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Ornamental plant breeding is tools for new generation

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Abstract
Plant breeding for crops and ornamentals has grown in importance over the past century. Mendel's theories about the inheritance of characteristics established the groundwork for contemporary genetics. While chromosomal duplication, mutation breeding, and intra- and interspecific cross-breeding remain the mainstays of ornamental plant breeding, plant breeding has advanced dramatically since Mendel's day. Advanced accuracy breeding and selection towards more challenging to measure or quantify characteristics are now possible because to new genomic techniques. The breeding of ornamental plants nowadays is a challenging endeavor with constantly evolving and new obstacles. Collaborations between research and industry will be necessary to apply current technology to small-scale crops.

Keywords: Genomics, ornamental plants, interspecific hybridization, molecular markers

Introduction

It was during the 17th and 18th centuries that plant hunters, botanists or adventurers brought new plants to Europe from Asia and the Americas that many of today's popular ornamental plants were bred and selected. A new era of plant breeding was initiated by Mendel's discovery of how traits are passed from generation to generation. In addition to cross-breeding and selecting seedlings combining the desired characteristics of both parents, ornamental breeding was gradually applied. It became an industrial activity in private companies starting in the mid-1800s, resulting in the wide variety of ornamental species and cultivars Long *et al*. Approximately 85,000 to 99,000 ornamental plant species exist worldwide, according to (2018) extrapolations. It determines the huge potential of natural differences and germplasm in addition to the requirement to conserve genetic resources of ornamental plants for breeding and future growth. These facts include the wild relations of educated plants. Reasonable benefit-sharing will encourage the development of conservation of ornamental plants and will conserve imperative genetic variation for future demands and challenges. In recent decades legal organizations as The Convention on Biological Diversity (CBD), the Convention on International Trade in Threatened Species of Wild Fauna and Flora (CITES) and the Nagoya Protocol were recognized to govern the conservation and supportable use of plants.

Intra- and interspecific hybridization

The majority of ornamental species have high levels of heterozygosity, which generates enough variation in F1 populations to allow for selection of new valuable cultivars. Selection of novel phenotypes in progenies from controlled intraspecific crosses or even in open pollination seedling inhabitants has been, and still is, a successful method in various ornamental crops. The limited genetic variation in crossing parents makes it problematic to achieve truly advanced breakthroughs. New crossing mixtures between changed species (interspecific hybridization) in ornamental crops is therefore the most suitable tool to increase variation and represents an excellent way to present new stimulating genes into a breeding gene pool (Huylenbroeck *et al.*, 2020) [28]. In rose, only around 8 to 15 species contributed to the original germplasm of the modern cultivars (Leus *et al.*, 2018) [29]. In many of the most popular ornamental crops, interspecific hybridization forms the substance of the present variety. Chrysanthemum appeared from natural hybridizations between dissimilar wild species, important to a wide-range cultigens complex (Spaargaren and van Geest, 2018) [16].

This has led to a significant shift in the produced assortment (Van Tuyl *et al.*, 2018) [30]. Asexual propagation kinds it likely to propagate new types arising from interspecific hybridization even if they are sterile. Further examples are described in Marantaceae (Van Huylenbroeck *et al*, 2018) [19] *Asclepias* sp. (Lewis *et al.*, 2021) [12], *Pavonia* (Yue and Ruter, 2021) [25], and various additional crops.

In order for successful interspecific or extensive intergeneric crossing within a specific genus to occur (Eeckhaut *et al.*, 2006) [31}, a number of hurdles must be overcome. More and more studies are highlighting the importance of these data as an important indicator to predict crossing efficiency in breeding programs as has been shown for example in Geranium (Akbarzadeh *et al.*, 2021) [32], Helleborus (Meiners and Winkelmann, 2012) [33] and Hydrangea (Granados-Mendoza *et al.*, 2021) [34]. After postzygotic fertilization, numerous interspecific crosses exhibit issues such lower growth vigor, embryo abortion, endosperm development defects, or albinisms.

Chromosome doubling

In ornamental breeding, polyploidy, or chromosome doubling, is still significant. Spontaneous chromosomal doubling is often reported in wild populations.

