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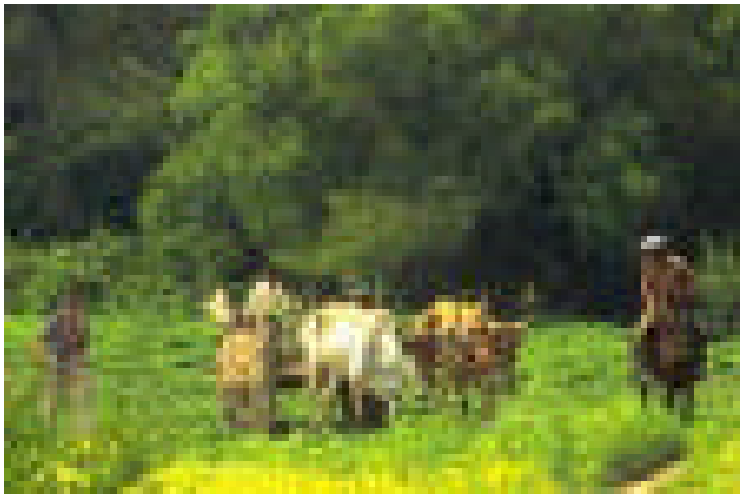

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Effects of pre-blossom temperatures on flower development and fruit set in apricot

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Abstract

The influence of pre-blossom temperatures on flower development and fruit set is ascertained in apricot (*Prunus armeniaca* L.), a species without previous records on the effect of pre-blossom temperature on fruit set, but that is particularly prone to erratic fruit set. A polyethylene cage was used during pre-blossom development of flower buds to increase maximum temperatures by 6–7 °C and mean temperatures by 3 °C in orchard conditions. This increase in temperature accelerated flower bud development, caused a hastening in flowering time and following hand-pollination, reduced fruit set. At anthesis, flowers that had developed in warmer conditions weighed less and showed less development of the pistil than control flowers. Pistil growth of flowers under warm conditions did not differ from that of the control flowers when both the populations were compared on a real time scale in spite of the fact that warmed buds were at an advanced external phenological stage. Thus, hastening of external floral development by warm pre-blossom temperatures was not accompanied by advance in pistil development. This lack of synchrony resulted in premature flowering of flowers with underdeveloped pistils that had a reduced capability to set fruit. The results are discussed in terms of flower quality and its implications in fruit set and subsequent crop load.

Keywords: Apricot; *Prunus armeniaca*; Flower development; Fruit set; Pistil; Anthesis; Temperature

1. Introduction

Irregularity of yield is one of the main problems in fruit production (Tromp, 1986). Year-to-year variations in crop production have been traditionally related to weather conditions in spring. Thus, wind and low temperatures affect bee activity and therefore pollination (Dennis, 1979), and frosts can reduce the number of buds, flowers and fruits

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Pedogenesis in Lutitic Cr Horizons of Gypsiferous Soils

O. Artieda and J. Herrero

Pedogenesis in Lutitic Cr Horizons of Gypsiferous Soils

O. Artieda and J. Herrero*

ABSTRACT

The weathering of lutites in aridic or near-aridic environments leading to soil horizons is not well known. Lutites are a common soil parent rock composed of silt and clay, that may be massive or may have their sedimentary origin marked by layers of alternating color or granulometry, or by fissility along planes. Lutites underlying soils are considered Cr horizons and show different alteration stages recognizable in the field by the degree of the layering disturbance or by the loss of coherence. In the study area, neither the dry climate nor the kind of clay minerals, mainly illite, can explain the weathering of lutites. This study was conducted to investigate the initial weathering reactions as encountered in Cr horizons, and to depict the processes responsible for pedogenesis from lutites in gypsiferous soils of the Ebro Valley (Spain). We described 12 soils in the field under two different soil moisture regimes, with further characterization through chemical analyses and micromorphology by thin section and scanning electron microscope (SEM). The microscopic study revealed two distinctive pedofeatures in the Cr horizons: (i) lenticular gypsum crystals; and (ii) "queras," sub-millimetric biotic features produced by calcification-decalcification processes. Growth of gypsum crystals in these horizons resulted in an "isles fabric," that is, isles of fine materials in a mass of gypsum crystals, with much greater porosity than the parent lutite. The growth of gypsum crystals and the development of queras result in a particle-size distribution change and an increased porosity of the Cr horizons.

