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REVIEW ARTICLE

Stock scion relationship: A review from the ornamental plant perspective

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Abstract

Grafting is a widely used horticultural technique that enhance plant performance, especially in ornamental species with poorrooting ability. It involves joining a desirable scion with a compatible and vigorous rootstock, as seen in crops such as rose, bougainvillea, jasmine, hibiscus and cactus. This method is primarily adopted to combine desirable traits such as growth vigour, disease resistance, adaptability stress tolerance and aesthetic appeal. Grafting scions from mature, flowering plants onto juvenile rootstocks retains their maturity, allowing earlier flowering. Inter-specific grafting merges traits for ornamental breeding and hybrids. Although practiced for centuries, the precise physiological and molecular interactions between the rootstock and scion remained unclear until recent advances in plant science. Modern research, particularly through next-generation sequencing, has confirmed that genetic and molecular exchanges occur across the graft union. These interactions significantly influence the scion's physiology, including nutrient uptake, growth patterns, stress resistance and flowering behaviour. As graft incompatibility can result from hormonal imbalance, phenolic accumulation, or poor vascular connection between scion and rootstock. It highlights recent findings on morphological, physio-chemical and molecular mechanisms involved in rootstock-scion communication. Understanding these complex interactions enables the development of superior grafted ornamentals with enhanced aesthetic qualities, resilience and extended blooming periods. This integrated perspective is crucial for improving the efficiency and creativity in ornamental plant production and providing a foundation for future research into grafting-induced trait enhancement.

Keywords: graft union; molecular mechanism; ornamentals; physiological mechanism; scion; stock

Introduction

Ornamental and flowering plants have long been valued worldwide for their cultural, social and economic significance. With their colourful blooms and attractive foliage, these plants play a vital role in landscape architecture, urban greening and home gardening. Beyond aesthetics, they also hold deep significance in traditional rituals, festivals and ceremonies in many cultures (1). Grafting is a method that has long been a mainstay of the multiplication of ornamental plants. It involves joining two plant sections, the scion and the rootstock. With this method, the best traits of the scion and the rootstock are combined. Grafting enables the improvement of characteristics, including disease resistance, growth vigour, stress tolerance and aesthetic attributes such as flower colour and bloom duration, in ornamental gardening (2). During the rapid healing phase, tissues bond, cells divide, grow and differentiate, forming efficient circulatory connections between the scion and rootstock (3,4). The stock and scion have a complex relationship that encompasses not only the physical union of tissues but also extensive physiological, biochemical and molecular interactions that determine the graft's ultimate success (5). Although grafting has been practised for centuries, there is still much to learn about the molecular mechanisms underlying stock-scion interactions. Research indicates that the rootstock can have a significant impact on the scion's growth and development, particularly in terms of nutrient uptake, hormone regulation and responses to biotic and abiotic stresses (6). This review aims to analyse the development of grafting techniques in ornamental plants, focusing on the physiological mechanisms of union formation, the molecular transfer processes across graft unions and the hormonal mechanisms driving graft-induced change. Compatible & incompatible grafts are shown in Fig. 1a, b.

Methodology

This review aims to address this gap by examining the potential improvements achievable through grafting in ornamental horticulture. By focusing on ornamental species, this review seeks to underscore the significance of grafting as a strategic tool for

Fig. 1. Plant graft compatibility: union success comparison.

(a) Compatible graft; (b) Incompatible graft

advancing both the quality and adaptability of ornamental crops. This study searched Scopus and Google Scholar databases for scientific literature on the stock-scion relationship between ornamental plants. A thorough procedure was established for the scientific review process and suitable study papers were initially vetted based on an examination of their titles, keywords and abstracts, as shown in Fig. 2. The process involves a literature review, secondary data collection and comparative data analysis across different literatures. This study provides a comprehensive examination of the stock–scion relationship and this section outline the search steps employed in this systematic literature review.

