PROBLEMS OF INCOMPATIBILITY IN THE PLUM-TREE

On writing plum-tree in the title of this article, we refer to the species *Prunus americana*, *Prunus cerasifera*, *Prunus domestica*, *Prunus hortulana*, *Prunus insititia*, *Prunus munsoniana*, *Prunus salicina* and hybrids among them as all have, or have had, representation as varieties or rootstocks in the cultivation of the plum-tree in different countries.

On the other hand, some of these species and hybrids have been and are the object of selection as rootstocks, not only for the plum-tree but, also, for other species of the *Prunus* genus (peach-trees, apricot-trees and almond-trees). The tests to which these selections give rise reveal new cases of incompatibility which should be appraised and evaluated.

1. TYPES OF INCOMPATIBILITY IN FRUIT-TREES

The diverse manifestation of symptoms of incompatibility in different combinations of varieties and rootstocks has resulted in that in the bibliographical reviews of the subject attempts have been made to group the known cases in different groups or types of incompatibility. In the present article, we refer to the types established by Mosse (1962) in his review on the subject.

Mosse bases his classification on the fact that certain types of incompatibility "translocate" through an intermediate whilst others "localize" themselves in the tissues of the union.

The cases classified by Mosse as "translocated incompatibility" are characterized by the fact that the interposition of an intermediate compatible with the variety and

the rootstock does not avoid incompatibility. Besides, they have the following characteristics in common: 1) Starch blockage, i.e. accumulation of starch above the union and total, or almost total, absence under the same; 2) Degeneration of the phloem; 3) Different behaviour in the reciprocal combination; 4) Normal vascular continuity in the union, although at times there are overgrowth in the variety with the consequent apparition of compressed tissues; 5) Early effects on growth.

Typical examples of translocated incompatibility are sweet orange grafted on sour orange (in presence of the tristeza virus) and peach grafted on Myrobolan.

The cases classified as "localized incompatibility" are characterized by the formation of weak unions susceptible to breaking due to mechanical actions such as the wind. This weakness of the union can be avoided by the interposition of an intermediate compatible with the rootstock and the variety. Besides, they have the following characteristics in common: 1) typical breaks in the cambial and vascular continuity although unions with normal structure can also present themselves; 2) similar behaviour in the reciprocal combination; 3) gradual starvation of the root system, with slow development of external symptoms proportional to the degree of vascular discontinuity in the union.

Typical examples of localized incompatibility can be found in unions of pear/quince and of plum/Myrobolan.

These two types of incompatibility can present themselves jointly in a same combination and, on the other hand, neither of them is privative of determined species.

In some cases of translocated incompatibility it is known that the cause of the same is a virus infection; a virus which manifest itself only in certain combinations of rootstock and scion. It is the case of sweet orange grafted

on sour orange in presence of the tristeza virus.

However, in other cases of translocated incompatibility, the hypothesis of the presence of a virus, although it is not completely ruled out, seems not to be very probable in the opinion of some authors (Herrero, 1955 a; Mosse, 1962; Tabuenca, 1962; Kester et al., 1965).

With regard to the localized incompatibility it is known that the immediate cause of breakage of the trees at the union is due to discontinuity in the tissues of the cambium and wood in the area of contact between the rootstock and the variety (Proebsting, 1928; Bradford and Sitton, 1929; Herrero, 1951). However, no evidence exists regarding the fundamental causes which produce this discontinuity.

Different authors express the opinion that this discontinuity is due to the presence of a virus; Williams and Campbell (1957) in combinations of the Conference pear grafted on a quince; Bernhard and Duquesne (1961) in the Canino apricot on the A-843 apricot; and Campbell (1967) in combinations of pear-trees and related species. However, Posnette and Cropley (1959, 1962), using Williams clones with different compatibility when grafted on quince, did not achieve the transmission, through grafting, of the condition of incompatibility. These authors conclude that the differences of compatibility among Williams clones are probably due to bud mutation.