SOILS DEVELOPED on lutites in environments rich in carbonates and gypsum are common in dry regions, such as the central Ebro Valley (northeastern Spain). Most studies relating to the weathering of lutites have focused on the clay minerals, for example Ducloux et al. (1995), or El-Kammar and El-Kammar (1996). Other studies have looked at the weathering of lutites under wetting-drying or freezing-thawing cycles (Pardini et al., 1996; Cantón et al., 2001). However, little attention has been paid to other factors of the comminution of the lutite, which can be considered as the inception of soil formation. Studies of the processes of gypsification or of calcification and decalcification have been limited to the solum itself or other unconsolidated materials (Chen, 1997; Toomanian et al., 2001). In this study we stress the action of these processes on lutitic Cr horizons. These processes reorganize the soil components, either with or without loss or gain of gypsum or carbonates at the horizon scale.

Several authors (Stoops and Ilaiwi [1981], Allen [1985], or Jafarzadeh and Burnham [1992]) have described the sizes and morphology of pedogenic gypsum crystals. However, to properly understand the genesis and the properties of the soil horizons in areas with ubiquitous gypsum, one needs to take into account the generalized formation of gypsic pedofeatures, that can reach the isles fabric stage (Herrero et al., 1992). Soil carbonates have been studied either from a genetic point of view (Goudie, 1996; Kaemmerer and Revel, 1996) or from a micromorphological one (Monger et al., 1991a). However, little attention has been paid to queras, pedofeatures of 1 to 2 mm wide and <2 cm long in thin section, including calcification and decalcification traits found by Herrero et al. (1992) in the sola of hypergypsic soils; queras appear in the present study in lutitic Cr horizons.

Queras (Herrero et al., 1992) are a complex pedofeature composed by both calcification and decalcification features. The calcification feature is made by carbonatic grains, whose size, shape, and internal characteristics are associated to root pseudomorphs in many studies. References to features somewhat similar to queras have been found in Barzanji (1973), Barzanji and Stoops (1974), Bal (1975), Fang et al. (1994), and Khokhlova et al. (2001). Klappa (1980) observed calcite crystals replacing cells of the root parenchyma, but these crystals (20 μm) were smaller than the quesparite grains studied here (from 80–120 μm). Jaillard (1984, 1987) and Jaillard et al. (1991) reported rhizomorphic, carbonated structures in soils resulting from marl alteration. These works consider these structures, which are similar to queras, as calcified root residues. These calcified cells are homometric, with diameter of about 80 μm, similar to our quesparite grains. Similar morphologies in Quaternary loess paleosols of several sites in Europe were interpreted by Becze-Deák et al. (1997) as root pseudomorphs. The same authors report that these morphologies occur not only in soils with a carbonatic matrix, but also in non-calcareous matrices. The decalcification feature described by Herrero et al. (1992) is similar to the decalcified crown reported by Jaillard (1984) and by Jaillard and Callot (1987) on both sides of the rhizomorphous structure.

In this article we focus on the genesis of soil horizons from in situ lutites in areas with abundant gypsum and dry climate. Our objectives are (i) to describe the two most abundant pedofeatures found in the lutitic Cr horizons, (ii) to show that the development of both these pedofeatures have parallel effects leading to a soil material coarser and looser than the parent lutites, and (iii) to propose a genetic model explaining the production of soil horizons from lutite.

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Abbreviations: BSE, backscattered electron; CCE, calcium carbonate equivalent; EDS, energy dispersive spectrometer; GE, gypsum equivalent; MAP, mean annual precipitation; MAT, mean annual temperature; OC, organic C; RET, reference evapotranspiration; SEM, scanning electron microscope.

