is our last spring item and beside grafting fairly high 6-8″ off the ground, we found 2 and 3 year old wood has given best results, provided good buds are retained. While results with Fagus are only in the 25 — 30% success range, most of our other graftings are very successful, usually in the higher 80%.

Aesculus hippocastanum is used in the summer as soon as scions are available and are inserted on the side of the stock into a T cut, well waxed, and if carried out early enough so that enough callus is formed, very successful. Waxing and defoliating is a necessity. Not only the forms of *A. hippocastanum* such as *A. h. plena, A. h. carnea, A. h. brioti,* but also *A. h. parvifolia* can be propagated and much more successful than by budding.

After care of grafted plants consists of cutting off the raffia tie after the graft has knit well and shows signs of growth. Staking of too vigorously growing grafts to prevent blowing out by high winds, and where necessary, pinching for bushier growth are carried out. The wound covering is taken off on a cool day, when it does not stick.

MODERATOR CANNON: Our next paper, "Four Years of Nut Grafting Chestnut", will be presented by Dr. Richard A. Jaynes.

FOUR YEARS OF NUT GRAFTING CHESTNUT

RICHARD A. JAYNES AND GEORGE A. MESSNER[1]

Several clones of chestnut have been selected and named because of desirable characteristics of blight resistance, form, vigor, and nut bearing. Many of these, selected primarily for orchard traits, are Chinese chestnuts, e.g. Nanking, Orrin, and Crane; others, selected largely for ornamental or forest use are complex hybrids between the Chinese, Japanese, and American chestnut, e.g. Clapper, Sleeping Giant, C9. Unfortunately large scale propagation of these or other chestnut clones has never proven feasible in the United States. Spring grafting with dormant scions has met with limited and variable success. Budding has failed, and the rooting of cuttings by many methods has invariably met with complete or nearly complete failure.

In 1963, Moore (4) described before this group a promising method he called the nurse-seed graft. The technique involved the grafting of a dormant scion into a germinated nut from which the root and shoot had been removed. Substances in the cotyledons of the nut presumably stimulated root formation from the scion near the area of contact. In 1965 one of us reported (3) the results of 450 nurse-seed grafts of chestnut using several clones and seed sources. Although roots were readily formed they did not arise from the scion, but differentiated from the seed nut near the surface of the cut petioles. Since the nut is more than a "nurse" — it contributes the root

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system — the method is more appropriately called *nut grafting*. The potential advantages of the nut grafting technique include the following; large stock plants are not needed, grafting is done indoors, timing is not critical, and the technique is relatively simple. However, more experience was needed. The following is a summary of our successes and failures with nut grafting over the past four years.

Technique

The nut graft method used (3) is summarized in Figure 1. This technique differed from Moore's in that the nuts were at an earlier stage of germination; the epicotyl and secondary roots were generally not evident.

The first year all grafts were placed in a polyethylene enclosed propagating frame in a greenhouse and, though this was used for two additional years, we have also had three years experience with enclosed outdoor frames. Grafts were set in the greenhouse frame from January through June, and in the outdoor frame from March 27 to May 30. They were placed with the union about 1½ inches deep in a mix of 5 parts sphagnum peat moss to 2 parts coarse perlite or vermiculite. It was found that the grafts grew better in the mix containing vermiculite. The medium was kept at about 70° F; the air temperature fluctuated.

Grafts started in the greenhouse frame were moved shortly after rooting, usually within 1 to 2 months, whereas in the outdoor frames they were left in place for the full growing season. In the latter beds a 2 inch layer of sandy loam under the 4- to 5-inch layer of peat-vermiculite helped sustain growth. Under the loam was hardware cloth and electric cables, which in turn rested on sand and gravel. After rooting, light applications of complete fertilizer were added every 3 or 4 weeks until mid-August.

