Down here in the front row are some of my best friends, good nurserymen in this region, progressive men who are growing new types of plant materials, and who have problems. I think in a meeting of this sort you will discover that you can take your hair down and as one of us advances we all advance. Let's give as much as we can to this meeting, with the hope of getting out of it just as much as we can. For Mr. Scanlon and for myself and for the horticulturists of Cleveland, I would like to say we are very happy to have you all here today. We hope this will be even more successful than the two previous conferences. Thank you very much. (Applause)

PRESIDENT WELLS: Thank you, Mr. Davis, thank you very much. I am sure all of us here are determined to do just that.

A little later in the afternoon we will give you some information about this evening meeting, but before that, we have a paper which I think is going to be of real interest and of fundamental value to us all.

One of the aims of this Society, which is only just beginning to take shape, is to interest speakers in what might be called scientific papers and information obtained from scientific sources with downright practical knowledge obtained from the members who in the final analysis have to apply the scientific knowledge to their day-by day work.

We want to try to present a balanced diet of both types of papers. Roger U. Swingle of the United States Department of Agriculture, will present the first paper. Mr. Swingle is a rather quiet and unassuming sort of person and I feel quite sure that tucked underneath his quiet, smiling countenance there is a tremendous fund of really fundamental knowledge of plants which we all need. We hope and believe that he will present something which will make all that follows a little more clear to us.

Roger U. Swingle presented his paper on "Some Facts and Theories Concerning Compatibility in Relation to Plant Propagation." (Applause)

Some Facts and Theories Concerning Compatibility In Relation to Plant Propagation

ROGER U. SWINGLE, Senior Pathologist
Agricultural Research Service
United States Department of Agriculture

The essential role of compatibility in plant propagation by graftage and seed production has been recognized for many years. Its importance is reflected by the numerous reports in plant science literature on incompatibilities or uncongenialities and their effects on plant production and utilization. It has been possible for me to review only a very small part of the literature dealing with this subject but I have attempted to include more recently published reviews and articles in order that some of the basic aspects of incompatibility could be presented.

Incompatibility as applied to aspects of plant propagation has been variously defined. The term itself means "not capable of coexistence in harmony," "lacking affinity," "intolerant" or "antagonistic." Argles (1), in his review of literature on graft incompatibility, considers it to be an inherent antagonism between certain stocks and scions, the cause or causes of failure or abnormalities arising out of the nature of the two plants. He believes that the form or type of failure is governed or influenced by environment and treatment. However, incompatibility should not be applied to failures that are caused by environment or treatment. Bradford and Sitton (3), in an excellent paper on defective graft unions, characterize incompatible unions as those in which there is failure to maintain cambium continuity. Roberts (10), in a review of some of the theoretical aspects of graftage, states that "Compatibility refers to the long-time success of a graft for economic, esthetic or scientific purposes. Anything less is incompatibility." This broader concept considers compatibility as any influence between stock and scion and not merely effects arising directly from the union

Compatibilities affecting seed production or hybridization are of equal or possibly greater importance than their effect on graftage. Incompatibility in such cases affects phases of the normal reproduction processes. It is a common cause of self- or cross-sterility and may offer a natural "curb" on either inbreeding or outbreeding. Although frequently being an exasperating hindrance to the desires and objectives of the plant breeder it provides stability of species.

Incompatibility in Relation to Seed Production

Incompatibility in relation to hybridization and seed production has received considerable study, especially in the fields of food and forage crops. Some workers have applied the term "incompatibility" only to failures of functional gametes to achieve union or fertilization. Others consider incompatibility to include post-fertilization failure of the embryo or endosperm to develop in a normal manner.

Many flowering plants will not produce seed when self-pollinated. However, viable seed is produced from reciprocal crosses with other plants, showing that both pollen and egg cells are functional. Also, some plants produce seed when crossed in certain combinations but not in others. Such cases of self- and cross-sterility are commonly caused by incompatibility between pollen and pistil.

