ered from the nursery stock. If necessary, heat treatment will clean it up.

The program outlined does imply the practical desirability of a scion orchard rather than cutting wood from miscellaneous orchards. Inspection of nursery stock should not be necessary other than routine observation than is done in any growing operation. With some knowledge of symptoms on nursery stock, the grower would be able to detect any significant virus infection. With a clean scion orchard the chance of any virus in the nursery stock would be very remote. Even if there was an occasional tree with a minor virus like ringspot, the significance to an ultimate user would be nil.

Official certification programs are expensive because of the inherent high overhead costs of government agencies and the unwillingness to take reasonable risks, "bending over backward" to ensure absolute freedom from all viruses in every nursery tree, with overly stringent indexing, isolation and inspection procedures, using highly trained personnel on routine matters that less skilled persons could do. The practical program outlined for nurserymen will achieve the same freedom from virus for all practical purposes.

In conclusion, it is suggested that commercial nurseries establish their own virus-control programs, with heat chambers, rather than let regulatory agencies pre-empt the field. Not only is it more practical and cheaper, but in principle the responsibility lies with the nurseryman. Most viruses are important as affecting tree quality, of concern only between the nurseryman and the orchardist. The regulatory agency has no business setting quality standards. As already pointed out, though, it should have the responsibility where certain viruses are of serious importance and spread beyond the control of nurserymen and orchardists — becoming of genuine public concern.

While I have been discussing stone fruits, I believe the same thing applies to other plants.

[*Editor's Note*: The following paper was presented by Dr. John Mahlstede, Iowa State University].

PEACH BUD — GRAFT UNION ON *Prunus besseyi*[1, 2]

W. E. FLETCHER[3]

Introduction

The use of selected rootstocks for dwarfing fruit and ornamental plants has been an established practice in Europe for many centuries (Dana, 1952 and Scholz, 1957). Only recently.

[1]Based a portion of a dissertation submitted by W. E. Fletcher to the Graduate College, Iowa State University, Ames, in partial fulfillment of the requirements for the Ph.D. degree, 1964. The author is grateful to Professors J. P. Mahlstede and J. E. Sass for advice during the course of the study and for presentation of the paper at the Western Regional Meeting.

[2]Journal Paper No. 5040 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No. 1310.

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however, has the use of dwarf fruit and ornamental plants gained widespread acceptance in the United States. This has developed primarily because of increased production costs in commercial orchards that have relatively tall bearing trees. Contemporary architecture, featuring the single-story dwelling, has also created a demand for low-growing trees and shrubs which will maintain the scale of the home-lot landscape complex.

As a result of continued research and experience, the use of vegetatively propagated dwarf fruit trees has gained popularity. Reasons include (1) reduction in operational cost and damage to trees as a part of the necessary cultural operations, (2) the facility of handling a greater number of varieties per unit area, (3) reduced injury to developing fruit and trees as a result of severe winds, (4) earlier bearing and increased yields in comparison with standard-sized trees, (5) higher quality, improved color and better-flavored fruits, and (6) trees more adaptable to mechanized culture.

Some of the main disadvantages of grafted dwarf trees include (1) shorter life of dwarf trees in comparison with standard units, (2) increased need for pruning and maintenance practices as compared with those required for standard trees, (3) higher initial cost of the plant, (4) the difficulty of finding compatible or winter hardy sttocks suitable for dwarfing pur-