Effect of rootstock scion interaction on growth, quality and stress tolerance in ornamentals

Grafts enable the conservation of attractive genotypes with high commercial value, as well as the preservation of genetic diversity and the prevention or mitigation of its loss. Various improvements in flower crops obtained through grafting are listed in the Table 1. The grafting process has become a popular for propagating cacti, ensuring the persistence of variegated and brightly coloured cacti that lack chlorophyll, quickening the establishment of slow-growing species, preserving the survival of plants with weakened root systems and increasing the development rate of plants for commercial use. Horticulturists are now making significant amount of money from growing conifer decorative trees through conifer grafting. Since their canopies bloom in a variety of hues, trees in the genus *Handroanthus* and family Bignoniaceae are frequently employed for landscape purposes. It may be significant to employ methods like grafting, which promote early flowering and the potential for canopies to produce flowers of various hues

Table 1. Effect of grafting on growth and quality in ornamental species

Ornamental plant	Rootstock	Scion	Key outcomes	References
Rose	*Rosa chinensis* 'Gruss an Teplitz'	*Rosa hybrida* 'Gold Medal'	Exhibited superior vegetative growth, enhanced floral yield and improved flower quality.	(12)
	Natal Briar, *Rosa indica* Major	Pink Beauty and Pink Shine	Grafting improved yield, stem traits, petal count and seasonal adaptability.	(3)
Jasmine	*Jasminum grandiflorum*	*Jasminum officinale*	Improved yield quality.	(13)
	J. sambac (Gundumalli Double Mogra (ecotype of Gundumalli*).*	*Jasminum* sps.	Ensures year-round flowering, bridges off-season market gaps, provides steady flower supply and offers economic gains to growers.	(14)
Chrysanthemum	*Artemisia scoparia*	*Chrysanthemum* cv. 'Jinba.	Improved abiotic stress tolerance in chrysanthemum.	(15)
Gardenia	*Gardenia thunbergia*	*Gardenia jasminoides*	Improved flower yield.	(16)
Schefflera	*Polyscias fruticosa*	*Schefflera arboricola*	Strong intergeneric grafting in Araliaceae aids propagation training and potted plant	(17)
Cactus	*Cleistocactus candelilla*	*echinocereus*	Improved lenght and diameter in cactus.	(18)
Handroanthus	*Handroanthus impetiginosus*	*Handroanthus heptaphyllus,* *Handroanthus chrysotrichus,* *Handronthus roseo-albus.*	Multi-colored flower canopies for landscape purpose.	(7)
Bonsai	*Pinus thunbergii*	*Pinus parviflora*	Artistic bonsai forms and effective control of most pests in grafted bonsai	(19)

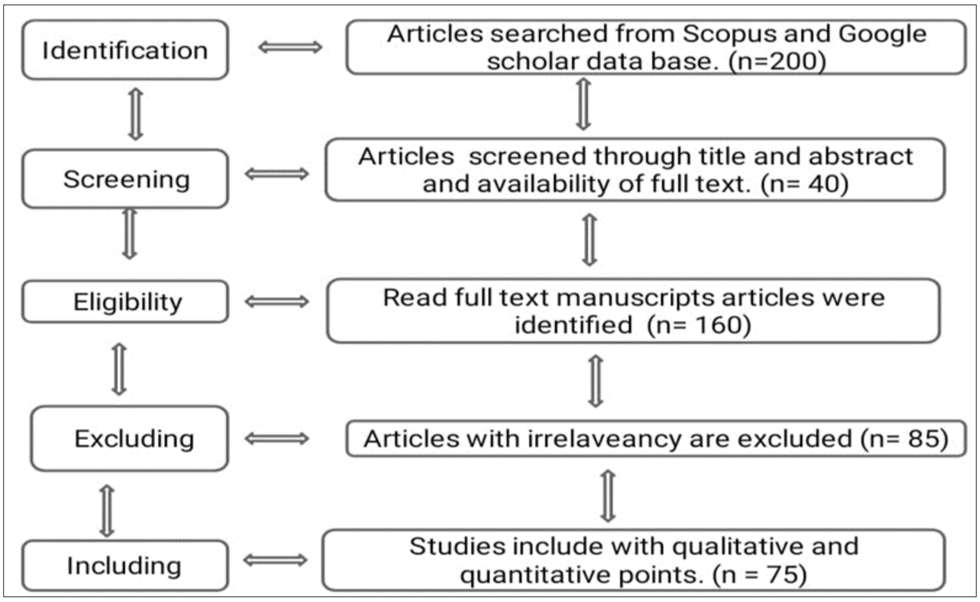

Fig. 2. Process of methodology.

