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Anatomical graft compatibility study between apricot cultivars and different plum based rootstocks

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ABSTRACT

The introduction of some new rootstocks requires knowledge of the extent and nature of (in)-compatibility reactions before releasing these rootstocks on the market, providing both nursery and fruit growers valuable information about the risk of weak unions ('localized' incompatibility). Therefore, trials were established at Aula Dei Experimental Station (Zaragoza, Spain) nurseries to assess graft compatibility between four apricot cultivars ('Búlida', 'Canino', 'Moniquí' and 'Paviot') and twenty-one plum based rootstocks. In general, 'Paviot' cv. exhibited good graft compatibility with all tested rootstocks, although several discontinuities in the bark were observed in the case of Ademir, Myrobalan 713 AD and Miral 3278 AD. 'Búlida' cv. was graft compatible with all rootstocks, with the exception of Marianna 2624 and Miral 3278 AD. They showed vascular and wood discontinuities in their graft unions. In the case of the exigent cvs. group ('Canino' and 'Moniquí') graft incompatibility was observed, in general, with all fast-growing plum rootstocks (mainly *Prunus cerasifera*) and some interspecific hybrid rootstocks. On the contrary, the hexaploid *P. insititia* plums showed good graft compatibility with all apricot cvs., with the exception of Montizo and PM 140 AD rootstocks. A positive and significant correlation ($r = 0.628$, $P \leq 0.01$) of graft incompatibility occurrence was found between the first or second year and the fourth year after grafting. Finally, the study of the ratio 'stem circumference / union circumference' showed that most of the scion-rootstock graft combinations presenting a ratio inferior to 0.8 showed discontinuities in the bark and/or in the wood at the graft union.

1. Introduction

Commercial apricot trees (*Prunus armeniaca* L.), like other commercial stone and pome fruit trees (apple, peach, pear and plums), are usually composed of two genetically different parts: scion and rootstock. Traditionally, the rootstocks used for *P. armeniaca* cultivars were seedlings from the same specie due to their good graft compatibility performance with apricot cultivars (Hernández et al., 2010). In particular, these seedlings rootstocks adapted well on permeable soils, with pH 6.5–7.5 and no more than 8–10% of active lime (Tsipouridis, 1999).

The Spanish Mediterranean area (Aragon, Murcia, Valencia), which represents one of the most productive apricot area in the world (FAOSTAT, 2017), is characterized by heavy and calcareous soils with iron chlorosis and waterlogging problems. To solve these problems together with the need to control the high vigour induced by seedling rootstocks, plum based rootstocks, such as the hexaploid 'Pollizo de Murcia' (*Prunus insititia*) and *Prunus domestica*, the diploid Myrobalan (*Prunus cerasifera*), and different plum based hybrids as Marianna (*P. cerasifera* × *P. munsoniana*), became more important for apricot production in the last two decades. However, the limiting factor for the widespread use of some *Prunus* spp. for apricot production is the lack of commercial rootstocks having a wide range of compatibility with all cultivars (Bassi et al., 2006; Dos Santos Pereira et al., 2014). Therefore, to choose the right rootstock, it is important to take into account rootstock-cultivar affinity as well as the climate and soil conditions.

Graft compatibility/incompatibility is defined as success or failure of a graft union to form between rootstock and scion (Chen et al., 2016). In fact, it is a complex response including a wide range of anatomical, physiological, and biochemical interactions. In particular, the graft union process includes, besides the adhesion between grafted partners, callus formation, the creation of a continuous cambium, establishment of new vascular tissue, and the formation of a functional vascular system across the graft interface (Pina et al., 2012). The effectiveness of grafting primarily depends on survival rate and the quality of vascular connections formed in the graft union. This last one, nonetheless, varies between rootstock–scion combinations. The healing of the graft union can take anywhere from days in the case of herbaceous plants to more than one year in the case of some woody perennials,

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and in some cases graft incompatibility may not become apparent for several years (Zarrouk et al., 2006; Warschefsky et al., 2016). Late graft rejection in fruit trees has been associated with limited plasmodesmal coupling at the time of grafting within one of the partners (Pina et al., 2009). For this reason, the delayed appearance of the symptoms increases the time required for detection of graft-compatibility and slows down rootstock selection programmes, since the commercialization of new rootstocks requires preliminary evaluation of possible incompatibility reactions.

Graft incompatibility is one of the most important problems in the fruit tree industry. Mosse (1962) described two types of graft incompatibility: ‘translocated’ and ‘localized’. The first one is characterized by visual symptoms in the tree (yellowing of leaves which later became redder or more orange, premature defoliation) and an earlier stop of tree growing and a radicular system not fully developed (Moreno et al., 1993; Zarrouk et al., 2006). ‘Localized’ type is characterized by anatomical irregularities at the graft union interface accompanied by anatomical abnormalities of vascular tissue in the callus bridge (Hartman et al., 2002). It is also characterized with breaks in cambial and vascular continuity and poor vascular connections (Errea et al., 2001; Zarrouk et al., 2010). These structural anomalies cause mechanical weakness of the union which may break after some years or after strong wind conditions, and subsequently leading to major economic losses. These two types of incompatibility can present themselves jointly in a same graft combination, and neither of them is privative of determined species.

