

Research progress of Chinese rose breeding techniques

Wenran Xie

Collage of Horticulture& Forestry Sciences, Huazhong Agricultural University,
Wuhan, Hubei Province, China, 430070

15511582156@163.com

Abstract. Chinese rose is one of the top ten most famous traditional flowers in China, as well as one of the world's four cut flowers and the most frequently used ornamental flower, known as the "queen of flowers." According to the records of the American Rose Association, in 2000 there were more than 24,000 varieties of Chinese roses worldwide. In China, the Chinese rose has a lengthy history of cultivation, a strong mass base, a positive moral symbol, and a robust group of varieties. In recent years, an increasing number of plant breeders have been devoted to the study of Chinese rose breeding, and Chinese rose breeding techniques have advanced by leaps and bounds and produced fruitful outcomes. This paper summarized the breeding objectives of contemporary Chinese rose, analyzed and discussed the breeding techniques of molecular breeding, introduction and screening, crossbreeding, bud sport breeding, mutation breeding, and so on, and anticipated the future research field of Chinese rose breeding.

Keywords: Chinese rose, breeding objective, breeding techniques.

1. Introduction

Rosa hybrida L. is part of the Rosaceae family. It has numerous flower varieties, a lengthy blooming period, beautiful colors, a strong fragrance, and a high ornamental value. Chinese rose is commonly used in gardens, horticulture, and fresh-cut flowers, as well as in green central reservations, flower arrangements, flower landscapes, flower beds, etc. In addition, rose has positive ecological benefits and can purify the air. Lijuan Lian et al. also discovered that it has medicinal properties [2].

As one of the earliest nations to cultivate Chinese roses, China has made significant contributions to the global development of Chinese rose breeding [3]. Currently, the propagation of Chinese roses focuses primarily on aspects such as flower color, flower type, floral fragrance, plant type, and so forth. Molecular breeding, introduction and screening, crossbreeding, bud sport breeding, and mutation breeding are among the techniques utilized. Currently, Chinese rose propagation is plagued by issues such as low quantity and poor quality [4], which result in low economic benefits. Consequently, in order to promote the growth of the Chinese rose breeding industry, breeders have to cultivate more new cultivars with high ornamental value and high adaptability, utilizing the newer breeding techniques.

In light of this, this paper provides an overview of the research results of several breeding techniques for Chinese rose, so that researchers can comprehend the research progress and development status of Chinese rose breeding technique, so as to maximize the advantages of various breeding techniques and provide references for the achievement of multiple breeding objectives for Chinese rose.

2. Breeding objectives of Chinese rose

2.1 Color

As one of the most colorful flowers, the Chinese rose can be arranged in a spectrum ranging from white to black. Dubois et al. discovered that the color variation of Chinese rose was due to the plant's varying proportions of anthocyanin [4], carotenoid, and flavonol. Due to the lack of flavonoid-3'-5'-hydroxylase (F3'5'H) to produce delphinidin that can make the rose appear blue, there is no genuine blue or black in roses [5], and people have paranoid affection on the blue rose, so this has become the primary research objective for some breeders. In 2009, the Suntory Company of Japan cultivated blue rose 'Acclaim' that can be stably inherited through transgene technology [6], but it has not been extensively promoted and applied in domestic and international flower markets. As for the breeding of black Chinese roses, they are progressively darkened from a base of red or purple until they approach black [5].

2.2 Flower type and plant type

The Chinese rose's flower type contains both petal and flower shapes. Typically, 30 to 50 petals are required, preferably with a velvety or satiny sheen and velvety or satiny texture. It is optimal for flower buds to have a spherical or long, pointed shape. Flower shapes should be attractive, open to the end, and buds should have a spherical or long, pointed shape. Various flower types are required for various purposes. Flowers with a disk-shaped open form are suitable for garden greening, those with a heart-shaped cup are suitable for cut flowers, and those with a cup-shaped heart with a crooked corner are suitable for container plants.

According to the characteristics of its plant type, roses can be divided into shrub, vine, and erect varieties [7]. In general, shrub roses with a medium plant type and a robust, independent trunk are suitable for landscaping; those that are too tall or too thin are unsuitable. To enhance the decorative effect of a winding veranda, the rose should be longer, thinner, and softer. The miniature rose should be a compact plant suitable for container cultivation and indoor landscaping. Particularly, cut flowers should have long and sturdy branches, which require long internodes, firmness, storage and pruning resistance, powerful germination, and a high yield [5].