(7). The procedure known as Tender Twig Grafting (TTG), with a success rate of over 75 %, is used to create the highly sought-after multicoloured flowering of bougainvillaea on a single stock (8). Silver fir decorative trees should be produced on a large scale using the double-sided veneer grafting technique, which has proven to be an effective method (9). Hybrids grafted onto sturdy rootstocks make up most garden roses. In terms of growth and development, rootstock can affect the scion in several ways. The most significant ones are pH value adaptation, soil drainage, climate, disease resistance, plant longevity, compatibility, productivity and flower quality. Grafting roses with buds typically yields between 80000 and 100000 seedlings per year in Kosovo (10). Grafting techniques have been enhanced to adapt to harsh environmental conditions. In this process, a ball cactus acts as the rootstock, while the scion, a heterogeneous or related cactus shoot, is placed into the rootstock's pit. This method achieves an impressive survival rate of over 90 %, demonstrating its effectiveness. Both heterogeneous and related plants can successfully undergo grafting. The resulting potted ornamental plants not only exhibit aesthetic appeal but also hold significant financial value. With proper auxin treatment, micrografting offers excellent potential for large-scale production of this cactus species. Additionally, it can be employed to propagate other micro-grafted cactus varieties (11). Fig. 3 represents the benefits of grafting in ornamental plants.

Physiological interactions of the stock scion

The physiological interactions between stock and scion in grafted plants are complex and involve various biochemical and molecular mechanisms. Successful grafting relies on the compatibility of the rootstock and scion, which influences callus formation, development and overall plant health.

Callus formation

Callus is the mass of parenchyma cells that grows from and around injured plant tissues to promote healing and reduce evaporation from the wound. The success of sprouting processes (callus formation) in grafted plants is influenced by several critical factors, including the grafting technique, the timing of the grafting season, the phenological and physiological states of both the scion and rootstock, the taxonomic compatibility between the organs, the age of the buds and rootstocks, the microclimatic conditions at the graft maintenance site and the genetic, anatomical and histological differences between the grafted components (20). A dead layer is created at the graft interface by the combination of the collapsed cells and cytoplasmic remnants. A few scion parenchyma cells adjacent to the dead layer break down on the innermost layer of the injured tissues to create the callus (21). A "cement" or binding material helps the scion and rootstock cells adhere to one another in *Sitka spruce*. It displays pearl like projections out of the callus that consist of a fibril/vesicular component primarily composed of carbohydrate as well as pectins and an even matrix composed of a mix of pectin, carbohydrate, protein and fatty acids (22). In addition to serving as a force or attaching cells, these pearl-like projections may have a more active function in identifying cells and facilitating and the effective fusion of the graft partners' tissues. In addition, since the initial binding of stock and scion is an inactive event that occurs in response to injury, it was determined that the connection between the structural instances linked to graft development in Crassulaceae and the absence of understanding events, was required for this adhesion. But at least during the procambium's differentiation among them, some kind of cell interaction is necessary (20). Consequently, within compatible auto grafts of *Sedum telephoides*, in which the early integration of stock and scion is achieved through certain extracellular interaction among the graft partners, grafts surfaces can be cohesive even when they lack direct cellular connection and protoplasmic continuity (23).

Plasmodesmata and their role in cell-to-cell communication

Plasmodesmata are intricate and extremely dynamic structures that can serve as conduits between cells in a graft bridge by forming specialized channels for symplastic cell communication. A few days following grafting, the adjacent cells develop when the pectin layer that formed across those opposing tissues weakens (24). In contrast, non-connecting and irregular plasmodesmata form at the cortex, in addition to displaced tissues. Meanwhile, ongoing and connecting plasmodesmata occur, which allow consistent vascular tissues to connect (25). It may be crucial for