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The impact of transition from flood to sprinkler irrigation on water district consumption

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Abstract

The 'Irrivol' method for calculating the water volume required in an irrigation district is expanded by correlating it with soils map. The resulting water volume maps are used to analyze a proposed change from controlled flooding irrigation to sprinkler irrigation. The soil map is then used to evaluate the productive potential of the land in order to select the soils for sprinkler irrigation, to extrapolate field measurements of flood irrigation efficiency, and to account for the reuse of the non-consumptively applied water to higher landforms. The soil map is crossed with four years of remote-sensed crop maps. For each year the calculated water volumes applied currently and the volumes that would have been applied using sprinkler irrigation were compared. Our calculations overestimated the measured supply by 10% for two years, with marginal differences for the other two. With the present crops, sprinkler irrigation would have saved about 7% of the water supply. Most likely this will not result in real water saving, but in a higher beneficial use of water.

Keywords: Irrigation; Soils; Remote sensing; Water reuse; Aridity; Spain

1. Introduction

Flood irrigation is the most common irrigation technique worldwide, and also prevails in Spain both in the old irrigated areas and in the large new irrigation districts that were built up during the past Century. Manpower shortage, introduction of new crops, irrigation water saving, and environmental concerns about soils and water are some of the arguments of farmers, water authorities, and ecologists when they advocate the modernization of the irrigation water application methods in developed dry countries like Spain (Herrero and Snyder, 1997; Herrero, 1999), where irrigation diverts 89% of available water. The change from controlled flooding to sprinkler or to drip irrigation is often perceived as introducing an 'industrial' water management, and is thus preferred over the improvement of the design and infrastructure of flood irrigation schemes. The change of system saves time dedicated to irrigation, and eliminates the need to rotate irrigation because the pressurized irrigation schemes will be based on pumping stations from new regulation reservoirs within the district, often called 'night reservoirs'. In spite of the investment needed for the change of

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Revisiting the definitions of gypsic and petrogypsic horizons in Soil Taxonomy and World Reference Base for Soil Resources

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Abstract

Gypsic and petrogypsic horizons occur in large areas of arid and semiarid regions of the world. The occurrence of gypsum in soils is considered a key feature by most soil classification and mapping systems that have coined specific names for these soils and horizons. However, the current methodology for description and definition of gypsic and petrogypsic horizons in the two most popular soil taxonomic systems "Soil Taxonomy" and "World Reference Base for Soil Resources" (WRB) does not address sufficiently the advances in knowledge of the constitution, genesis, and behaviour of gypseous horizons. Some of their basic statements, like the presence of secondary gypsum or the degree of cementation, are often ambiguous in the field. Further, the definitions of gypsic and petrogypsic horizons should not be interlocked, each definition should be based on field characteristics linked with microscopic and hydric properties that control the durability and the life-supporting capability of gypseous soils. The avoiding of confusion between gypsum-rich and calcium carbonate-rich horizons when grouping soil taxa or diagnostic horizons by means of soil-forming processes is stressed.

Keywords: Soil classification; Gypsum; Diagnostic horizons; Aridity

1. Introduction

Soil Taxonomy (Soil Survey Staff, 1999) has become a world reference for soil classification and survey, at least at the most detailed scales. Although the system is not easily applied by nonprofessional soil scientists, some recent adaptations have made it more accessible utilizing already existing knowledge, as pointed out by Swanson (1999). This perspective depicted by Swanson, together with the accelerated convergence among national or international soil classification systems, and the global access to information based on the new technologies make clear the need for a sound representation of all the soils of the world in Soil Taxonomy. The World Reference Base for Soil Resources, or WRB, (FAO, 1998) has been developed from previous FAO documents with a worldwide scope and has achieved a high degree of convergence with Soil Taxonomy. A process-related emphasis in soil classification has been claimed (Bockheim and Gennadiyev, 2000) as a way to illustrate the global soils and for a better understanding of both Soil Taxonomy and WRB.

In Europe and the United States, gypsum-rich soils occur mainly in arid or semiarid areas, often in lands marginal for production, whereas in other countries with arid regions, these soils are common in agricul-

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Viñateros
de la Costa
de Berisso

Fotografía
Xavier Kriscautzky
Color
Mariela Theiller

Origen del proyecto desde la Facultad ...