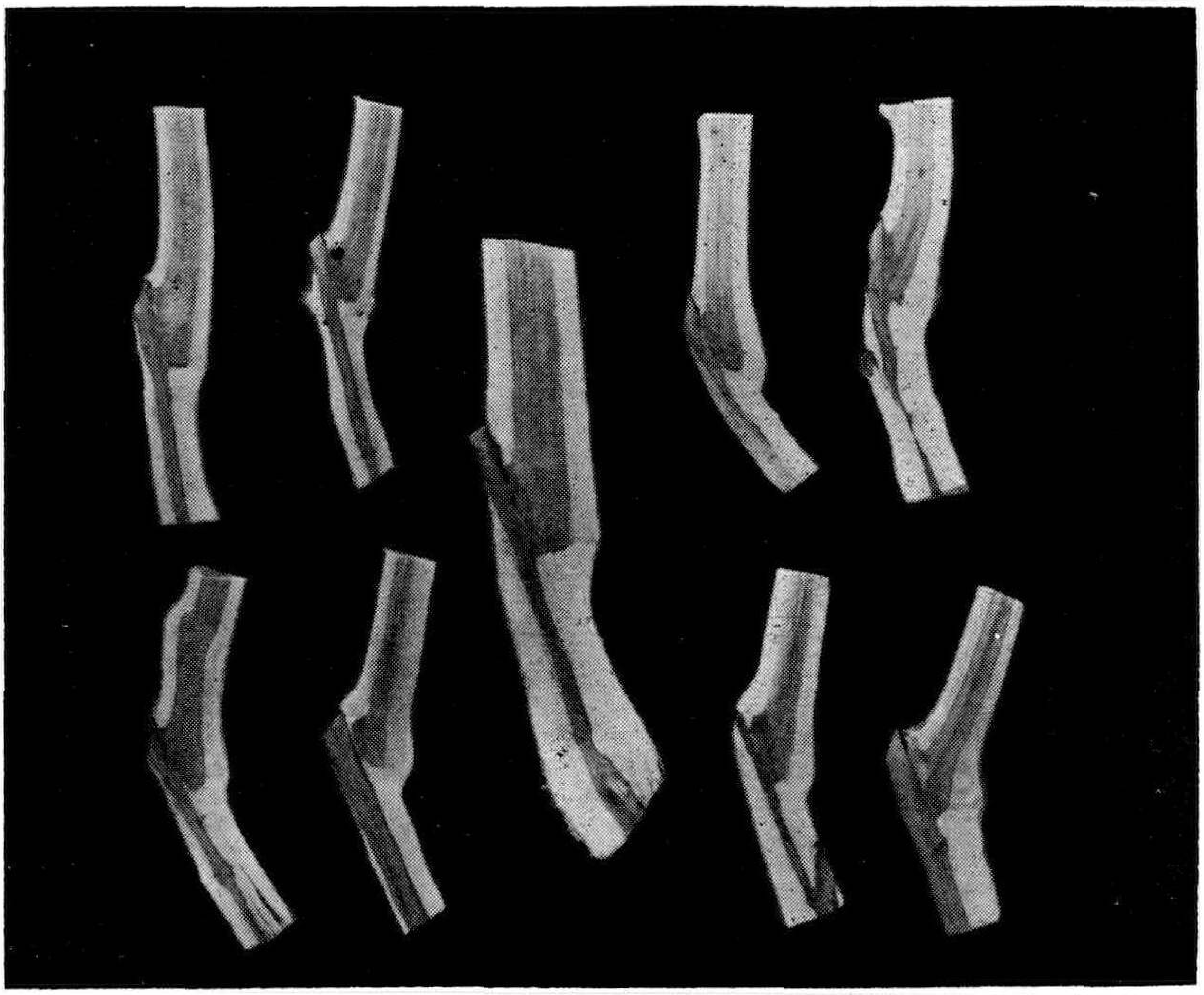

Figure 1. Longitudinal sections of the bud unions of the Polly peach budded onto **Prunus besseyi** rootstocks, showing the internal structure of bud grafts.