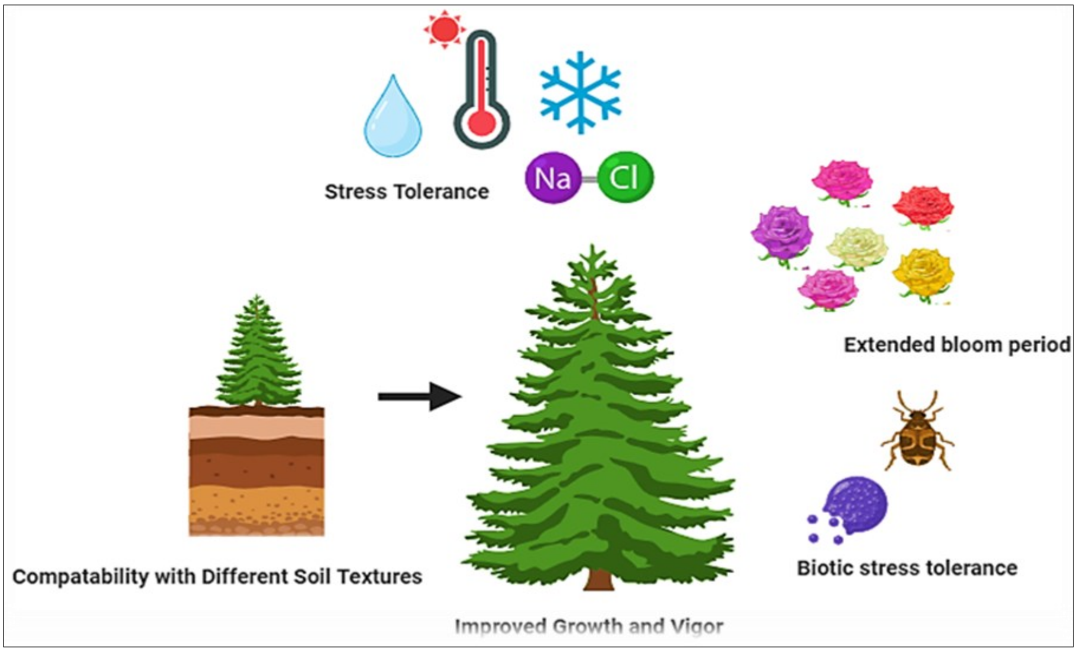

Fig. 3. Benefits of grafting in ornamental plants.

encouraging graft development and can develop between grafts of different species. When callus cells come into contact, the cell walls undergo dissolution and holes in the cell walls appear; the formation of plasmodesmata will occur (24). They merely allow for a chemical exchange between the grafting partners in the interacting cells (26). To accomplish this, certain compounds must leach or diffuse through the cell walls from either end of the union to create a strong bond among the scion and rootstock (27). Significant variations in the emergence of interspecific plasmodesmata within graft partners were observed during investigations on the workings of plasmodesmata formation, indicating that graft establishment could include identification of cells and functional integration (25), with particular focus on the growth and alteration of primary plasmodesmata, as opposed to secondary plasmodesmata that are formed or modified from the beginning (28). The connection of the endoplasmic reticulum's smooth areas to it determines the position and structure of the growing plasmodesmata strands and it is the first step in the process that results in the formation of secondary plasmodesmata. This then invaginates around the endoplasmic reticulum's cisternae, which is explained by the release of wall material by a plasmalemma/Golgi vesicle fusion procedure. The plasmalemma that borders the plasmodesmata connections is made up by the membranes of the merging Golgi vesicles (29). Because the interactions between the Endoplasmic Reticulum (ER) and the plasmalemma are thin and occur precisely before any symplasmic contact is established between cells, the coordination may involve the transfer of signalling information through the cell wall (24). Therefore, two cell partners must cooperate precisely to establish prolonged secondary plasmodesmata. Inadequate communication between neighbouring cells can result in formation of mismatched, partial plasmodesmata across the cell wall of one partner. Ultrastructural characteristics of *Helianthus annuus* grafts have confirmed the presence of secondary plasmodesmata between the scion and rootstock. These structures enable the formation of a continuous symplast, allowing cells from the rootstock and scion to connect through secondary plasmodesmata. This interaction facilitates material transfer and communication among neighbouring cells, promoting a more efficient exchange of nutrients and signals, which is essential for overall plant health and development. Consequently, the establishment of these connections is crucial for the successful integration of grafted tissues, enabling the plant to thrive in diverse conditions. Such connections may be vital for the continued growth of the graft union. Graft interfaces of incompatible heterografts have been identified using species-specific cell markers and discontinuous half-plasmodesmata have been observed in graft unions between various cell types (30). Although they may not be directly related to graft compatibility, these reports suggest that plasmodesmata may contribute to graft failure by causing the graft partners to become misaligned. Recent developments in caged probe have provided experimental methods for examining the physiological regulation of plasmodesmata, as eliminate the need for experimental manipulations such as pressure adjustments or the introduction of injured cells through microinjection (31).

