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Rootstock Breeding and Rootstock-Scion Interaction in Prunus Species

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Abstract

Stone fruit species belonging to the genus Prunus are important fruit groups both in the world and Turkey. Most of these fruit species because cannot be propagated by seeds due to the long generation period are propagated by grafting. Rootstocks affect many factors in cultivars, including plant vigor, yield and quality, and maturation time. Thanks to the rootstocks selected in grafting, resistance to soil-borne diseases and pests and abiotic stress conditions can be achieved. Ideally suited rootstocks should be perfectly compatible with the varieties on which they are grafted. Graft incompatibility is a major problem in rootstock breeding studies. The reasons for the graft incompatibility have not been fully explained. Although anatomical studies on graft incompatibility give important opinions, there are many studies proving that biochemical analyzes also provide important results.

Keywords

Compatibility, grafting, prunus, rootstock, scion.

PRUNUS TÜRLERINDE ANAÇ-KALEM INTERAKSIYONU VE ANAÇ ISLAHI

Özet

Prunus cinsine ait olan sert çekirdekli meyve türleri hem dünyada hem de Türkiye'de önemli meyve grupları içerisinde yer almaktadır. Bu meyve türlerinin çoğu, rejenerasyon süresinin uzun olması nedeniyle tohumla çoğaltılamadığı için aşılama ile çoğaltılmaktadır. Anaçlar, üzerine aşılanan çeşitlerde bitki gelişme kuvveti, meyve verim-kalite ve erken verime yatma gibi birçok faktörü etkiler. Aşılama ile, seçilen anaçlar sayesinde toprak kaynaklı hastalık ve zararlılara ve abiyotik stres koşullarına karşı dayanıklılık sağlanabilmektedir. İdeal olarak uygun anaçlar, aşılı oldukları çeşitlerle mükemmel uyumlu olmalıdır. Bu nedenle aşı uyuşmazlığı anaç ıslah çalışmalarında önemli bir kriterdir. Aşı uyuşmazlığının nedenleri ile ilgili birçok çalışma olmasına ragmen fizyolojik anlamda her yönüyle tam olarak açıklanamamıştır. Aşı uyuşmazlığı ile ilgili anatomik çalışmalar önemli fikirler verse de biyokimyasal analizlerin de önemli sonuçlar verdiğini kanıtlayan birçok çalışma bulunmaktadır.

Anahtar Kelimeler

Anaç, aşı uyuşmazlığı, aşılama, kalem, Prunus.

INTRODUCTION

Production and sales of fruit species such as apricot, peach, plum, and almond have a very important share in the world (Yaman and Uzun, 2021). Prunus spp (Rosaceae) consists of over 250 different species, many of which are not botanically defined. Among these, there are many deciduous and evergreen species in the form of trees or shrubs, but there are also fruit species that are produced in a significant amount in modern fruit growing, such as apricot, peach, cherry, almond, cherry, plum (Yilmaz et al. 2012; Chin et al. 2014). Anatolia, which has different ecological environments from subtropical to cold climates, is the homeland of many species belonging to the genus Prunus (Ercisli, 2004; Yilmaz and Gurcan, 2012). Among these species that grow in the natural environment are P.domestica, P.cerasifera, P.divaricata, P.spinosa, P.microcarpa, P.scoparia, P.amygdalus, and P.arabica. Recently, clonal rootstock breeding studies have been started especially in these species grown in natural environments in Turkey (Yilmaz and Gurcan; Bolat et al., 2017). Almost all of prunus fruit species are propagated by grafting in commercial cultivation due to the long generation period. In this case, the breeding of rootstocks adapted to the ecological conditions and compatible with the scion is of great importance. Grafting is a widely used practice for obtaining better yields, propagation, and control vigor in horticulture plants. Thanks to the rootstocks selected in the grafting; soil-borne diseases and pests and abiotic stress conditions can be resisted (Webster, 1995; Errea et al., 2000; Lee et al., 2010; Ramirez-Gil et al., 2017; Mehdi-Tounsi et al., 2017; Zhou et al., 2018; Jimenes et al., 2018). The use of dwarf rootstocks also reduces the distance between plants and increases production potential. Graft development; starts with the formation of a callus against damage, continues with the formation of the cambium, and as a result, a functional vascular system is formed between the two graft partners (Andrews and Marquez, 2010; Pina et al., 2017).

Some stages are required such as the cell recognition of each other, the ensuring the cell cycle, cell division, cell differentiation, and the development of plasmodesmata on graft union (Pina et al., 2009). In addition, secondary substances such as phenolic compounds are concentrated in the area in question (Bennett and Wallsgrove, 1994; Errea et al., 2000; Mng'omba et al., 2008). It is also known that these substances take place in the defense mechanisms of plants (Errea et al., 1994; Guclu 2019; Okatan,2018; Yaman,2022). Synthesis of these substances is encouraged under stress conditions such as infection and damage. (Bennett and Wallsgrove, 1994). The formation and subsequent accumulation of secondary compounds is intense, and these compounds play a significant role in the union of the graft during the callus formation stage (Errea et al., 2000). Yin et al., (2012), grafting; defined 6 basic events as (1) response to damage, (2) clearance of cell and recovery, (3) cellular communication, (4) auxin accumulation and response, (5) cell division and differentiation, and (6) vascular connection.