The hypothesis that the causes which produce incompatibility of the localized type fall within the field of biochemistry was already discussed in Argles's review (1937). Later, Herrero (1951) and Mosse and Scaramuzzi (1956), as a result of detailed anatomical observations in compatible and incompatible unions, consider that the causes responsible for the necrosis and ruptures in the cambial continuity were of biochemical nature and were influenced, in the tree, by seasonal metabolic changes. The studies of Thiel (1954), Gur (1957)

and Buchloh (1958, 1960) in unions of pear/quince fall within the field of biochemistry and constitute important advances on the subject. Mosse (1962), making use of the evidence furnished by the above mentioned authors, discusses the presence in different fruit species of the substances studied in unions of pear/quince, concluding that "phenolic and cyanogenetic compounds may be important factors determining symptom expression".

2. TYPES OF INCOMPATIBILITY IN PLUM-TREES

The two types of incompatibility previously commented upon have been observed in combinations in which plum species intervene.

The most typical case of translocated incompatibility is that of the peach/Myrobalan combination. Various authors have contributed to the knowledge of the behaviour of this combination: (Argles, 1937; Herrero, 1951, 1955 a, 1955 b, 1956; Mosse, 1955, 1960 b, 1962; Tabuenca, 1962).

Other combinations in which the plum intervenes and which can be classified as translocated incompatibility are peach/Mariana (McClintock, 1948; Herrero, 1955 a), the Non-pareil almond variety grafted on Marianna 2624 (Kester et al., 1965) and certain percentages of peach grafted on Saint Julien of Orléans commented upon by Bernhard (1967).

The cases cited in the bibliography as localized incompatibility are very numerous. Already in Argles's review (1937) many cases of clean breakage were cited among varieties of *P.domestica* grafted on clones, seedlings and varieties of *P.americana*, *P.armeniaca*, *P.cerasifera*, *P.domestica*, *P.insititia*, *P.Mume* and *P.persica*. Among varieties of *P.salicina* and *P.Armeniaca* and *P.Mume*. Between *P.insititia* and *P.domestica*. And between varieties of *P.Armeniaca* and *P.cerasifera*, *P.domestica* and *P.insititia*. Subsequent to Argles's review nume-

rous cases have been listed in the bibliography. We quote only as an example a rather rare case of localized incompatibility between a Spanish peach variety and the Brompton (Cambrá, 1966).

The curious example of induced incompatibility between the President variety and the Myroblan B rootstock, when top-grafted with the Victoria variety, has been classified by Mosse (1962) as localized. Various authors have contributed their knowledge to the study of this combination (Montgomery et al., 1943; Roach and Thompson, 1947; Herrero, 1951; Mosse and Garner, 1954; Mosse, 1960 a; 1961, 1962).

3. PROBLEMS FOR THE BREEDER

One of the problems of the breeder consists of studying the compatibility between the new rootstock and varieties, and, in cases of localized incompatibility, of determining the most suitable intermediate.

The use of intermediates in plum-trees is, perhaps, more delicate than in other fruit species due to the fact that frequent incompatibilities exist among varieties of a same species (Herrero, 1951; Mosse, 1960 a) and that the degree of incompatibility may increase considerably in combinations of three components (Mosse, 1960 a, 1962).

Attempts to establish previous diagnosis, that is to say, the knowledge of incompatibility before carrying out the grafting, have not given positive results. Argles (1937) reviews studies in which a previous diagnosis was attempted by using precipitin reactions, Herrero (1951) tried to establish it, without results, on the basis of histological differences between the components of the graft; studies carried out in the field of the biochemistry (Gur, 1957; Buchloh, 1958, 1960) are promising but it does not appear that, up to now, any methods have been established for arriving at an efficient previous diagnosis.

The breeder therefore resorts to the early diagnosis once the combination has been grafted. The early diagnosis is made difficult by the following facts: 1) Lack of knowledge as regards the fundamental causes; for this reason one has to resort to the appraisal of symptoms. 2) Variability of symptoms in trees of the same combination; for this reason, it is necessary to observe a sufficient number of trees. 3) Variability in the apparition of symptoms in the time; for this reason, the symptoms are observed after a prudential time period has elapsed.

Early diagnosis in cases of translocated incompatibility

In all those cases where the peach forms the leaf system of the incompatible tree, the combinations studied have shown external symptoms during the first and second year of growth (Herrero, 1951, 1955 a; Tabuenca, 1962). This fact has been utilized in rootstock trials for the elimination of incompatible combinations in the nursery.