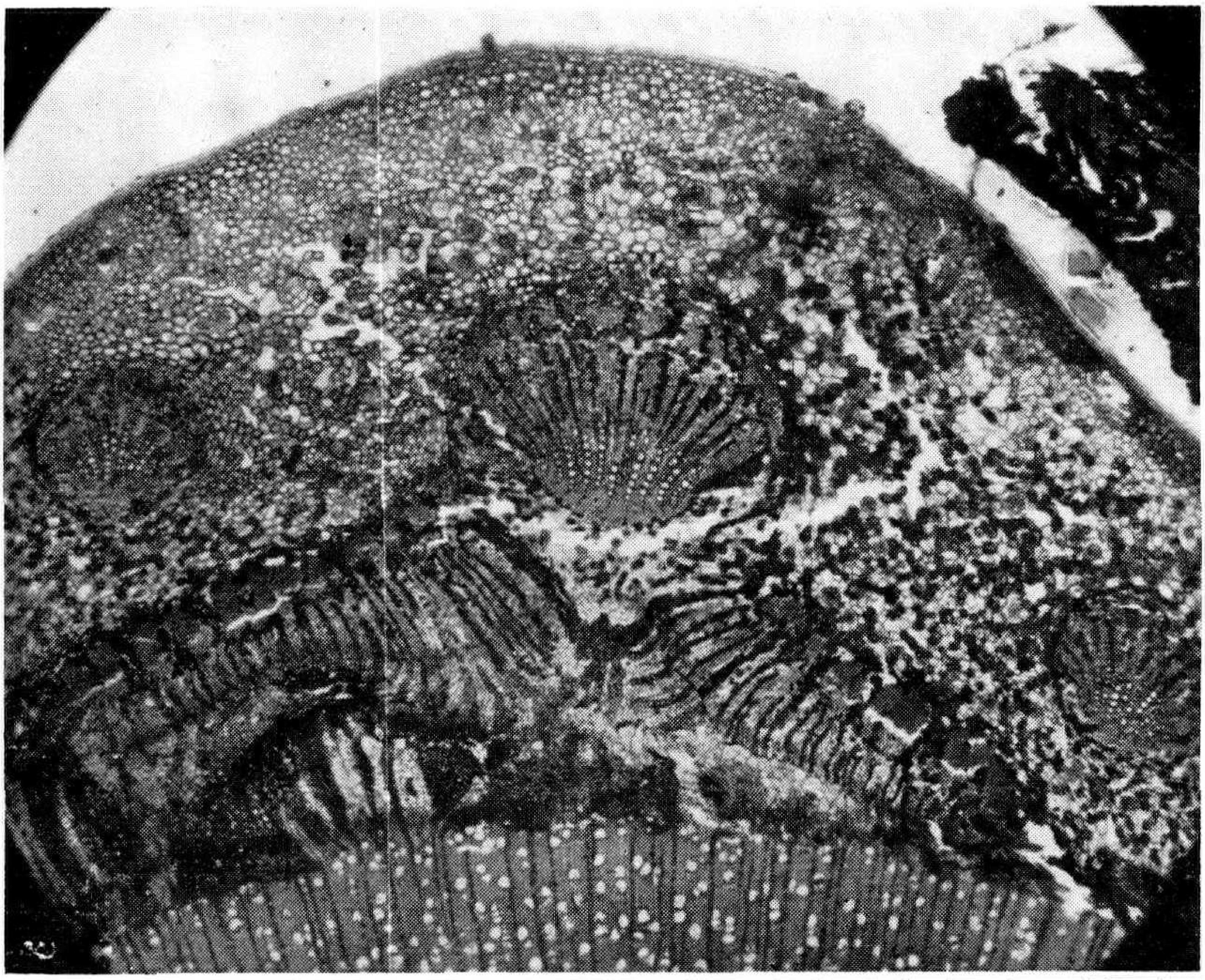

Figure 2. Cross section through a normal peach/sand cherry bud union eight days after budding. 36X. Upper right, bark flap; top, inserted bud; center region of merged calli of stock and scion; and bottom, stock.

poses, (5) the tendency for many dwarfing stocks to sucker and (6) the large number of trees that are poorly anchored or have an undesirable root system attributable to the dwarfing stock employed.

One specific problem which has been partially investigated is concerned with the use of the western sand cherry (*Prunus besseyi*) as a possible dwarfing stock for peaches. Although this rootstock has many attributes that make it one of the best of the dwarfing peach stocks, delayed incompatibility, resulting in loss of plants in the nursery, has created a serious problem for plant propagators.

This study was undertaken to investigate the histological process of bud union development between the peach and the western sand cherry. The purpose of this project was to follow the normal sequence of events that result in a successful union between component parts and to investigate the possible reasons for delayed incompatibility or graft failure.

Review of Literature

The western sand cherry has several attributes which should make it a good dwarfing stock for peaches, (Brase, 1953 and Brase and Way, 1959). It is a dwarf plant naturally, is very hardy and can easily be grown from seed. The propagation of clonal selections would be quite easy since the plants sucker readily in the field.

Sax (1956a) also advocated the use of *Prunus besseyi* for the production of dwarf peaches. Brase (1956) maintained that seedlings of *P. besseyi* had a limited use as dwarfing rootstocks for peach varieties, but Overholser *et al.* (1943) maintained that peaches, as a rule, were not satisfactorily grown as dwarfs.

In the early 1950's, peach varieties grafted onto *P. besseyi* in Iowa showed disorders that closely resemble symptoms expressed by the X virus. In addition, nurserymen observed that bud take and the subsequent growth and development in the field were not satisfactory during the first year of growth, when these plants were used as rootstoks. An extensive study has indicated that the incompatibility between peach varieties and these rootstocks is not disease induced, as previously postulated, but is attributable to a poor graft union (Agrios, 1960).