Incompatibility may occur between pollen and stigma of the pistil, resulting in failure of pollen to germinate or the pollen tube to penetrate the stigmatic surface. With other plants incompatibility may occur between pollen tube and tissues of the style. In this case the pollen tube may either disintegrate after penetration of the style for varying distances or growth of the tube may be so greatly retarded that the egg cells or ovules disintegrate before fertilization can be accomplished In still other combinations, fertilization may occur only to be followed by degeneration and disintegration of the immature embryos. Finally, a mature embryo may be formed but fail to survive unless artificially cultured because of failure of endosperm development.

Numerous investigations have been made on the basic cause of incompatibility. These have shown that hereditary factors are commonly involved: the plant chromosomes carry genes that control compatibility or unfruitfulness. The incompatibility factors are variable in type. Sterility results only when similar types are brought together in hybridization. Thus, if a plant carries a factor or factors for incompatibility, the same factors occur in both pollen and female reproductive parts and incompatibility results from attempted self-fertilization. Or incompatibility will result if this same plant is crossed with other varieties or species that carry the same incompatibility factors. Fruitfulness will result if the other variety or species lacks the factor for incompatibility or if the incompatibility factors are present but different in type. Similarly, a plant lacking in the sterility or incompatibility factor will be fruitful when self-pollinated if proper conditions are provided.

The subject of incompatibility is a complex one and is far from being completely understood. Enzymatic disturbances, differences in chromosome numbers and types, or chemical and mechanical alterations or differences may be involved.

Of primary importance to the plant propagator are the facts that incompatibility is common among the flowering plants and that the degree of expression of incompatibility varies both within and between species. Self-incompatibility has been estimated to occur in over 3,000 species and 20 families of plants. Also of primary importance to this group is the fact that no satisfactory method has been found for predicting these incompatible relationships. Experience is the only method by which they can be determined.

Several hybridization techniques have proved useful in overcoming incompatibilities. In some cases where the gametes are functional but incompatibility prevents pollen germination or pollen tube penetration of the stigma, removal of the incompatible surface of the stigma with a sharp razor-blade and pollination of the cut surface has resulted in successful seed production.

In some cases of incompatibility in which growth of the pollen tube is retarded in the style, seed production has been obtained by "bud" pollination. This involves opening the buds and applying pollen to the immature stigma. The time thus gained between application of pollen and normal deterioration and abscission of flowers sometimes allows the slower growing pollen tube to reach the ovules and effect fertilization.

Lewis (9) reports that, in general, use of growth hormones has failed to decrease incompatibility and increase viable seed set. However, Emsweller and Stuart (6) obtained seed set in incompatible crosses of *Lilium longiflorum* by use of 1% naphthalene acetamide at the time of pollination. The hormone was effective when applied at the base of the ovary, at a wound made by breaking or removing a petal. The treatment delayed abscission and stimulated growth. The commercially available "fruit set" hormones may be useful in this respect.

If apparently mature embryos develop but failures occur at the time of germination, dissection and removal of the embryo and its incubation on synthetic culture media may give successful seedling production. Considerable success has been achieved in the culturing of dissected plant tissues in artificial media (13, 14) and further trials with this technique would be of value. Attempted artificial culturing of immature female reproductive parts and pollination under such controlled conditions might be a useful technique in some difficult hybridization problems.

Incompatibility and Graftage

The problem of incompatibility as it concerns budding and grafting was recognized centuries ago. Chang (4) cites a Chinese publication in the year A.D. 500, which states that the pear *Pyrus serotina* is best suited on *Pyrus phaeocarpa* and that, in peach-plum combinations, the plum can be successfully grafted on peach whereas the peach usually fails to grow on plum stocks. A general rule or conception is that incompatibility can be expected in attempted combinations between taxonomically unrelated plants and that related plants, and especially ones of very close relationship, can be combined into a satisfactory composite plant without difficulty. Although this conception seems to offer the best basis for trial in new combinations, experience has demonstrated that this concept is not always reliable. Successful graft combinations have been made of commercial citrus varieties on trifoliate orange (*Citrus* sp. x *Poncirus*), lilac on privet (*Syringa* x *Ligustrum*), English walnut on Chinese wingnut (*Juglans* x *Pterocarya*) and many others that are not considered to be closely related. On the other hand, unsuccessful grafting results are frequently obtained from attempted combination of closely related plants, incompatibility occurring between varieties or strains of the same species. A few of the many examples that might be given concern the apple, pear, plum, grape, chestnut, white pine and holly. Heppner and McCallum (8) report that all varieties of peaches seem to show a strong affinity for both almond and apricot stock but apricots of all varieties seem to be a failure on almond. Adding further confusion to attempted prediction of successful graft combinations are reports in which two varieties have proved to be highly successful in one combination but their reciprocal combination has been highly incompatible.