However, the symptoms in the peach-tree can also be produced by other different causes of incompatibility (Herrero, 1956) and, for this reason, in the trials referred to, we introduced, to compare with, the same peach varieties grafter on a compatible rootstock.

In the trials carried out by us with peach varieties grafted on plum species, the manifestation of external symptoms has been clear and it has not been necessary to complement the diagnosis with the examination of other internal symptoms, such as the abnormal distribution of the starch or necrosis in the floema. On the other hand, all these symptoms appear practically at the same time than external symptoms of ill-health.

Tabuenca (1962) finds a greater concentration of starch in the leaves of the incompatible peach-tree even though before other external symptoms appear. The study of this observation in combinations such as Almond/Marianna 2624 (Kester et al., 1965), which require a great number of years for manifesting their incompatibility, could, perhaps, allow the establishment of a method for an earlier diagnosis.

Early diagnosis in cases of localized incompatibility

Argles, in 1937, gives as the only symptomatic characteristics of incompatibility the presence of parenchymatous tissue at the line of union in place of normal differentiated tissues, and the clean and smooth breaking off of trees at the point of union. The author is not aware of any other studies subsequent to Argles's review which allow the clear establishment of other absolutely symptomatic characteristics of localized incompatibility.

The diagnosis based on breaking off of unions has the disadvantage that, sometimes, these do not present themselves until the tree has reached a certain age. On the other hand, breakage of very young unions must be interpreted with care (Mosse, 1962).

With the early diagnosis based on the internal examination of the unions, the breeder can eliminate the combinations which, because they present layers of parenchymatous tissue in the union, contain the immediate cause of later breakages.

In the rootstocks trials which, with a view to early diagnosis, we carry out at the Aula Dei Experimental Station, we make observations in unions of two, three and four years. We obtain the unions from a nursery including thirty or more trees of each combination, which we thin by 50% in successive years as from the second year. With the successive thinnings we are also trying for a normal development of the trees as it frequently happens that weak growing trees manifest locali-

zed incompatibility to a lower degree (Herrero, 1951; Cambra, 1966).

We carry out the internal examination of the unions by macroscopic observation of the surface which is obtained by sawing the union radial-longitudinally along the highest and lowest points of the same. The structural defects observed are classified in categories in accordance with the discontinuities observed in bark and wood (Herrero, 1962; Herrero and Tabuenca, 1962; Brosier, 1965; Tabuenca and Herrero, 1966).

In a work of selection of Myrobalan which we are carrying out at the Aula Dei Experimental Station, we are determining the compatibility of different clonal selections of Myrobalan with the variety Oullin's Golden Gage.

Of twenty-five clones included in the trial, five have shown parenchymalayer in their unions after two, three and four years according to the percentages shown in Table I.

Table I - Unions of Oullin's Golden Gage grafted on different clones of Myrobalan.
Percentages which present parenchymalayer.

Clon of Myrobalan	2 years old	3 years old	4 years old
MB	75%	100%	100%
AD 469	80%	80%	100%
AD 653	54%	83%	61%
AD 715	90%	100%	100%
AD 726	100%	100%	100%
Other 20 clones AD	0%	0%	0%

From Table I it can be deduced that the observations on 3 and 4 years old unions do not modify the diagnosis which

can be established with two years old unions. This is in agreement with the observations of Mosse (1960 a) on studying ten years old plum unions who found a good correlation with the diagnosis made by Herrero (1951) on two years old unions of the same combinations.

However, Cambra (1967), in the study of a case of localized incompatibility between the peach and Brompton concludes that early diagnosis in this combination must be prolonged during a period of time of more than three years.

We see, therefore, that methods for evaluating compatibility require the observation of the grafted combination during a variable number of years, in accordance with the combination dealt with, and that one needs a certain amount of knowledge regarding the variability of the same in space and time. When the fundamental causes of incompatibility will be known, if these are due to, or are related with, differences existing in the non grafted plants, one may expect the establishment of methods for a previous diagnosis which will save the observation time necessary nowadays for an early diagnosis.

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