In ornamental breeding, polyploidy, or chromosome doubling, is still significant. Spontaneous chromosomal doubling is often reported in wild populations. The somatic chromosome number of male or female gametes can spontaneously arise and give rise to new polyploids. This natural process is called gametic polyploidization. In certain instances, when flowers are created under temperature stress or after chemical treatment, there is a noticeable increase in production (Eeckhaut *et al.*,2018) [5]. Fertility issues can be resolved with unreduced gamete production, particularly following interspecific hybridization. Moreover, when breeding for triploid progenies, this method likewise produces a one-step process.

Somaclonal variation

The main cause of genetic variability is genetic mutations. Unplanned alterations continue to be a significant source of novel varieties, particularly for decorative plants lacking intentional breeding initiatives. Mutations are the source of new introductions in many woody ornamentals (Laere *et al.*, 2018) [20], such as variegated leaf forms or dwarf growing cultivars. The primary factor turning a wild species into a cultivated ornamental is mutations in several common genera of greenhouse-grown plants, particularly leaf plants. Certain examples can be observed in genera likewise *Aglaonema*, *Marantha*, *Monstera*, *Ficus*, *Hedera*, and many more. Plastid mutations give rise to a unique category of variegations, which includes leaves with white or yellow cell lineages. Extensive research is currently being conducted in several Asian countries, including as Malaysia, Japan, and South Korea, to improve mutation technology for the purpose of developing new types of ornamentals. (Ibrahim *et al.*, 2018) [8].

In some cases, it is possible to select genotypes resistant to biotic or abiotic stress factors (salinity resistance, low temperature tolerance) by utilizing somaclonal variation through cell cultures. Fungal toxins or filtrates from cultures can be used as selecting agents to achieve selection towards fungal resistance, as seen in carnations and other ornamentals. (Thakur *et al.*, 2002) [35]. Aside from morphological modifications, different amounts of ploidy have also been noted. Chrysanthemum protoplast regenerants exhibit a variety of somaclonal variations, such as variations in blossom quantity and size, a decrease in plant height, a modified blooming induction time, and varied flower kinds and colors. (Eeckhaut *et al*, 2020) [6].

Marker assisted breeding and genomics technology

The sequences of DNA known as molecular markers are those that are closely related to and inherited from the genomic area of concern. These markers can be used in breeding to precisely identify the individuals that carry the desired genetic region. Using marker-assisted selection, floral characteristics like double flowers, flower color, and floral longevity have also been chosen. (Smulders *et al.*, 2012). MAS can be beneficial for difficult-to-assess variables and complicated traits like productivity and flowering time that are regulated by several loci or regions.

Even with their benefits, molecular markers are primarily utilized in ornamental breeding for cultivar development of economically significant crops including roses, carnations, chrysanthemums, petunias, and lily. (Onozaki *et al.*, 2004; Von Malek *et al.*, 2000; Su *et al.*, 2019; Tychonievich *et al.*, 2011; Van Tuyl *et al.*, 2018) [36, 37, 17, 38, 30].

The availability of genetic and genomic resources determines the use of molecular markers. Big analyses of data and next generation sequencing have made reference genomes, linkage maps, SSRs, and SNPs for non-model crops more accessible and affordable. Numerous ornamental crops, including gerbera, hydrangea, impatiens, caladium, and others, have benefited from the discovery of genes, SNPs, and SSRs thanks to genome reduction techniques like transcriptome sequencing and genotyping by sequencing. (Bhattarai *et al.*, 2020, Wu *et al.*, 2021; Bhattarai *et al.*, 2018; Cao *et al.*, 2017) [1, 23, 39, 2].

Agronomic and horticultural crops are using arrays with a few thousand SNPs more frequently due to advancements in genome resolution and marker-trait connection. For roses and chrysanthemums, these arrays have been established by (van Geest *et al.*, 2017; Koning-Boucoiran *et al.*, 2016) [18, 10]. These arrays might be utilized for gene or QTL identification, quality checks (keeping plants true to type), safeguarding plant variety, and analyzing the population structure in the germplasm if they were created for other ornamental crops.

CRISPR genome editing technology

CRISPR, or clustered regularly interspaced short palindromic repeats, is one of the gene-editing techniques that has emerged fastest in recent years for crop enhancement. It's an inexpensive, broadly useful, easy-to-use, and very effective method. Single guide RNA (sgRNA) and Cas9 protein combine to form a complex. The complex is directed by sgRNA to a specific target site next to the protospacer- adjacent motif (PAM), and Cas9 protein cleaves the DNA at the targeted location twice (Jinek *et al.*, 2012) [40]. There are two techniques for repairing the cleaved site(s): homology-directed repair (HDR) and non-homologous end joining (NHEJ) (Symington and Gautier, 2011) [41].