Symptoms of inherent incompatibility in acute cases are failure of stock to unite with the bud or scion. In less acute to chronic cases, the bud or scion may unite with the stock but the bud may remain inactive, or bud or scion growth may occur with varying degrees of vigor only to decline and die after a few weeks, months, or years. In addition, the wide range of chronic or delayed incompatibility symptoms may include the common swelling or fracturing at the point of union, dwarfing of root or top, windthrow, a reduction in quantity and quality of fruit, and changes in resistance to climatic conditions.

A number of reports have been published concerning the growth aspects involved in graft incompatibility and theories concerning their cause. Since wounding and healing are the basic processes involved in graft union, healing and growth processes involved in recovery from different types of wounds have been studied and compared with those occurring in incompatible grafts.

Crafts (5), in a study of graft unions in *Nicotiana,* found that following wounding callus tissue was formed from the parenchyma of pith, phloem, xylem and cortex. This parenchymatous tissue is the first tissue to become united. Vascular strands were differentiated from the callus parenchyma and connected stock and scion within five days. Cambium arose within these strands and by lateral extension a complete continuous layer was formed to bridge the cambium of stock and scion.

Bradford and Sitton (3) reported that in simple wounds or those involved in compatible grafts, parenchymatous or callus tissue is formed first and becomes united by the intermingling or interlocking of cells at the interface. Tracheids, vessels and fibers appear in the bridge of parenchymatous tissue and soon establish continuity with those of stock and scion. If the fit of stock and scion is close, the parenchymatous zone is of limited extent and gradually disappears. The presence of parenchyma in the graft union was not found to be a sign of a weak or incompatible union unless the amount was excessive and union of callus or development of other tissues was arrested. The exactness of fit between stock and scion was found to be the chief factor underlying the union process but, within certain limits, the troubles arising from poor fit were gradually overcome.

Bradford and Sitton (3) also studied incompatible bud and cleft grafts of pear on apple and pear on quince in an attempt to determine the underlying processes involved in decline from incompatible unions. In some cases involving budding, good union occurred at the margins of the bud shield but there was no union, even of parenchymatous tissue from scion and stock, under the shield. This may explain why some buds fail to develop into active vegetative growth although good union appears to have been obtained. The incompatible reactions of bud and cleft grafts were similar, varying primarily in degree of intensity. In general, good union occurred at first, the interfaces being bridged by parenchymatous and vascular tissue. Later, breaks between scion and stock occurred along the line of union. New growth sometimes produced a rebridging of these breaks, amounting to a series of regrafts. Separations continued to occur with less frequent rebridging, tending to produce a more or less continuous line of separation. Tissues were distorted and cambium and vascular continuity was broken. Failure of continuity was often even more pronounced in the bark than in the wood.

Armstrong and Brison (2) have reported similar observations in a report on delayed incompatibility of a live oak-post oak graft union in which live oak scions were set by cleft grafts into two-inch limbs. Only one of four attempted grafts grew but this one made apparently normal growth for sixteen years. Between sixteen and nineteen years, the live oak top declined rapidly and a detailed examination was made of the union. Breaks began to occur at the union between stock and scion about 6 or 7 years after the graft had been applied. Some separations reunited as growth continued but the process did not occur readily and finally the graft union was girdled despite close contact and even alignment of cambial layers. There was no evidence of abnormal swelling at the union, and a point of interest to plant propagators should be that sixteen years passed before there were any visible external signs of deterioration from this incompatible union. Moreover, this case is not unique; graft failure on chestnut and walnut has occurred twenty or more years from the time of grafting.