Vascular connections in the graft process

Most experts believe that the establishment of vascular linkages during the final step of graft development is a fundamental prerequisite for an efficient graft. Vascular development includes: (a) development of the longitudinal pattern of primary vascular strands; (b) development of the radial pattern of xylem and phloem within vascular strands; (c) differentiation of xylem and phloem precursors into specialized cell types; (d) vascular cambium's cell division and proliferation. The union occurs, a necrotic layer develops and the callus bridge emerges at the graft junction prior to the vascular cambium binding across the callus bridge. After differentiating, the new vascular cambium creates a constant cambial bond within the rootstock and scion (21). The initial requirement for successful grafting development is the establishment of vascular bridges within the grafting zone. The process of vascular regrowth is complex, involving the structural differentiation of parenchymatous tissue into xylem and phloem tubes on either side of the graft union (32). By investigating species-specific secondary wall thickenings in a *Lophophora williamsii*/*Trichocereus spachianus* heterograft, it was able to identify xylary connections within a graft. It has been proposed that the primary cause of incompatibility in woody plants is that newly developed vascular connections may be poorly established or poorly differentiated (33). It was determined that in the adult internodes of *Coleus blumei*, where the endogenous cytokinin level was low, the cytokinins kinetin, zeatin and 6-benzylaminopurine regulated vessel regeneration surrounding a wound. Some herbaceous studies have focused on tissue regrowth through the graft interface (34). The investigation of assimilate transfer in a *Silene armeria* autograft using ^{14}C-labeled CO_2. They discovered that after 16 days, transmission from one of the partners to other partners was occurring at a high rate, having started 7 days following grafting. The source-sink concept is currently used to demonstrate how assimilates are transported (35). It is well known that the production of proteins and vascular development occur simultaneously during the ontogeny of the sieve element/companion cell interaction. Grafting approaches are being used to investigate the long-distance translocation of proteins and RNA via the phloem due to the phloem's significance as a mechanism for transporting nutrients and information (36). It is being demonstrated that the companion cells of the developing sieve element–companion complex inside the phloem transport synthesise the P-proteins (PP1, PP2), which are then transferred to sieve elements after they are functional and established (37). PP1 and PP2 expression is thought to be phloem-mobile and is likely associated with specific phases of phloem differentiation (38). It appears to be crucial for the growth and operation of the vascular system since the structure of PP2-gene activity within the sieve element-companion cell complexes is consistent across angiosperm groups (39). However, it is also known that most phloem proteins are involved in both direct and indirect stress and defence mechanisms in addition to maintaining sieve tubes (40). Additionally, several melon phloem proteins having RNA-binding ability have been found and described (41). Furthermore, growth hormones influence the interactions between scion and stock and it is hypothesised that graft incompatibility might also exist. For instance, auxin, which emerges from the vascular strands of the stock and scion, acts as a morphogenic substance that promotes the differentiation of vascular tissues. It is a crucial substance involved in the development of compatible unions (42). Because an above and basipetal shift of the hormone auxin can organise the morphogenetic structure of the whole plant body, its translocation via the root system was previously examined in apples and linked to graft incompatibility, even hastening the development of a fruitful graft (43). Furthermore, additional substances, such as polyphenols, along with their ability to precipitate proteins (44). It is being suggested that stresses can cause flavanols to accumulate as well as oxidases to break them down and this can have significant impacts on tissue development and metabolic processes, including lignin pathway blocking (45). From the researcher's viewpoint, the presence of these large molecules (phloem proteins, RNA and hormones) in sap may seem significant when vascular differentiation is the compatible method. Conversely, the significance of particular enzymes in cellular behaviour at the initial stages of graft development is being investigated in various species; however, the precise function and impact on incompatibility remain unclear (46). In order to reach a rapid rootstock selection, prior to which we recognise any external incompatibility signs, more research concerning the grafting process in ornamental trees is necessary to gain a deeper understanding of the mechanisms that occur during the graft incompatibility reactions. The connection between morphological modifications and the molecular process of grafting is demonstrated in the Fig. 4 (47).