NHEJ, which facilitates the creation of minor insertions or deletions, may be applied to the insertion of donor sequences, stacks several genes, and can be used to carry out functional study of genes. (Lieber, 2010) [42]. By focusing on two particular genes—the flavanone 3′-hydroxylase (F3H)A and F3HB coding genes—the CRISPR-Cas9 system, which is currently the most widely used CRISPR-Cas system, has been successfully used in ornamental plants to engineer flower color modifications from purple violet to pale purplish pink (Yu *et al.*, 2021) [24]. In I. nil, delayed petal senescence has been attained by disruption of the EPHEMERAL1 gene (Shibuya *et al.*, 2018) [15]. With CRISPR-Cas9, the gene carotenoid cleavage dioxygenase 4 (CCD4), which prevents the deposition of carotenoids in I. nil petals, was deleted, resulting in light yellow petals in the mutant lines rather than white petals (Watanabe *et al.*, 2018) [22]. A male sterile maternal line in rice has been created using CRISPR-Cas9 based gene knockouts in a variety of crops (Zhou *et al*. 2016) [27].

Only a small number of decorative crops, including petunias, morning glory, chrysanthemums, and orchids, to mention a few, have successfully undergone genome editing, despite the fact that the list is anticipated to grow quickly. (Zhang *et al.*, 2016; Kishi-Kobashi *et al.*, 2017; Kui *et al.*, 2017; Watanabe *et al.*, 2017) [26, 9, 11, 21].

Root inducing technology

It's a useful tool for encouraging dense plant development. It has proven possible to make genetically engineered flowers in crops such as Dianthus, roses, and chrysanthemums. An intriguing substitute transformation approach solely employs Rhizobium rhizogenes wild type strains. In many dicotyledonous plant species, this group of pathogenic bacteria causes the so-called crazy root disease because they carry a root-inducing (Ri) plasmid. Natural transformation occurs when the bacteria and plants are co-cultivated in a lab setting. Since regenerated Ri phenotypic plants are not thought to be genetically modified, there are no legal restrictions on their commercialization. 2020a; Desmet *et al*. 2021.

These Ri phenotypes can exhibit changes in the morphology of the leaves, flowers, blooming period, and roots, in addition to the most intriguing characteristic: growth behavior. Pre-breeding material is provided by Ri technology and used in traditional cross-breeding procedures. Effective transformation and regeneration tissue culture techniques guarantee the production of several Ri lines within a given genus. Among other things, Kalanchoe blossfeldiana has been shown to successfully employ the technology (Christensen *et al.*, 2008) [43].

Challenges faced by breeders

Traditionally, the objective of breeding has been to create cultivars with better esthetic qualities, such as improved plant habit, leaf features, or flower properties (color, shape, aroma, and extended vase life). Increasing output is another key objective for cut flowers. Enhanced resistance to pests and diseases as well as greater tolerance to abiotic stressors are among the new breeding objectives. This is a significant task that is anticipated to grow in importance as a breeding objective. The output of ornamental plants may also be impacted by decreased fertilizer application. Although it has historically primarily been a concern for agricultural crops, nutrient utilization efficiency is expected to become a problem for ornamentals as well.

It will be extremely difficult to meet all of these medium-long term targets without the cooperation of industry and research, as most breeding programs are carried out by small-scale breeding companies that lack the knowledge and financial resources to accomplish these goals. Better drought-resistant varieties or cultivars—that is, plants that require less water input and can withstand more extreme weather conditions—are needed for application in gardens and public green spaces.

Conclusions

Breeding ornamental plants has grown to be a significant industry. Nowadays, breeding ornamental plants is a complex process that calls for far greater flexibility than the medium- to long-term goals of the past. It's not always the greatest idea to use the newest technology and make large expenditures in today's dynamic world, where quick changes in the global environment call for creative and adaptable solutions. Indeed, the most inventive results in minor crops are frequently being produced by ardent "traditional" breeders and even amateur plant enthusiasts. Only through more active coordination across the various industry and research components can this seeming conflict be resolved.

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