Chang (4), in his study of incompatible unions of pear, apple, quince, plum, peach and cherry, found that separations between stock and scion may develop in either the bark or the wood or in both the bark and the wood. Similar observations have been made by other workers to support one definition of incompatibility as the failure to maintain cambium and therefore conductive continuity. However, in cases of acute incompatibility in which initial union is weak or fails to develop, lack of affinity or antagonism between parenchymatous or callus tissue of scion and stock seems to be involved prior to any initiation of true cambium or vascular tissue.

The possible varied mechanisms involved in incompatibility reactions other than complete failure and death of vegetative growth are more elusive and difficult to determine. A number of reports have been made of the effect of varied rootstocks on clonal scions. For example, variation in rootstocks have been reported to have a pronounced effect on pollen fertility of citrus scions, on mineral content of fruit and foliage of tung and citrus, on shedding of flowers and fruit of persimmon, on susceptibility to disease, on vigor, and on other aspects of growth. Such variations, since they concerned clonal scions on varied rootstocks, may involve incompatibility.

The underlying or basic causes of graft incompatibility are still theoretical and primarily concern differences in physiological or anatomical characteristics of scion and stock. A lack of synchronization in growth processes may be a cause of graft separation and failure. Early cambium activity or tissue differentiation and expansion in one component of the graft union when the other component is dormant or more retarded may create breakage and planes of separation leading to structural weakness and disrupted translocation. This conception has led to several suggested means of determining possible compatible combinations. The suggestions have concerned comparison of the plants to be united in respect to the time of spring foliation, the time of spring cambial activity, or the differences in growth rates or curves. Such methods have not proved to be reliable in practice, and as in incompatibilities affecting sexual propagation, the only successful guide is actual experience. Other theories on causes of incompatibility concern differences between scion and stock in vigor, enzymes or hormones, protein specificity, permeability and the presence of toxins. Climatic conditions also have been suggested as playing a possible role in incompatibility since some graft combinations constantly failed or have proved to be unsatisfactory in some geographical areas but quite satisfactory in others. It is possible in this case and others, however, that factors other than inherent incompatibility are involved.

Needless to say all graft failures or unsatisfactory performance of composite plants during subsequent growth are not due to incompatibility. Suspected incompatibility in a number of fruit tree grafts was found by Bradford and Sitton (3) to be caused by mechanical faults in the grafting technique. In cleft and bark inlay grafts a common fault was insufficient pressure from the graft tie to prevent pushing apart of the stock and scion and consequent failure of the calli to unite. In bridge and cleft grafts the scion was frequently set too deep, the bark of the scion preventing union between scion and the top of the stock. Swelling and abnormal growth at the union were not signs of incompatibility; the most uncongenial combinations produced no swelling. Swelling was frequently caused by poor fit, by failure to remove the graft tie when of material that did not deteriorate to prevent girdling, and by setting the scion in cleft grafts at an excessive outward tilt. In the last, union occurred only at the base of the scion and none at the upper rim of the stock which resulted in swelling and failure to heal over the stub. Tilting of the scion in an attempt to obtain cambium contact between scion and stock is not a good practice, the most important consideration in cleft grafts is to secure good cambial alignment at the top of the stock.

Several reported or suspected cases of incompatibility have been proved upon further investigation to be caused by infectious diseases U.S.D.A. 227, an apple rootstock of Northern Spy origin, was reported from several sources as being incompatible with a number of apple varieties. Weeks (12) and Gardner, Marth, and Magness (7) demonstrated, however, that the suspected incompatibility was due to a virus. The virus was nonlethal to most apple varieties but lethal to this rootstock. Apparent cases of incompatibility were produced when virus-carrying scions were placed on the susceptible rootstock. Tristeza or quick decline of citrus is another and similar example of pseudo-incompatibility produced by virus infection (11). The disease appears when sweet orange and certain other virus-carrying but tolerant citrus varieties are grafted on the sour orange, which is susceptible.

Means by which incompatibility between scion and stock of a desired combination may be overcome involves "double working." Bridging the desired scion and stock with an intermediate piece consisting of a variety that is compatible with both is a common practice. Although the practice is commonly used, it is questionable whether adequate consideration is always given to the influence of the intermediate piece on scion or rootstock and the diverse delayed incompatibility reactions that may be produced. The other alternative in propagating highly and generally incompatible material is the production of own-rooted stock from vegetative cuttings. In this connection, the incompatible "nurse-root" method for obtaining own-rooted plants should be mentioned. Material that is difficult to root is sometimes grafted to an incompatible root-piece and then planted rather deeply in the rooting material. The incompatible root-piece provides sufficient temporary support to the scion for scion roots to be produced before the graft union deteriorates.