Molecular mechanism between the scion and the rootstock

The complex molecular mechanisms underlying the interaction between the scion and rootstock comprise a multitude of physiological, biochemical and genetic components. Grafting is a common horticultural technique that enables the exchange of genetic and molecular signals affecting growth and stress responses, thereby maximising agricultural output and enhancing plant resilience. For grafting to be successful and produce vascular tissue and callus bridges, vascular cambium alignment and a wound healing response are required. Auxins, in particular, are essential phytohormones for maintaining compatibility and promoting the development of a successful graft union (2). Rootstocks can influence scion traits like yield, growth and stress tolerance through genetic exchange at the graft junction (48). Grafting enhances heat tolerance in roses. Using RNA-sequencing, researchers compared transcriptomic responses in self-grafted (XX) and hetero-grafted (XW) lines of *Rosa chinensis* and heat-tolerant *Rosa multiflora* under heat stress. The hetero-grafted line (XW) showed stronger activation of heat-responsive genes, including HSFs (Heat Shock Transcription Factors) and HSPs (Heat Shock Proteins) also key differences in metabolism, enzyme and lectin gene expression, with physiological traits confirming greater heat stress resistance in hetero-grafted (XW) plants (49). Research indicates that rootstocks can change the scion's transcriptome, affecting how it responds to environmental stresses, including drought and cadmium. Moreover, rootstocks alter the way scions receive hormone signals and nutrients, which can impact traits like dwarfism in particular graft combinations (50). *Petunia hybrida*, like *Nicotiana benthamiana*, exhibits strong interfamily grafting ability, supported by sustained high expression of the β-1,4-glucanase gene GH9B3 during grafting, inhibition of GH9B3 reduced graft success, confirming its essential role (51). The highest plant performance and longevity can be achieved by selecting appropriate partners, even though scion and rootstock interactions are typically beneficial. Issues like graft incompatibility can arise. The directional flow of DNA, RNA, proteins, hormones and plastid DNA through graft union explains the function of hormones, along with molecular signalling and the impact on the scion-rootstock connection in Fig. 5.

Hormonal signalling

In the past, scientists concentrated on how hormones affect vascular reconnection. The efficient development of graft unions is now attributed to molecular signalling via phloem, which causes morphological and physiological changes in both components for the smooth connection of vascular tissues.

The grafted plant's scion and rootstock depend on the molecular transfer of the entire plastid genome across the graft junction. Plants physiological activities are regulated by a protein that migrates from the companion cells of

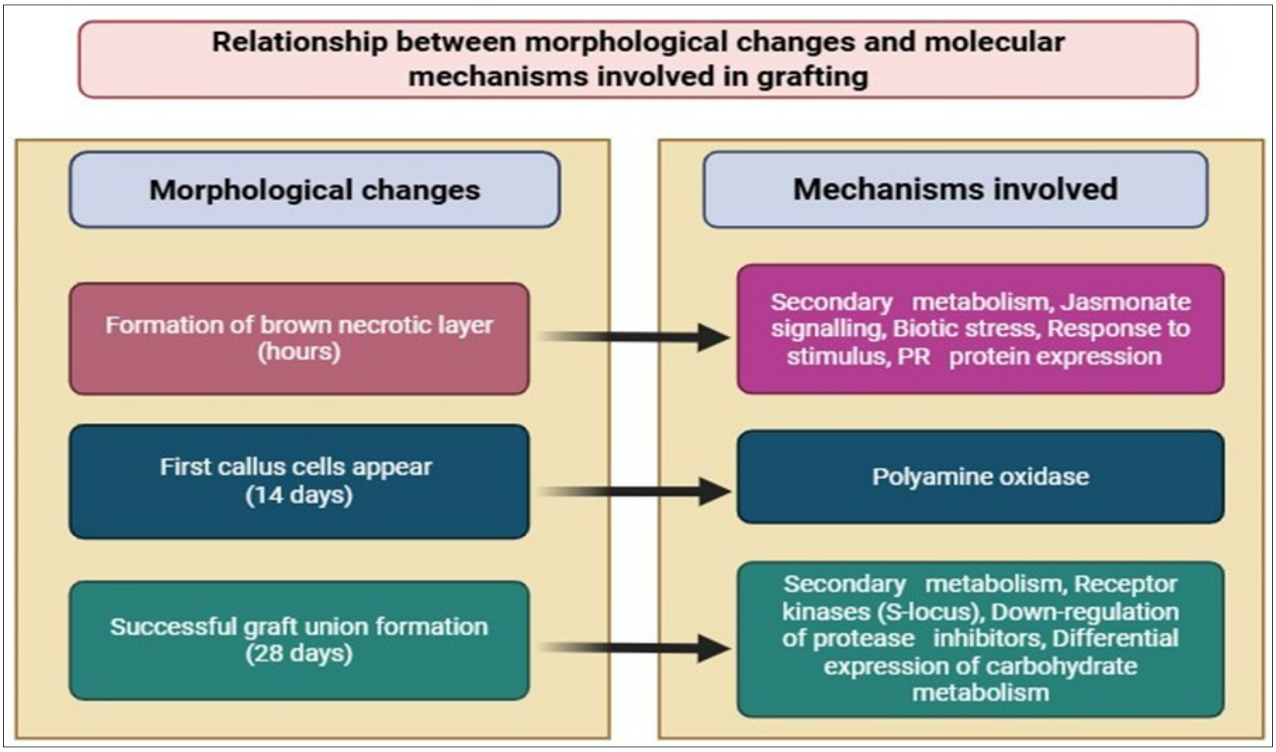

Fig. 4. Relationship between morphological changes and molecular mechanisms involved in grafting.