Brase and Way (1959) reported a similar problem in the State of New York. Trials began in 1944 involving the use of *P. besseyi* as a dwarfing stock for peaches indicated that combinations utilizing this stock have disorders similar to those found in Iowa. Bud unions developed abnormally, primarily because of the injury of the phloem tissue of the understock seedlings.

Figure 3. Cross section through the bud union area 25 days after budding. 36X. Abnormal unoin. Note the injury to the xylem area during budding and the arrested development of the scion (bud).

In transplanting tests, the budlings that grew normally without bud union disorder developed into typical dwarf trees. Trees that defoliated prematurely either failed to grow or made poor growth. Death usually followed within two years after transplanting.

Materials and Methods

During a two-year study, buds of the peach variety, Polly, were placed onto a dwarfing rootstock, *P. besseyi.* Budwood used in these investigations was collected from stock blocks certified to be virus-free as well as from trees which had not been indexed. Buds of these two types were placed onto both young and more mature growth of the dwarfing rootstock by use of the "T" budding technique.

A regular collection schedule was followed in which developing unions, as well as those not growing satisfactorily, were periodically removed for laboratory examination. Samples of unions were collected from one day to a point sixty days after budding. Field observations were recorded on symptoms used to detect early union, per cent bud take, per cent budding development and growth after two and three years in the nursery.

Summary and Conclusions

The major results from this study are:

1. The mechanical operations of removing the bud and included shield from the bud stick and preparation of the T incision on the understock injures or destroys all tissues that are either cut or torn. These injured cells form a necrotic plate over the interface of the graft components.
2. The development of callus strands from the terminal, uninjured cells of the immature xylem of the stock occurred rapidly and ruptured the necrotic plate of the stock in the normal sequence of bud healing by the fourth day. Shortly thereafter, the necrotic plate contained on the bud shield was also ruptured by callus; growth, mainly the result of divisions in the secondary phloem. Delayed penetration of the necrotic plate by callus tissue results in the death of the bud, caused by the absence of connective tissue and resultant desiccation.
3. Active cell division was observed in some bud unions collected two days after budding. By the fourth day, considerable callus had been produced by dividing cells of the stock. In sequence of meristematic cell activity, the intact cells of the immature xylem adjacent to the lateral flaps were the first to activate, followed by the extremities of the bud shield and finally the area immediately below the central axis of the inserted bud.
4. Six days after bud insertion, contact between the callus produced by the stock and scion had been established. By eight days, the lower half of the bud shield was connected to the stock by callus bridges. The area of the bud shield adjacent to the horizontal stock incision may never fill with callus.
5. The first continuous cambium connecting component parts

of the bud graft system occurred shortly after fourteen days. Subsequent development of xylem and phloem tissues by this layer forced the bud away from the stock. Although the intact cambium layers of the stock and scion contribute little to the early development of a successful union, cambium continuity was established between graft components.

6. Distinct differences in the rapidity of cell divisions and completeness of healing were observed between unions collected after fourteen days. After three weeks distinct areas devoid of cells were apparent in all bud unions. Although these areas may persist, they are not believed to influence the effective functioning of the union.

7. Symptoms of incompatibility were expressed as early as the third week and could be discerned anatomically in the stock-scion interface, or in the area of the stock adjacent to the T incision. In the order of occurrence, disorders between the stock and scion were observed in the following sequence: (1) necrotic tissue inclusions and the presence of wound gum ribbons in the anastomosing calli, (2) necrotic cell areas present on the stock-scion junction, (3) large deposits of wound gum in the connective tissue region and (4) failure of callus formation on an injured portion of the stock or scion.

8. No discernible differences were observed in the rate of healing, in the morphology of the bud union and in the gross appearance of the budlings when current season's growth or shoots in their second year of development were used as the rootstock. Under the conditions of this experiment, no differences in the morphology of the bud graft union or plant performance were found between seedlings budded with indexed and nonindexed scions.

9. The general processes of development for the peach-western sand cherry bud graft are basically the same as for other plant material propagated in this manner. The events were (1) formation of necrotic cell areas over cut or torn tissue regions, (2) formation of callus from the uninjured cells adjacent to the wounded portion, (3) formation of callus in the stock-scion interface, (4) formation of a continuous cambium between scion and stock from resultant callus differntiation and (5) resumption of cambial activity, lignification and connection of fascular tissue.