Conclusion

Despite the possible confusion engendered by this presentation on the subject of incompatibility, some of its aspects and implications are worthy of emphasis. The plant propagator should be constantly aware that incompatibilities do exist and may seriously affect attempted propagation by either sexual or asexual methods. These adverse effects may be immediate or delayed for weeks, months, or a considerable number of years.

The immediate effects are probably of least concern since they are pronounced and occur in the plant propagator's domain. The craftsmanship of the propagator is immediately challenged, either by the problem itself or by the propagator's employer, and a serious effort is usually made to determine the cause of failure and methods by which it may be overcome. On the other hand, the delayed failures or unsatisfactory performance of the finished stock at some period during utilization may receive little or ineffectual attention. The latter should be of equal concern to the plant propagator and the sphere of his interest should not end with the production of lining-out stock or even attractive, vigorous-appearing stock of saleable size.

Incompatibility may be the basic cause of varied types of propagation failure or unsatisfactory plant performance. However, it is but one possible cause and it should not be ignored or overemphasized when propagation problems arise. The propagator's skill, knowledge and initiative are also involved

Compatible combinations in hybridizing and graftage can be predicted only on the basis of experience. But relatively little guidance is provided by any one textbook or other publication to insure compatible relationships. Many successful and unsuccessful experiences have not been recorded and the best source of information concerning a specific problem may be through the free discussion and exchange of information which has been made a requirement for membership in your Plant Propagators Society.

LITERATURE CITED

1. ARGLES, G. K. 1937. A review of the literature on stock-scion incompatibility in fruit trees, with particular reference to pome and stone fruits. *Imp Bur. Fruit Prod , East Malling, Tech. Commun* 9: 5-115.
2. ARMSTRONG, W. D. and F R. BRISON. 1949. Delayed incompatibility of a live oak-post oak graft union. *Proc. Amer. Soc. Hort. Sci* 53:543-545.
3. BRADFORD, F. C. and B. G. SITTON. 1929. Defective graft unions in the apple and the pear. *Mich. Agr. Expt Sta. Tech Bull* 99.
4. CHANG, W. T. 1938. Studies in incompatibility between stock and scion, with special reference to certain deciduous fruit trees. *Jour. Pomol. and Hort. Sci.* 15: 267-325.

5. CRAFTS, A. S. 1934. Phloem anatomy in two species of *Nicotiana*, with notes on the interspecific graft union. *Bot. Gaz.* 95: 592-608.

6. EMSWELLER, S L. and N. W. STUART. 1948. Use of growth regulating substances to overcome incompatibilities in *Lilium*. *Proc. Amer. Soc. Hort. Sci.* 51: 581-589.

7. GARDNER, F. E., P. C. MARTH and J. R MAGNESS. 1946. Lethal effects of certain apple scions on Spy 227 stock. *Proc Am. Soc. Hort. Sci.* 48: 195-199.

8. HEPPNER, M. J. and R. D. McCALLUM. 1927. Compatible and non-compatible graft unions. *Proc. Am. Hort. Sci.* 24: 137-138.

9. LEWIS, D. 1949. Incompatibility in flowering plants. *Biol. Rev.* 24: 472-496.

10. ROBERTS, R. H 1949. Theoretical aspects of graftage. *Bot. Rev.* 15: 423-463.

11. WEBBER, J. J. 1943. The "tristeza" disease of sour orange rootstock. *Proc. Am. Soc. Hort. Sci.* 43: 160-168.

12. WEEKS, W. D. 1948. Further scion and stock combinations with Spy 227. *Proc. Am. Soc. Hort. Sci.* 52: 137-140.

13. WHITE, P. R. 1943. A handbook of plant tissue culture. Jacques Cattel Press, Lancaster, Pennsylvania, 277 p.

14. WHITE, P. R. 1946. Plant tissue culture II. *Bot. Rev.* 12: 521-529.

* * * *

PRESIDENT WELLS: Thank you very much, Roger, for the excellent discussion of the role of Compatibility in Plant Propagation. Following the established custom of our meetings, we are now ready for questions on Roger Swingle's paper.