Texto: Irene Velarde, Mariana Marasas, Leonardo Davies, Joaquín Otero y Mariela Theiller.

La Universidad Nacional de La Plata fue fundada en 1905. Desde la reforma universitaria de 1918 se propone articular tres funciones básicas: la docencia, la investigación y la extensión.

Apoyados en este espíritu, los docentes universitarios nos hemos propuesto continuar ejercitando la interrelación entre dichas funciones a fin de generar procesos de cambio dirigidos a los sectores menos favorecidos de la sociedad.

De acuerdo con esta concepción, surge en el año 1999 y en forma ininterrumpida el proyecto de extensión universitaria "El vino de la costa de Berisso, Argentina: diferenciación agroalimentaria para la reactivación y valorización de la producción y consumo local" mediante el cual, la Facultad de Ciencias Agrarias y Forestales, a través de integrantes del Curso de Extensión Agropecuaria (Departamento de Desarrollo Rural), asesoran, capacitan y promueven la organización de productores rurales en Berisso. Apoyados por instituciones como el Ministerio de Desarrollo Humano y Trabajo de la provincia de Buenos Aires, el Municipio de Berisso, el Programa Cambio Rural Bonaeren-

se, la REDAR Argentina y el Prodar/ IICA; que juntos han contribuido con financiamiento de diferente tipo y redes organizacionales, al desarrollo del presente proyecto.

Berisso constituye junto a otros municipios del Gran Buenos Aires uno de los más azotados por la crisis económica de fines del 2001: altísimo índice de desempleo, dificultades de acceso a la alimentación, violencia social urbana, entre otros, provocan una gran desesperanza en los jóvenes que sólo pueden aspirar a la ayuda social del gobierno, ya que no han tenido la oportunidad de incluirse en empleos formales y ven restringidas las posibilidades de acceso a la educación.

En este marco de extrema vulnerabilidad social, productores propietarios y ocupantes rurales están dispuestos a continuar apostando al futuro, alrededor de productos que los identifican y dignifican como trabajadores y como hombres que además de producir un bien agroalimentario, producen su propia cultura.

Este proyecto se propone gestar un proceso de desarrollo local de carácter ascendente haciendo eje en la promoción de productos diferenciados en su calidad y origen, que le devuelva a los protagonistas de Berisso, productores y consumidores, esa dignidad, identidad y esperanza en ambas.

Los productores nucleados en el "Grupo de Viñateros de Berisso" (hoy "Cooperativa de la Costa de Berisso, Ltda."), son pequeños productores familiares que producen Vino de la Costa en la cercanía del Río de la Plata. Dicha actividad se gestó de la mano de los inmigrantes de origen europeo (italianos, portugueses, españoles...) a principios del siglo XX. En la actualidad continúan produciendo en una escala mucho más pequeña pero manteniendo valores de las generaciones pasadas.

A través del proyecto se ha realizado un conjunto de actividades con la Facultad de Ciencias Agrarias y Forestales que han dado como resultado una dinámica local generadora de excedentes económicos que, dada la deteriorada situación socio económica actual, resulta uno de los logros más apreciados por los propios productores y técnicos.

En su implementación han surgido acciones que combinan la producción agropecuaria, la ecología, la historia, la cultura y el arte. El equipo técnico, en esencia interdisciplinario, ha permitido generar sinergias y en consecuencia, ello ha derivado en cambios en la forma de enseñar, de investigar (a través de demandas concretas de grupos sociales postergados) y también en su relación con el medio y los actores locales.

Regresan así cultivos y oficios, retorna una particular atención por el paisaje y los recursos naturales.

"*... Una nueva etapa en la producción de vino de la costa*" (sic), es la que se inicia y es como lo expresan los actuales productores de Vino de la Costa de Berisso.

El vino es un amor incómodo, dicen los poetas. El hombre ha producido y tomado vino desde que es hombre, hoy intentamos valorar esa historia y reinventar las tradiciones.