10. Bud failure between the peach-western sand cherry graft combination may be the direct result of propagation technique, environmental conditions, inherent differences between graft components or the failure of either symbiont to function normally. Under the conditions prevalent in Iowa nurseries, incompatibility of peach on *Prunus besseyi* casts doubt on the suitability of this rootstock for dwarf peach tree propagation.

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DR. CLARKE: Is *Prunus besseyi* useful as a dwarfing rootstock for peach or just what is the interest there?

DR. MAHLSTEDE: In our part of the country the nurseries are using primarily two stocks, namely, *Prunus tomentosa* and *besseyi*. Neither is entirely satisfactory for dwarfing peach. Nurserymen are using them but they are not satisfied with the performance of these stocks in the nursery. When you are talking stands of sixty or seventy per cent salable trees, you are talking money.

DR. AL ROBERTS: Karl Brase at Geneva, New York, has worked with *P. besseyi* and has suggested that some of the *besseyi* types are sufficiently compatible with peach but they need to be selected and propagated as clones.

We have work under way using the Wild Pacific plum, *Prunus subcordata* as a dwarfing interstock for peach. Twenty years ago, we selected a number of types of this species from native thickets in Southern Oregon. We propagated these on a number of stocks: peach, *P. americana,* Myrobalan and Marianna. It is compatible with all these plums. Gordon Kershaw of Medford, Oregon, suggested we test this wild plum as a dwarfing stock for peach. We ran into considerable difficulty when trying to transplant seedlings of *P. subcordata* from the wild or even seedlings grown in nursery row. It has an unbranched taproot and suckers badly even if successfully transplanted. We, therefore, decided to use 12-inch stem-pieces of the wild plum as dwarfing interstock between Lovell peach, Myrobalan and *P. americana* as roots and certain peach varieties as scions. This test has been on a limited scale, but it is amazing how compatible these combinations have been. A combination consisting of Lovell roots with a 12-inch stempiece of *P. subcordata* with Redhaven or Improved Elberta as scions has given us a half-standard tree that is thrifty and early bearing. We have obtained varying degrees of dwarfing depending on the wild plum selection used. The one that looks most promising as a dwarfing interstock for peach is a selection we call Klamath I, a very small growing tree in the wild. We are considering such dwarf peach tree as possible units in hedgerows for mechanization.

DR. DALE KESTER: What experience have you had in overcoming incompatibility by double budding? The reason I ask is that I have seen different experiences or opinions in the literature whether it works or not.

DR. MAHLSTEDE: This technique, as you know, was described by Nicolierin in Germany about the same time Garner came out with his doubleshield method of budding. The techniques are essentially the same. We haven't run comparisons long enough to tell much about either technique. We've worked specificaly with apple using this intershield in dwarfing combinations. Clark Dwarf, being used as the intermediate originally was a fairly good dwarfing understock or inter-stock in our part of the country. Lately, however, it has proven to be either virus infected or having some other problem evidenced by stem cracking. Our thought here is that if we use a budless shield as an interstock that it will be eventually covered up. If it does the job, we are ahead of the game so far as dwarf production is concerned.

DR. ROBERTS: Along this line, I think it is important that we consider early work in England and a recent study in Germany with pear on quince, with various compatibility bridges. The response to interstocks whether used as compatibility bridges or as dwarfing stempieces seems to be influenced by the length of the insert. I think this has been overlooked by many of us. Some of our work and certainly that in England and Germany shows the length of the bridge to have a pronounced influence on the thriftiness of the combination and early flowering. We have a five-year old block of Starking and Golden Delicious apples with 3, 6 and 12 inch stempieces of Malling IX (dwarf) with Malling XVI (very vigorous) as roots. There is little difference in the size of these trees; if any, the longer stempieces have given us larger trees, but there is a great difference in flowering habit. In the early years the longer stempieces have given us more bloom.

III. Difficult to Root, General Ornamentals

MODERATOR: Mr. William Tomlinson

THE PROPAGATION OF DECIDUOUS AZALEAS FROM CUTTINGS

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Golden Gate Park, San Francisco, California

Today's discussion deals primarily with the propagation of Knaphill Azaleas Exbury strain, although I am sure the techniques described would prove successful with other deciduous azales. As a preface, it might be of interest to review the background of this particular strain.