MR. RICHARD H. FILLMORE (Lakes Shenandoah Nurseries, Shenandoah, Iowa): Do you favor Robert's more broad concept of incompatibility or the concept of Bradford and Sitton, and others?

MR. SWINGLE: Personally I prefer the broader concept. In some cases, the only effect of incompatibility is plant sterility. To the plant hybridizer, sterility is as serious a problem as graft breakage or other types of failure.

PRESIDENT WELLS. In connection with the comments about the pressure necessary to insure a good union, which I believe concerned the grafting of fruit trees, how important is it in the more detailed grafting of conifers or the smaller material that many of us work with in greenhouses?

MR. SWINGLE: I think it is of utmost importance. Of course, the point I wished to make was that all failures are not due to incompatibility. In this case, graft failure was due to faults in grafting technique and not due to incompatibility. I know in our own narrow field of propagation one of our troubles has been in getting the men to make the proper tie. In the budding procedure, if the tips of the bud shield are not covered or crossed by the tie a high percentage of failures result. I think it is very important on all types of grafts. Also, it is important to examine the grafted stock frequently and make sure the tie is removed at the proper time.

PRESIDENT WELLS: With regard to the question of materials used for tying, of which there seems to be a great number—budding strips, wax twine, adhesive tape, etc.—do you have any preference?

MR. SWINGLE: We prefer the rubber strips on small stock. However, we watch those very carefully because we have found you cannot depend on them to deteriorate at the proper time. On the other hand, for grafting large stock we use twine and create a lot of pressure at the graft. We get good grafts that way, whereas the grafts fail if we don't have sufficient pressure. The twine tie must be watched and cut to prevent injury from girdling.

MR JAMES ILGENFRITZ (Ilgenfritz Nurseries, Inc., Monroe, Michigan): I understand the propagation of fruit trees by grafting and budding is probably 400 years old, more or less. Throughout this period has there been any compilation of compatibility information having to do with varieties of fruit trees and various kinds of stocks, particularly the Malling stocks?

MR. SWINGLE: There is information scattered throughout the literature. The best compilation I have found is in the article by Argles that I have cited in the paper that has been presented. It is primarily on the different fruit varieties. When you get into miscellaneous nursery stock, I don't know of any place to go for that.

DR. W. E. SNYDER (Cornell University, Ithaca, N.Y.): There is a classical example of incompatibility caused by faulty grafting of a coniferous tree from Norwich, New York. The tree reached a height of about 25 feet. One morning the cemetery caretaker noticed that the tree was down. It looked like vandalism because the place of severance was as smooth as a table top, however, there was no sawdust around. A detailed examination showed, first, that incompatibility existed; second, that the cut had been made three-fourths of the way through the understock, and third, that the graft was not tied tightly. Thus, incompatibility and faulty technique can sometimes be determined as much as 25 years after you have done the work.

PRESIDENT WELLS: I have one or two other questions. The first one is: Is it serious if in the course of the union of stock and scion external material, such as bark, is enclosed in the callus tissue which may cover the wound? The second one is: Has any work been done in the treating of scions by any of the hormones to overcome incompatibility, if incompatibility in this instance might be due to faulty union of the tissues?

MR. SWINGLE: Concerning the first question, foreign material between the graft inner faces might prevent close contact of the faces. The closer contact you have between faces, the better chance you have of good union. Also, if foreign materials are present, you open up the possibility of disease conditions developing. We always try to get as clean a surface as we possibly can.

On the use of materials to overcome incompatibility, I don't know of any work that has been done along that line, at least with any success. I believe some work has been done with some of the growth hormones to try to stimulate healing. I don't believe they have worked out satisfactorily—not to my knowledge, anyway.

MR. JACK HILL (D. Hill Nursery, Dundee, Ill.): I wonder about this question of removal of the tie in the case of conifer grafts. Just when do you determine the optimum time for removing the tie, whether it be one of rubber grafting strip, of waxed twine, or tape?