"*Recuperarnos del cansancio de la gente vieja*" (sic), seguir produciendo, ser de algún lugar, identificarnos con lo que fuimos y seguimos siendo, aprender de nuestra historia, de la tenacidad y constancia de esa gente vieja y aportar nuevos conocimientos que nos ayuden a mejorar.

"Es cuestión de no quedarse en el camino. Yo creo que por eso se llega. Porque yo nunca me quedé en el camino. Si se vienen las malas o las buenas... A veces vino la creciente y me llevó todo. Al año siguiente de nuevo a trabajar. Ahora, si a estos chicos jóvenes les pasa un accidente de esos, dicen -dejamos la uva-. Es como son las cosas. Yo vine por un rato acá, y hace 50 años que estoy..."

Productor viñatero (Angel Lissi, 76 años, Enero de 2003)

La identificación con el territorio y las costumbres de productores y consumidores de la región permiten esbozar un futuro promisorio y en esa convicción se sustenta nuestro accionar.

Los resultados esperados están centrados en la valorización de los productos a través de la integración vertical, partiendo del "saber hacer" y el cuidado del medio ambiente y los recursos locales. Estas características heredadas, hoy, son una ventaja competitiva que pueden apropiarse los pequeños productores de la región y así poder seguir construyendo una nueva historia de los Viñateros de la Costa de Berisso.

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The Onset of Fruiting in Apricot (*Prunus armeniaca* L.)

J. Rodrigo and M. Herrero

(Received November 9, 2001)

Summary

Apricot (*Prunus armeniaca*) is a species particularly prone to erratic fruit set. However, the causes of these irregular productions are not entirely understood. This may be related to the lack of information as far available in this species on reproductive biology and the onset of fruiting. In order to provide a framework where the low adaptability shown by most of the cultivars could be studied, anatomy of the pistil and pollen tube growth through the pistil structures have been explored from pollination to fertilisation. Likewise, early fruit growth and fruit drop have been characterised in two apricot cultivars, 'Moniqui' and 'Bulida'. The phase elapsing from pollination to fertilisation took place in a considerably shorter period of time than in other related species. Thus, the first pollen tubes reached the base of the style in 3-4 days, and fertilisation was completed by 7 days after pollination. Most of the flowers and fruitlets dropped within the first 4 weeks following pollination, and the biggest drop wave took place 3-4 weeks after pollination. At this time, all the unpollinated flowers remaining in the tree dropped. In spite of starting with a synchronised population of flowers at anthesis, large differences in development were recorded among flowers and fruitlets in the days following pollination and some flowers clearly outgrew others, that eventually dropped. These differences, although at a different scale, also occurred in unpollinated flowers. The continuous fruit growth and fruit drop in both pollinated and unpollinated flowers, together to the fact that a number of fertilised fruits also dropped, suggest that in addition to pollination or fertilisation, other factors may be involved in flower and fruit drop and fruit set. Results are discussed in terms of the implications of the nutritional status of the flower in fruit set.

Introduction

Apricot (*Prunus armeniaca* L.) is a species particularly prone to year-to-year variations in fruit set that negatively influence crop load (Mehlenbacher et al., 1990). These irregular productions have been associated to the narrow adaptability range of this species. Indeed, while in other fruit tree species a few cultivars are grown all around the world, in apricot each cultivar is usually restricted to a particular geographical area with certain ecological conditions and low yields are obtained whenever particular cultivars are grown in other regions (Layne et al., 1996). However, the causes of this low adaptability are not entirely understood. Pollination has usually not been considered a contributing factor since this species is basically self-compatible (Mehlenbacher et al., 1990). However, a growing number of self-incompatible cultivars have been detected in the last years (Burgos et al., 1997), and in some cultivars, pollination failures appear to be responsible for erratic fruit set (Rodrigo and Herrero, 1996). Likewise, alterations along the reproductive process have shown to have a direct impact in fruit set. Thus, male sterility (Garcia et al., 1988; Lillecrapp et al., 1999), lack of stigmatic receptivity (Egea et al., 1991; Egea and Burgos, 1992) or ovule degeneration (Eaton and Jamont, 1964; Burgos and Egea, 1993, Burgos et al.,1995; Lillecrapp et al., 1999) have been related to erratic fruit set in different circumstances. In spite of the importance that these factors appear to have determining crop, a comprehensive picture that integrate these factors is missing. This may be related to the lack of information, so far available in this species, on the reproductive process and the onset of fruiting. The elucidation of these processes could contribute to a better understanding of the agronomical behaviour of this species and provide a framework to evaluate the problems in fruit set.