The introduction of some new rootstocks requires knowledge of the extent and nature of (in)-compatibility reactions before releasing them on the market, providing both nursery and fruit growers valuable information about the risk of weak unions. Several anatomical studies have been done in fruit tree species such as cherry (Moreno et al., 1995a), litchi (Chen et al., 2016), peach (Zarrouk et al., 2006) and pear quince (Ermel et al., 1999), but apricot anatomical graft compatibility research has been poorly addressed (Errea et al., 1994; Errea et al., 2001). Apricot cvs. have been traditionally classified in two groups in terms of graft compatibility exigency: the exigent (difficult-to-graft non congenial cvs.) and the non-exigent cvs. (Crossa-Raynaud and Audergon, 1987).

The main objectives of this study were: 1) identify and determine the graft compatibility between four apricot cvs. and twenty-one different *Prunus* rootstocks, some in process of selection and others already introduced into the European market, and 2) establish comparisons in terms of compatibility between them.

2. Material and methods

2.1. Plant material

Four apricot cultivars (‘Búlida’, ‘Canino’, ‘Paviot’ and ‘Moniquí’) were T-budded *in situ* each summer during four years on different plum based rootstocks (Table 1). Approximately, at 15 cm from the ground, a T cut (approximately 1 cm width and 1.5 cm long) was made across the bark at each rootstock (one-year old tree, diameter approximately 1 cm). Cultivar bud shields from 5–10 year-old mother trees (apricot germplasm collection) were cut starting from below the bud to obtain a pointed end that can be easily inserted into the stock.

For practical purposes, scion and rootstock genotypes were divided into different groups. In the case of apricot cultivars, ‘Búlida’ and ‘Paviot’ were considered as ‘no exigent’ cultivars in terms of graft compatibility exigency, whereas ‘Canino’ and ‘Moniquí’ were considered as ‘exigent’ cultivars with a greater tendency to express graft-incompatibility (Crossa-Raynaud and Audergon, 1987). Among the twenty-two rootstocks used in this study (Table 1), the hexaploid plums ‘Pollizo de Murcia’ rootstocks, the interspecific hybrid Miral 3278 AD, and the diploid Myrobalan 713 AD are under process of selection by the Aula Dei Experimental Station.

The trials were established in different nurseries at the Aula Dei Experimental Station (NE Spain; lat. 41° 43′ 42.7″ N, long. 0° 48′ 44.1″ W), with a soil description as following: calcareous, with 29–30% total calcium carbonate, 7.4–7.6% active lime, water pH 8.0–8.5, and a clay-loam texture. The nurseries were level-basin irrigated every 12 days during the summer.

Each scion/rootstock graft combination was replicated 15–30 times (trees) depending on the availability of plant material. Ten replicates per combination were considered the minimum acceptable for assessment. Some combinations suffered field losses, after three years of field testing, mainly due to the grafting process failure.

Stock-plants used for hardwood cutting production of rootstocks were routinely tested to maintain trees free of Prunus necrotic ringspot virus (PNRSV), Prune dwarf virus (PDV), Tomato ringspot virus (TomRV), Apple chlorotic leaf spot virus (CLSV) and Plum pox virus, Sharka (PPV).

2.2. Anatomical incompatibility evaluation

Anatomical examination of unions (‘localized’ incompatibility) was carried out on one to four year-old grafted trees. According to Mosse and Herrero (1951), graft unions were sawed by a radial-longitudinal plane, and each visual rating of ‘localized’ graft incompatibility (Fig. 1) was classified as follows: 1) category A: Perfect unions (the line of the union between bark and wood is hardly visible); 2) category B: Good unions (the bark and wood are continuous although the line of union in the wood is often clearly distinguished by excessive ray formation); 3) category C: Unions with discontinuities in the bark (the bark tissues of rootstock and scion are separated by a dark brown layer of corky appearance); 4) category D: Unions showing vascular and wood discontinuities (the woody tissues of rootstock and scion are separated in many places by clusters of living, non-lignified parenchyma, whereas bark tissues are generally as category C); and 5) category E: Observed breakage of the tree at the graft union in the nursery or orchard. Categories D and E were considered ‘incompatible’ unions because breakage might occur caused by mechanical damage or wind.

2.3. Growth measurements

At the time of internal examination, stem circumferences at 5 cm above and below the graft union, and at the graft union itself were measured. This method enabled searching for correlations between growth characteristics and compatibility-incompatibility occurrence (Zarrouk et al., 2006). In addition, a ratio was made between circumference above the graft union and at the graft union to search values in which graft incompatibility can be predictable.

2.4. Statistical analysis

For each cultivar, data from growth measurements were evaluated by two-way variance (ANOVA) analysis with the software SPSS 21.0 (SPSS Inc., Chicago, USA). When the F test was significant, means separation were conducted using a Duncan test at $P \leq 0.05$. The analyses of Pearson correlation were carried out to study correlations between graft incompatibility occurrence and year after budding.

3. Results and discussion

In terms of ‘localized’ graft incompatibility, as expected, most graft combinations were compatible when apricot cultivars were budded on hexaploid slow-growing plums (Table 2). Among them, it is noteworthy some ‘Pollizo de Murcia’ plums such as Adesoto and PM 105 AD, the Greengage RC GF 1380 and Torinel rootstocks. Similarly, the pentaploid hybrid Damas GF 1869 exhibited good compatibility with the exigent cv. ‘Moniquí’.

Anatomical evaluation of the apricot ‘Búlida’ graft unions indicated