MR. SWINGLE: When is the optimum time to remove the tie? I can't answer that. We try to watch the grafts carefully for compression of bark under the tie. If there is any evidence of the tie starting to girdle, we cut the tie. If a good union has not occurred, the graft is retied. We may do that two or three times, especially where we are grafting large stock and using heavy twine.

MR. MARTIN VAN HOF (Rhode Island Nursery, Newport, R. I.): I would like to ask about Malling stock No. IX. Can you give me any information on its compatibility with all varieties of apple?

MR. SWINGLE. I think that No. IX has been incompatible with certain combinations but somebody else may be better able to answer that question than I am. Dr. Chadwick may know more about it.

DR. L. C. CHADWICK (Ohio State University, Columbus, Ohio): I don't know that I have the answer to that question but this point might be mentioned. Talking with some of the men at the East Malling Station a little over a year ago, they wouldn't admit that there was any incompatibility with Malling No. IX. They claim the dwarfing is due to other factors and not incompatibility. I think some question could be raised about their interpretation about that, however, as it has been shown that you do get dwarfing as a result of incompatibility. Some recent work has indicated that the length of the Malling IX piece, if it is used as intermediate stem piece, influences the degree of dwarfing. In other words, if you used a 6-inch piece, you would get more dwarfing than if you used a two-inch piece of Malling IX.

MR. VAN HOF: You mean to say to plant your union above the ground?

DR. CHADWICK: In this case, that is right. The comment, of course, was on the use of Malling IX in the stem piece, which would be above the ground.

MR. VAN HOF: In reference to a slow-growing variety, would it be advisable to graft them on a more vigorous understock—Malling No. VII, for example?

DR. CHADWICK: If I get your interpretation right, you are thinking of increasing vigor on slow-growing varieties? I think, yes, it would definitely be true that you would get more vigorous top produced on a Malling VII than on Malling IX.

MR. VAN HOF. Would it lose dwarfing?

DR. CHADWICK: Different Malling stocks produce various degrees of dwarfing. Malling VII will not give you as intensive a dwarfing as No. IX.

MR. A. M. SHAMMARELLO (South Euclid, Ohio): I would like to ask is it compatibility or incompatibility when a lilac grafted on privet won't grow on its own roots? For instance, we have difficulty with white lilacs.

MR. SWINGLE: I wouldn't say that this is a case of incompatibility. I can see the possibility that incompatibility might influence rooting of a scion, but I would question whether incompatibility is concerned in this case. In our propagation work, cuttings of certain elm selections or strains have failed to root. We don't know why and have covered up our ignorance by saying they are inherently difficult to root. Factors other than incompatibility are probably involved. Can you root the lilac any other way?

MR. SHAMMARELLO: Yes, you can root them by soft-wood cuttings, but we usually graft on privet. The blue and purple varieties immediately succer and root. The white ones make a big knob at the base and they don't grow on their own roots.

MR. SWINGLE: I doubt that incompatibility is concerned. I, personally, would suspect some other condition.

MR. HARVEY GRAY (Long Island Agricultural Technical Institute, Farmingdale, N. Y.): I would like to raise the question relative to this business of tying. It has been my observation that wax twine is often bound so that there is no space between one cord and the next. There seems to be some conviction that if there is a slight space between one strand and the next the union develops more readily than with the tight construction. I wonder if that is an observation of Mr. Swingle?

MR. SWINGLE: I haven't made any specific observations along that line. A number of years ago it was common to wax over the ties and I think it may have been a bad practice. Possibly oxygen relationships are involved. We get much poorer results than if we don't use wax and exclude the air. This was primarily on elm propagation. It may vary with different plants.

PRESIDENT WELLS: If there are no other questions at this time, I think we should proceed to the next part of the program. There will be opportunity to ask further questions of Roger during some of the open sessions.

At this time, I would like to ask Bill Snyder to tell us about the Plant

Propagation Question Box which he has arranged for the session for Friday night.

DR. SNYDER: Since it is quite probable that there will not be sufficient time for all of the speaker-exhibitors this afternoon, this evening's session will be used to complete this section of our meetings. The exhibits will be displayed during the entire meeting so that each of you will have an opportunity to examine them at your convenience.