2.3 Floral fragrance

Fragrance is an essential criterion for assessing the quality of Chinese roses, as well as an essential research direction for cultivators. In addition to enhancing its own ornamental value, the aromatic rose can be used to extract essential oil for use in perfumes, skin care products, and other cosmetics, which has a tremendous economic value. In addition to the typical rose fragrance, there are also fragrances of tea, citrus, fennel, and myrrh, which can be divided into four categories based on their intensity, ranging from fragrance-free to aroma. The floral aroma of the Chinese rose is followed by a strong quantitative inheritance. The hybridization of parents with strong and non-fragrant fragrances can produce progeny with varying degrees of fragrance, thereby enhancing the floral fragrance of rose. This trait has also been utilized by breeders to create numerous varieties with unusual aromas.

2.4 Resistance

In recent years, as the global ecological environment has deteriorated and people's cognizance of environmental protection has increased, plant resistance has received increasing attention. In terms of resistance, adaptability, and other aspects of climate conditions, the requirements are more stringent; environments that are too hot or too chilly are not conducive to growth; this will shorten the flowering period, diminish the quality of the flowers, and increase the cost of maintenance. In order to expand the planting range of roses and embellish people's living environments, many breeders have devoted significant efforts in recent years to developing heat- and cold-resistant varieties. U.S.-grown poly-rose 'Carefree Beauty' can withstand temperatures as low as -38 degrees Celsius. Despite the fact that the cold resistance of roses has improved substantially in recent years, there are still many practical cultivation issues to be resolved in cold regions. According to the natural characteristics and production

needs of different regions, breeders are also committed to breeding varieties that are resistant to salt, alkali, humidity, low light, high altitude, and environmental pollution, as well as varieties that can be used to beautify urban parks and streets, and are easily managed with multiple flowers and tolerant to bloom.

In terms of disease resistance and insect resistance, when Chinese rose is grown as a shrub in an unprotected field, it rarely becomes ill, even in the absence of any protective measures. However, once transferred into a greenhouse or container planting, its pests and diseases are particularly severe and difficult to control; at the very least, plant growth does not meet standard requirements, and the entire rose may be damaged. Powdery mildew, black spot, rust disease, canker, red spider, aphids, and scale insects are the most prevalent maladies of roses [5]. The introduction of a large number of disease-resistant varieties can produce a rapid control effect, but it is difficult to maintain a high level of disease resistance over time. Consequently, there is still a great deal of unexplored land for the breeding of roses resistant to diseases and parasites. It has always been the objective of Chinese rose cultivators, and some progress has been made.

3. Breeding techniques for Chinese rose

3.1 Molecular Breeding

The technique of molecular breeding has been effective in enhancing flower color and type, enhancing resistance, extending bottle life, and devising fresh-keeping solutions, among other things. Holton cloned the F3 '5' H pigment from petunia and utilized antisense and justice suppression techniques to reduce the activity of chalcone synthase [9], thereby effectively altering the flower color of the Chinese rose. Gion et al. created a chimeric protein overexpression vector in order to obtain a transgenic variant of Chinese rose with undulating folds at the petal margins [8]. Consequently, molecular biology can be used to enhance a particular rose characteristic. Molecular breeding is highly targeted, which can in some cases abbreviate the breeding process and eliminate cross incompatibility. However, the molecular mechanism of each characteristic of the Chinese rose is extremely complex, and the difficulty of the molecular breeding technique prevents its application to large-scale Chinese rose breeding. By further investigating the formation and genetic mechanism of ornamental traits and combining molecular breeding with other modern breeding techniques, it is possible to achieve more ideal breeding results in practice.

3.2 Introduction and screening

Over ninety-five percent of the Chinese roses that are extensively cultivated in China are imported at this time. In the 1780s, the Western nations brought the ancient Chinese rose to the rest of the globe, thereby forming the massive Chinese rose variety group. Chinese researchers directly import rose varieties with both ornamental and economic value from other regions, conduct adaptive cultivation experiments in various regions, and compare the comprehensive performance of growth, cut flower quality, resistance, etc. [8], in order to select the most locally adapted cultivated rose varieties. After domestication, cultivation on a broad scale is encouraged. Introduction and domestication can also transform wild rose species into cultivated species and maximize the use of wild resources, and the majority of wild rose species have robust growth and excellent resistance [6], qualities that are lacking in contemporary rose varieties. Consequently, the introduction of the Chinese rose merits consideration.