In this work, the reproductive process and the onset of fruiting are characterised in apricot. Thus, anatomy of the pistil and pollen tube growth through the pistil structures have been explored from pollination to fertilisation. Likewise, both fruit growth and fruit drop have been sequentially examined, to relate the microscopical observations with the behaviour of the trees in the field. These processes have been characterised in two cultivars, 'Moniqui' and 'Bulida'. To examine which of these processes are determined by pollination or fertilisation and which are developmentally regulated, events have been compared in pollinated and unpollinated flowers.

Material and Methods

Plant material

Apricot (*Prunus armeniaca*) cvs 'Moniqui' and 'Bulida' were used. Experiments were performed in three trees per cultivar and repeated over two consecutive years. In order to compare development, only flowers at the same developmental stage were left on selected branches; both older flowers and younger buds were removed. Flowers were emasculated and their petals removed at balloon stage 1 day before anthesis to make the flowers unattractive to insects and to avoid self-pollination. At anthesis, a group of flowers was left unpollinated and another group was pollinated with pollen from cv. 'Canino', that is compatible with both cultivars (Rodrigo and Herrero, 1996). Pollen was previously obtained from flowers at balloon stage by removing the anthers and placing them at room temperature on a piece of paper. Pollen was sieved 24 hours later with a 0,26 mm mesh and frozen at -20°C until required.

Microscope preparations

A total of 100 pistils of each cultivar were processed and observed, 10 pistils per day from anthesis to 9 days later. Pistils were preserved in FAA [70% ethanol:glacial acetic acid:formalin (18:1:1, v/v/v)]. Pollen germination and pollen tube growth in the style were monitored on squash preparations. For this purpose, following fixation, the styles were washed three times, one hour each wash, with distilled water and left overnight in 5% sodium sulphite. On the following day, the pistils were autoclaved at 0.1 MPa (at 121 °C) for 10 min in 5% (w/v) sodium sulphite to soften the tissues and stained with 0.1% (v/v) aniline blue in 0.3 M K_3PO_4 (Linskens and Esser, 1957) and 0.01 %

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Almond Bloom in a Changing Climate

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Abstract

Almond shows an extended blooming season. Later blooming cultivars avoid the possibility of late frosts and also benefit from temperatures more favorable for pollination and fertilization. For these reasons, the almond breeding program of Zaragoza has mainly pursued the development of very late blooming cultivars, and also cultivars showing a wide range of bloom times.

Introduction

The Mediterranean climate is characterized by very low rainfall during late winter and early fall. Thus, almond (*Prunus amygdalus* Batsch syn. *P. dulcis* (Mill.) D.A. Webb) is a nut species adapted to this climate (9) due to its specific requirements in relation to rains. Rains during the fall disrupt harvesting operations. Rains during bloom interfere with pollination, reducing the activity of pollinating insects. As a consequence, a high negative correlation has been found in California between the total rainfall in February and final crop level (2). Heavy rains over long periods are not typical for present growing regions during almond bloom, but a climatic change may disturb almond pollination if there is a shift of the main rainy season towards the almond blooming time (15). The global climatic change now in progress has affected rainfall patterns, leading to greater threats to the almond bloom.

Almond shows an extended blooming season when all cultivars are taken into account (12). Later blooming cultivars avoid damage from late frosts and also benefit from more favorable temperatures for pollination and fertilization. The almond breeding program of Zaragoza (6) has pursued not only the development of very late blooming, but also of mid blooming cultivars, thus opening the possibilities of selecting a bloom season from a wider calendar range. This paper summarizes progress in delaying bloom in almond and the strategy of breeding new cultivars in order to widen the cultivar choices with regard to bloom time.

