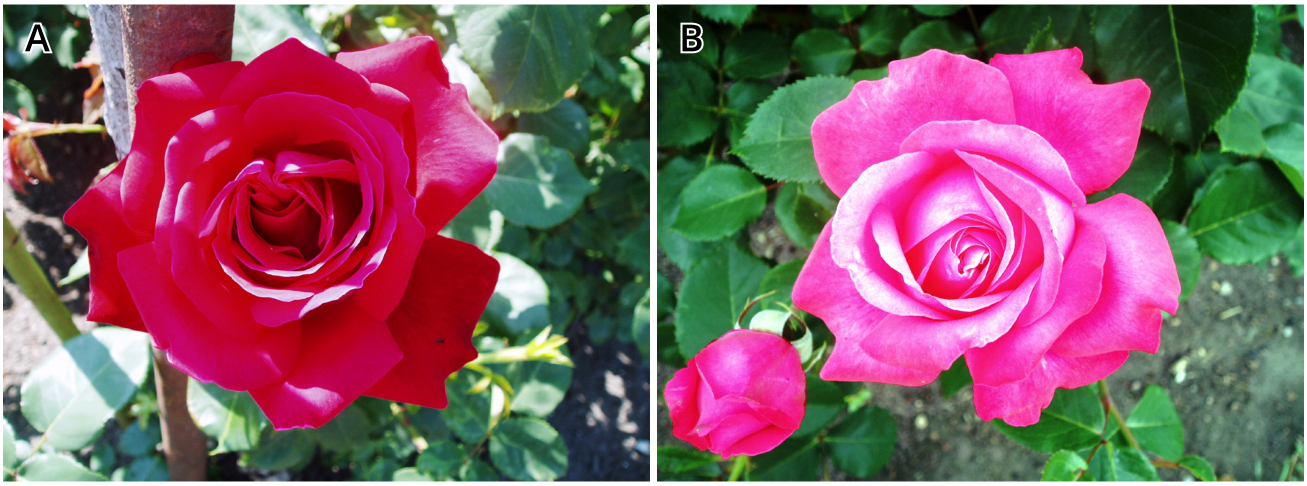

Figure 2. Spontaneous bud mutation with shift of red perianth color to pink: **A** – original cultivar 'Dame de Coeur'; **B** – derivative cultivar 'Akvarel Rose Park'.

The characteristics of these anomalies have been analyzed in detail in our previous studies (Rubtsova et al., 2023).

Significance of the revealed patterns for cultivar assessment

The established patterns of mutational variability in roses are of great practical importance for cultivar evaluation. The predictable direction of mutations allows for a more substantiated assessment of the origin of phenotypic differences arising within a cultivar. It helps to distinguish random variability from stable cultivar traits. The results of the study indicate that somatic mutations in roses can serve as an important source for the development of new cultivars, which, provided that trait expression is stable, meet the criteria of distinctness and may be eligible for legal protection. The integration of data on the origin of source cultivars, the nature of trait inheritance, and the direction of mutational changes provides a scientific basis for the practical assessment and breeding of ornamental crops.

A dependence of flower variability on the color of the original form was established. Analysis of bud mutations under natural conditions showed that the petals of the vast majority of cultivars exhibit the highest variability and are partially or completely colored in pink or red tones. Pink and red coloration in roses is dominant over other color types. Therefore, under natural conditions, cultivars with dominant flower coloration are the most mutable. A study of the origin of the source cultivars showed that during spontaneous mutagenesis, recessive traits of ancestral forms are most often expressed.

Mutation breeding can substantially contribute to the genetic improvement of ornamental plants and to increasing their socio-economic benefits. Mutation has great potential to modify one or more traits of an outstanding cultivar without altering the remaining characteristics, often preserving otherwise unique genotypes. The collection of mutant rose cultivars represents valuable material for theoretical generalizations and for analyses of origin, inheritance, and the direction of phenotypic changes.

Conclusions

1. As a result of long-term cultivar trials studies, it was established that the mutational variability of traits in garden rose cultivars is not random but follows regular and largely predictable patterns determined by the genotype, origin, and breeding history of the initial cultivars.
2. A relationship was identified between the direction of mutational changes and the affiliation of cultivars with particular garden groups. Cultivars that are closer in origin to primitive wild rose species more frequently produce somatic mutants with an increased expression of traits such as anthocyanin

pigmentation intensity and double-floweriness. In contrast, cultivars of modern, evolutionarily advanced groups (i.e., Hybrid tea, Floribunda, Grandiflora) are characterized by a predominant occurrence of mutants with reduced expression of these traits.

3. It was established that, alongside stable somatic mutants, cases of partial or complete reversion of phenotypic traits to the original cultivar are observed in rose collections, which emphasizes the need for long-term observations of mutant forms during cultivar trials and stability testing.
4. The identified regularities of mutational variability are of significant practical importance for cultivar assessment, as they make it possible to predict the direction of phenotypic changes and to select initial forms for mutation breeding of ornamental crops.
5. Provided that stable expression of traits is ensured, somatic rose mutants may be regarded as promising objects for cultivar trials and legal protection, thereby expanding opportunities for the development of new cultivars and the enrichment of the assortment of ornamental plants.

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У статті проаналізовано прояви соматичної (брунькової) мутаційної мінливості ознак у сортів садових троянд (*Rosa* L.) в умовах колекції Національного ботанічного саду імені М.М. Гришка НАН України. Дослідження ґрунтується на результатах багаторічних фенотипових спостережень за сортами різного походження та належності до садових груп. Встановлено, що мутаційна мінливість троянд має закономірний, а не випадковий характер і значною мірою визначається генотипом, походженням і селекційною історією вихідних сортів. Показано залежність спрямованості мутаційних змін від належності сортів до певних садових груп: у форм, ближчих за походженням до диких видів, частіше виникають мутанти з підвищеним рівнем прояву декоративних ознак, тоді як у сортів сучасних еволюційно просунутих груп переважають мутації зі зниженням інтенсивності їх прояву. Виявлено випадки як стабільного збереження мутантних ознак, так і часткової або повної реверсії до фенотипу вихідного сорту. Обґрунтовано практичне значення соматичних мутацій для сортовивчення, ідентифікації сортів, оцінки їх стабільності та використання в мутаційній селекції декоративних культур.

Ключові слова: *Rosa*, садові троянди, соматичні мутації, брунькові мутації, мутаційна мінливість, сортовивчення, стабільність ознак, декоративні рослини