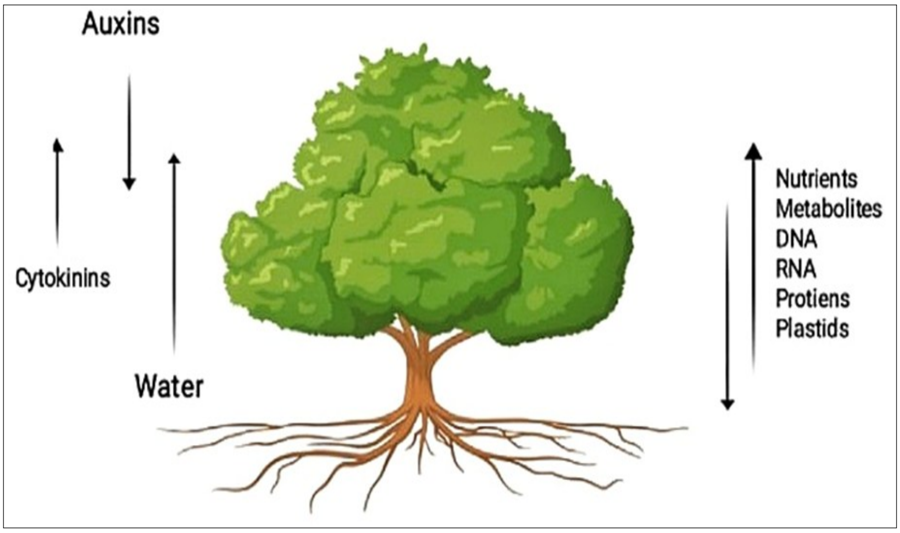

Fig. 5. The directional flow of DNA, RNA, proteins, hormones and plastid DNA through graft union explains the function of hormones, along with molecular signalling and the impact on the scion-rootstock connection.

the shoot into the root cells (52). Auxin transfer between the scion to the stock can speed up the formation of an efficient graft in cacti and auxins may play a role in morphogenetic reactions in Cactaceae (53). It was discovered that auxin relocation from the scion to the rootstock accelerated the development of a fruitful graft in cacti (43). The auxin IBA is responsible for the stimulation of the areole. The ideal method for achieving micropropagation in cacti is areole activation through the disruption of apical dominance (54). In addition, ethylene may trigger the production of reactive oxygen species which may lead to reduced growth and successful graft percentage (55). During the grafting and budding development processes of plants, auxins have a crucial regulatory role. The growth of xylem tissue and maintenance of auxin levels in the plant part are both facilitated by the Polar Auxin Transport (PAT) (56). Auxins are essential regulators in plants throughout the graft formation process. Vascular development is another important function of auxin. Exogenously given to undifferentiated tissues, it encourages the development of vascular threads. Auxins are necessary for the growth of both shoots and roots in plants. For example, petunias have more secondary xylem and phloem cells when auxin levels are high (57). The establishment of a successful graft in cactus can be accelerated by auxin transfer from the scion to the rootstock (58). Auxin and ethylene probably work together to encourage vascular cell divisions. Abiotic stressors are linked to ethylene; for example, injury causes ethylene production to occur surrounding the wound site. Cytokinin (CK) signalling is essential for the development and growth of cambium and procambium cells. Gibberellins (GAs) promote cell expansion, proliferation and differentiation (59). GAs promote xylogenesis in cambium tissue, which is crucial for wound sealing and cell proliferation. Then, by adjusting PIN protein turnover, GAs facilitate auxin transport (60). Abscisic acid (ABA) is essential for abiotic and biotic stress responses. ABA may have inhibitory effects on wound healing, as evidenced that wound-induced callus was more effectively formed by reduced ABA synthesis or signalling (61). Further details of the function of phytohormones encoding genes in graft compatibility, along with gene names, are given in the Table 2.