Last year I spent considerable time asking various members about germination and growth of a particular plant. I am certain that many of you did the same. This year, for the first time, there has been arranged a special session at which specific questions, not concerned with the topics to be covered in the various round-tables, can be asked. This session has been called the Plant Propagator's Question Box and is scheduled for Friday evening. If you have questions about plant propagation which you want answered, write the question on a card and place it in the Question Box at the rear of the room. Ask any question about propagation you want, except those relating to the panel topics. If you desire a specific person to answer the question, indicate this on the card also. The success of the Question Box requires your cooperation both by submitting the question and by being present to answer the questions of other members.

PRESIDENT WELLS: Thank you, Bill. Let's fill the box with good questions.

We now come to something new. Last year, as always when a group of plant men get together, a few people brought along some plants tucked underneath the bed in their room and people went around looking at them. We realized then that we should organize and direct that interest with proper exhibits and brief discussions Dick Fillmore was asked to organize a speaker-exhibitor session. Those of you who know Dick will realize how careful and methodical he is in work of this kind. From what we see around the room, the choice of Dick was an excellent one. Without more ado, I will turn the meeting over to him.

Mr. Richard H. Fillmore took the chair.

CHAIRMAN FILLMORE: It certainly has been a pleasure during the past several months to correspond with the large group of persons who have furnished exhibit materials for this meeting.

We are going to have ten speaker-exhibitors, each of whom will briefly discuss his exhibit. In addition, there are some twelve or fifteen persons who have set up other exhibits. You may, of course, ask questions concerning them, both directly to the persons who set up the exhibits and indirectly during one of the question periods which have been provided during the meeting.

We probably won't have time to finish the group of ten speaker-exhibitors this afternoon, but those who do not have an opportunity to speak this afternoon will speak this evening. In general, we are going to allow twelve minutes for each speaker-exhibitor: a couple of minutes for an introduction, about seven minutes for the discussion, and two or three minutes for questions. We should like to keep this session exactly on time.

The first discussion is concerned with budding. The first speaker is Mr. William Flemer of the Princeton Nurseries, Princeton, N. J. Mr. Flemer is a graduate of Yale University and, together with his father and brothers, is associated with one of the finest ornamental nurseries in the United States. Mr. Flemer will speak on the propagation of the American elm by budding.

MR. WILLIAM FLEMER, III: Thank you, Mr. Fillmore, and good afternoon.

Before I start the discussion of budding American elm, I should like to comment briefly on the question of compatibility. May I ask the committee which prepares our Proceedings whether it wouldn't be a good idea to have perhaps one sheet in the back of the Proceedings on which experimentally-minded growers might record their experiences with compatibility of understocks? I am thinking that we could set up a simple table in which there would be, for instance, a column for the scion, a column for the understock, and a column for a simple numerical key to indicate the degree of success for the particular graft. As a suggestion, the key might be. A for satisfactory growth; B, grows for a couple of years and then dies, C, grows briefly; and D, no evidence of a successful union. I think such a table might save a lot of experimentally-minded propagators from wasting time and effort and at some future date the information could be consolidated for the use of the members.

I might cite three examples in my own experience during the past five years. One is an attempt I made to bud Paul's Scarlet hawthorn on *Crataegus cordata* understock (Washington thorn), in which we got wonderful growth the first year, but signs of incompatibility the second year. During the third year, the trees reached a height of about five or six feet and died. Two other attempts were concerned with trying to find a better understock for the Japanese maple (*Acer palmatum*). We found that when *A. ginnala* and *A. buergerianum* were used as the understock, the scions grew actively for periods up to a month and then suddenly languished and died.

Mr. Flemer discussed the budding of the American elm. (Applause)

Budding the American Elm

WILLIAM FLEMER III
Princeton Nurseries, Princeton, New Jersey

Propagating American elms would seem, with the diseases which we have around, like propagating American chestnut from seed, but we at Princeton Nurseries haven't viewed it in that way. We have continued to grow elms and we have found that while we don't grow 40,000 or so annually as we used to do, we still grow between three and four thousand