It has been reported that graft incompatibility results from anatomical, morphological, and physiological differences in graft components, usually in combinations between species (Darikova et al., 2011). As the taxonomic class between rootstock and scion gets further away, the chance of success in grafting decreases. Theoretically, sequencing within clones > between clones > within species > between species > within genus > between genera > within family determines the success between combinations (Adrews and Marquez, 1993). For example, this is a common result when apricot is grafted onto other Prunus species. This type of incompatibility is called established and is expressed by breaking the tree from the graft point (Herrero, 1951; Mosse 1962). This breaking has been determined that it is related to the normal development of vascular tissues in the callus bridge (Hartmann et al., 1997). In understanding the mechanism responsible for graft incompatibility, two types of incompatibility have been described, translocated and localized (Mosse, 1962). The first of these has been defined as the visual symptoms (yellowing of leaves, underdeveloped leaves, and leaf wilting) seen in the tree, as well as the cessation of development in the early period and the incomplete development of the root system (Moreno et al., 1993; Hartmann et al., 2002; Zarrouk et al., 2006; Dogra et al., 2018). It has been determined that the use of interstocks in such conflicts does not solve the problem. On the contrary, the established incompatibility fractures in the cambial vascular continuity at the callus bridge (Hartmann et al., 2002), and anatomical irregularities in graft union due to weak vascular connection (Zarrouk et al., 2010). It has been determined that this situation can be solved with the use of suitable rootstocks (Hartmann et al., 2002). Yonemoto et al., (2004) reported that with the use of interstocks, the plant growth was reduced without a decrease in yield and there was no rootstock-scion compatibility. Simard and Olivier (1999) and Zarrouk et al., (2006) argued that there is a significant relationship between plant growth vigor and incompatibility in peach. When a callus bridge is formed between the stem and rootstock surfaces in grafted plants. It has been determined that water uptake from the rootstock to the stem is possible. However if vascular connection is insufficient, carbon assimilation, and stomatal conductivity losses occur as a result of reduced water flow (Magalhaes-Filho et al., 2008). It has been reported that plant death may occur in incompatible scion-rootstock combinations as a result of shoot growth and reduced water and mineral uptake (Davis and Perkins-Veazie, 2008).

The presence of prunin and high concentrations of flavan-3 (catechins) have been identified as potential markers of undifferentiated callus-like tissues (Feucht et al., 1988; Guclu and Koyuncu, 2012). In addition, catechin and other phenolic substances accumulated on the graft union can be counted as the first biochemical reactions related to incompatibility (Cooman et al., 1996; Guclu 2019). Musacchi et al., (2000) reported that epicatechin accumulated above the graft union indicates unsuccessful grafting. Errea et al. (2001) found that although less than 10% of the surface is covered with phenolic substance incompatible combinations, this rate is quite high in incompatible combinations.

Zarrouk et al. (2010) the main structural features were irregularity in cambium cells, low differentiation in vascular tissues, non-proliferation of phloem and xylem cells, accumulation of phenolic compounds on the graft union 5 months after grafting. Pina et al. (2012) determined that callus differentiation occurred 10 days after grafting in compatible combinations, while this period is prolonged in incompatible combinations and occurred on the 15th day. Melo et al. (2017) reported that vaccination does not show success in interspecies vaccination, but the connection between vascular tissues determines success.

Plum rootstocks show low plant growth (Moreno et al., 1995), heavy soil conditions (Rowe and Beardsell, 1973) and root-knot nematodes (Meloidogyne spp.) (Pinochet et al., 1999) and calcerous soils (Gogorcena et al., 2004). ; Jiménez et al., 2018b; Gurkan et al., 2018) were found to be tolerant. Plum rootstocks are used extensively in different parts of the world, especially in Europe. Despite the successful breeding of plum rootstocks in the rootstock breeding studies in Europe abiotic barriers caused by high pH could not be overcome. The parts of Spain dominated by the Mediterranean Region (Aragon, Murcia, Valencia) are an important area for apricot cultivation in the world. However, the soil structure in this region; has been reported due to its heavy and chalky nature, it shows iron chlorosis and has water retention problems. In order to solve this problem for the last 20 years, plum origin and hexaploid structure, which is important in apricot cultivation; In addition to 'Pollizo de Murcia' (Prunus institia) and Prunus domestica, and diploid Myrobolan (Prunus cerasifera), plum hybrids Marianna (Prunus cerasifera x Prunus munsoniana) are used.

RESULTS

The use of rootstock in modern stone fruit growing is becoming more important in parallel with the changes in global climate conditions. It is very important to develop of prunus rootstocks suitable for biotic and abiotic soil conditions sustainable fruit growing. Plum rootstocks have become widespread due to theirs features such as being more universal, providing a certain amount of weak growth, and easy vegetative propagation. Rootstock breeding by selection from different plum species found in the wild form in nature is an important opportunity for countries with homeland. It can be said that the most important problem of plum rootstocks is late period rootstock-scion incompatibility. For this reason, rootstock-scion relationships should be well observed. In rootstock breeding studies, attention should be paid to histological and biochemical knowledge of rootstock and scion relationships in order to avoid future problems in rootstock breeding studies. In parallel with the changes in the global climate, rootstock breeding studies will continue for sustainable fruit growing.

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