Materials and Methods

Phenological stages were recorded in 1997 for a collection of commercial cultivars and seedlings of the Zaragoza breeding program according to Felipe (4). Dates of the different blooming stages were established depending on the approximate percentage of opened flowers (Fig. 1). For the study of the possibilities of later bloom, the cross 'Felisia' x 'Bertina' was chosen because both parents are very late blooming (Fig. 1). 'Felisia' is a release from our breeding program (13), selected because of its self-compatibility and late bloom. It is derived from the cross 'Titan' x 'Tuono', and although 'Titan' is a seedling of 'Tardy Nonpareil', it has broken the linkage shown in the 'Tardy Nonpareil' progeny between late bloom and low productivity (7). 'Bertina', a local cultivar, is probably a chance seedling distinguished because of its late bloom. Almond bloom is rated according to the almond descriptors (8) on a rating scale from 1 (very early) to 9 (very late) by comparison to defined reference cultivars.

Results and Discussion

Figure. 1 shows the blooming time of several almond cultivars in Zaragoza in 1997. This bloom season was both earlier and shorter than usual due to high temperatures during this period. Bloom date changes from year to year depending on

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Cross-incompatibility of 'Ferragnès' and 'Ferralise' and pollination efficiency for self-compatibility transmission in almond

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Summary

The decrease in the number of pollen tubes in the style was studied in several compatible and incompatible pollinations involving the almond (*Prunus amygdalus* Batsch) cultivars 'Ferragnès' (incompatibility genotype S_1S_3), 'Ferralise' (S_1S_3), 'Tuono' (S_1S_f) and 'Marcona' ($S_{11}S_{12}$). After incompatible pollinations, the decrease of the number of pollen tubes was more pronounced and no pollen tubes reached the base of the style. No differences were observed among compatible pollinations, independently of the presence or not of a common *S* allele, thus confirming the full compatibility of half-compatible pollinations. The cross-incompatibility of 'Ferragnès' and 'Ferralise' suggested that their different behaviour in the transmission of self-compatibility from 'Tuono' to their offspring must be attributed to other genetic factors than the *S* alleles of pollen incompatibility.

Introduction

Most commercial almond cultivars are self-incompatible, possessing a gametophytic self-incompatibility system (Socias i Company et al., 1976) resulting in the stop of pollen tube growth in the middle third of the style (de Nettancourt, 1977). 'Ferragnès' and 'Ferralise' are two cross-incompatible almond cultivars originating from the French breeding programme (Grasselly & Crossa-Raynaud, 1980). Their cross-incompatibility has been explained by the fact that they share common *S* alleles, S_1S_3, which are identical by descent (Crossa-Raynaud & Grasselly, 1985). Thus, their compatibility behaviour when pollinated by the same pollen or when being used as pollinators for the same cultivar would be expected to be identical, in terms of the pollen tube growth dynamics (Socias i Company & Felipe, 1994).

However, transmission of self-compatibility to the offspring of these two cultivars when pollinated by 'Tuono' has shown to be very different (Grasselly et al., 1985). 'Tuono' is a self-compatible cultivar with the genotype S_1S_f (Crossa-Raynaud & Grasselly, 1985), thus sharing one allele with these two cultivars probably identical by descent because the S_1 allele of 'Ferragnès' and 'Ferralise' has been inherited from 'Cristomorto', a cultivar which originated in the same Italian region of Puglia as 'Tuono'.

The objective of this study was to follow the progression of pollen tubes through the pistils of these cultivars and to trace the presence of self-incompatibility symptoms in any type of pollination in order to assess whether any different growth behaviour would explain any efficiency difference among the different male parents, thus resulting in different rates of self-compatibility transmission among the offspring of both cultivars.

Materials and methods

Trees of all cultivars were grown in the almond germplasm collection of the CITA (Socias i Company & Felipe, 1992), grafted on GF 677 almond × peach hybrid clonal rootstock and managed according to normal growing practices. Flowers of 'Ferragnès', 'Ferralise' and 'Tuono' were collected at stage D (Felipe, 1977), emasculated and placed in trays with the ped-

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