3.3 Cross breeding

Presently, eighty percent of Chinese rose varieties are obtained through hybridization, and both domestic and international researchers have obtained relatively fruitful results. In Chinese rose breeding, Professor Junyu Chen [9] mentioned "wild breeding," or remote cross breeding between the modern rose and the original species of plant characteristics for variety improvement, which is a subset of remote cross breeding. For instance, Shanwu Huang et al. of the Chinese Academy of Agricultural Sciences crossed the cold-resistant curved prickly rose with the modern rose and bred exceptional varieties with

-20°C low temperature resistance [9], strong disease resistance, and robust growth. Bryson et al. bred Carefree Beauty [8], a gathering rose with a minimum temperature of -38°C, by crossing a sparsely-flowering rose with cold-resistant genetic material with a modern rose. Ma Yan et al. bred ten new rose varieties by crossing domestic wild rose species with ancient Chinese rose and modern Chinese rose [9]. In the process of cross-breeding, breeders hope that the offspring will exhibit all the positive characteristics of their parents; however, it is difficult for hybrid offspring to accomplish this goal, and their parents' characteristics are significantly diminished. Therefore, breeders must accomplish the desired outcomes through repeated tissue culture and screening, which increases the time and manpower requirements. In addition, the seed setting rate of different rose varieties varies widely, and the germination rate of roses is very low; therefore, a large amount of manpower must be invested in screening a large number of F1 roses in order to analyze the heredity laws.

3.4 Bud sport breeding

Bud mutation is the utilization of somatic mutation, which cannot be obtained through sexual hybridization and sowing in order to obtain novel varieties with desirable characteristics. Chinese rose buds undergo mutations at a relatively high rate in nature. According to incomplete statistics, approximately 300 novel Chinese rose varieties are the result of bud mutation [9]. 'Peace' was bred into 'Vine Peace,' 'Chicago Peace,' and 'Cologne Castle' via bud mutation selection [8]. Yunnan Academy of Agricultural Sciences selected and bred the new variety "Candy Snow Mountain" from the modern cut rose variety 'Snow Mountain' cultivation population. Compared to conventional cross-breeding, the breeding cycle of bud mutation is shorter, and it can be promptly applied once there are available character variations. Nonetheless, it requires a considerable amount of personnel and time to identify the available desirable traits, and since bud mutation is not directed variation, is not always useful and stable, the majority of bud mutation is meaningless. At this time, domestic and international research on the mechanism of bud mutation in the Chinese rose is limited. As soon as feasible, researchers need to comprehend the internal mechanism of bud mutation breeding using molecular techniques in order to break the current development limit of bud mutation breeding.

3.5 Mutation breeding

Mutation breeding consists of both physical and chemical mutagenesis. By radiating ^{60}Co -r rays from rose seedlings, Huifen Li et al. [8] produced the new variety 'Xia Hui'. MinZa et al. [8] exposed roses to varying doses of radiation, and their mutant petals exhibited a spectrum of hues spanning from white to dark pink. In addition to altering plant morphology, physiology, and biochemistry, such as plant height, leaf number, cell ultrastructure, and protective enzyme activity, mutation breeding can induce hard-to-obtain new characteristics. However, mutation breeding has a relatively limited spectrum of current applications. In the future, mutation breeding can be combined with other modern breeding techniques to accomplish a greater number of breeding objectives.

4. Conclusion

In recent years, numerous techniques have been applied to the study of flower form, color, and disease resistance in Chinese rose breeding. Nonetheless, cross-breeding of Chinese roses is currently the most popular technique, playing a crucial role in the breeding of Chinese roses due to its single operation, lack of complex steps, brief breeding time, and stable character of the resulting variety [10]. Presently, researchers are progressively favoring molecular breeding techniques such as gene cloning, gene gun, agrobacterium-mediated, and other techniques to breed new transgenic rose varieties with high productivity and stress resistance.

In the breeding of Chinese roses, it is necessary to combine different breeding techniques, particularly the organic combination of traditional cross-breeding technique and modern breeding technique, and to define breeding objectives in order to make greater strides in the development of new rose varieties. Breeders are conducting in-depth research on the breeding mechanism of the Chinese rose in order to increase breeding efficacy and satisfy market demand.

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