Table 2. Function of phytohormone-encoding genes in graft compatibility

Phytohormones	Genes	Responses	Reference
Auxin	Aux/ IAA	Regulate the compatible nature and repair of graft unions.	(61)
	PIN1 and ABCB1	Auxin transport carriers control the growth of grafts.	(59)
	CcPIN1b and CcLAX3)	PAT carriers promote the grafting procedure.	(62)
	ARF	Furthermore, this grafting process regulates several biochemical pathways that facilitate the vascular connection between the stock and the scion.	(63)
	MrPIN1, MrSHR	MrPIN1 and MrSHR gene expression was downregulated within the roots of grafted plants.	(64)
	MrPIN3	Auxins are upregulated and more widely distributed, which further promotes the division of pericycle cells.	(65)
	HCA2	The grafting site is crucial for reconnection of the phloem.	(59)
	ALF4	controls the development of lateral roots and the division of xylem pole pericycle cells.	(66)
	XTH 19 and 20	crucial for the growth of pith cells during tissue reunion.	(67)
	VND7	Indicates the formation of protoxylem.	(68)
	VND6	Indicates the formation of metaxylem.	(68)
	S1Cyp1	A signalling molecule that regulates the auxin response, xylem and lateral.	(69)
	ANAC071 and RAP2.6L	Promote pith cell division.	(70)
GA	GA20OX	Gene upregulation and involvement in GA biosynthesis.	(71)
	JcGA20ox1	More lateral bud development and improved stem elongation.	(72)
Ethylene	APETALA2	Each plant species has TFs, which are activated when subjected to various developmental pathways or stresses.	(70,71,73)
	ANAC071	Decreased the graft junction's vascular tissue formation.	(70)
Cytokinin	CRE1	proliferation as well as specification of vascular cells.	(74)
	LHW	growth of stele cells and protoxylem formation.	(74)
ABA	ATHB7	This gene is activated by drought stress and has a particular expression in differentiating xylem.	(75)

Future Prospects

Grafting in ornamental plants is an emerging and specialised area with a promising future, as it enhances plant resilience, uniqueness, aesthetic value and adaptability. The increasing urbanisation has boosted the demand for visually appealing greenery in spaces such as rooftop gardens, vertical landscapes and ornamental roadways. Grafted ornamentals are especially valued for their uniform growth, decorative appeal and adaptability, making them ideal for urban environments. This technique enables the creation of innovative plants, such as multi-coloured rose trees, multiple hibiscus varieties on a single plant and artistically designed bonsai. Advances such as micrografting and robotic grafting are enhancing accuracy and facilitating large-scale production. There is also strong potential to enter international markets with premium-quality grafted ornamentals and to develop patented plant varieties with unique characteristics.

Conclusion

The stock–scion relationship is fundamental to ornamental plant propagation, enabling the combination of desirable traits from different genotypes. This union enhances vegetative growth, stress resilience, disease resistance and supports extended or year-round flowering. Key advantages include improved aesthetic qualities and uniformity, while also overcoming limitations associated with seed propagation, such as genetic variability and delayed flowering, thereby ensuring high-quality and consistent planting material. Despite these benefits, graft incompatibility remains a significant challenge, often arising from anatomical, hormonal, or biochemical mismatches that impair vascular continuity and metabolic coordination. Long-term scion declines and limited species-specific grafting protocols further reduce efficiency, particularly in under-researched ornamental species. As molecular understanding of graft union formation continues to develop, advanced omics approaches such as transcriptomics, metabolomics and proteomics offer promising insights into compatibility mechanisms. Concurrently, breeding programs focused on developing robust, multifunctional rootstocks and refining techniques like micrografting and in vitro grafting are essential for improving grafting success. Ultimately, a multidisciplinary approach integrating traditional practices with modern molecular tools will be key to optimizing grafting outcomes and fully realizing its potential in ornamental horticulture.

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Authors' contributions

AT carried out the survey, analysed the data and formulated the manuscript. PM assisted in data collection and analysis as part of the research study. SRKC contributed by developing ideas, reviewing the manuscript and assisting with procuring research grants. RR examined the paper for intellectual content, spelling and grammar. SKB provided additional support and contributions to the review. MA assisted in preparing the draft manuscript. MMA guided the writing of the manuscript in the proper format and approved the final version. JT also guided the manuscript preparation. SVR provided additional support for the review study. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The Authors do not have any conflict of interest to declare.

Ethical issues: None

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