Time is important with any propagation method; we estimate that each graft takes approximately one minute to com-

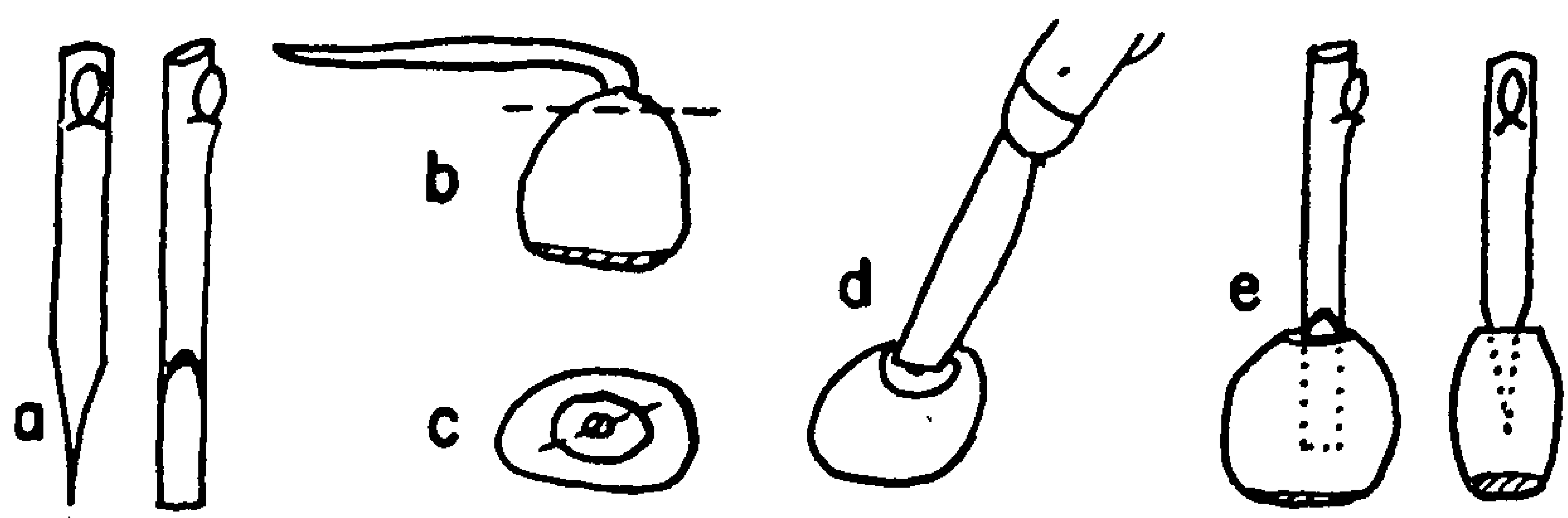

Figure 1 The nurse-seed graft A) Two views of scion prepared with wedge-shaped cut B) Germinating nut. Dashed line indicates cut that will remove root and shoot C) Shoot and root of nut removed Dashed line indicates where knife blade is inserted into nut through the petiole stubs D) Knife blade inserted in nut E) Two views of completed graft, scion inserted in nut (after Jaynes 1965)

plete. Thus, one man could graft approximately 500 nuts in a day, providing he did not have to keep track of many scion and nut sources.

Results

Over 5,600 nut grafts (Table 1) were made between 1964 and 1967 using numerous clones and nut sources. As previously reported, the time of grafting (from January to June) has little effect on success. Scions grafted in January and February broke dormancy more slowly than those grafted later. Root formation usually occurred within one month. Large nuts, about 10 grams, generally made better stocks than small nuts.

Fungicides and Growth Regulators

Prior to grafting, scions and nuts were dipped in a 0.06% w/v solution (1 tsp/gal) of 8-hydroxyquinolin sulfate to inhibit fungal contaminants. A test with this substance the first year indicated there was no harmful effect on the grafts; however, some decay of young grafts still occurred. To counteract this another fungicide was tried. A heavy suspension of thiram (Arasan 75) was sprayed around the union of 40 completed grafts before placing them in the frame. Compared to an equal number of untreated grafts, survival was reduced 22%, from 68% down to 46%. Thus the use of Arasan was discontinued.

In another test 0.8% indolebutyric acid (Hormodin Powder No. 3) was applied to the union of 20 grafts. Survival after two months was 80% as compared to 74% for 19 control grafts. A mixture of indolebutyric acid, naphthaleneacetic acid and thiram (Rootone F) was similarly tested on 2,200 grafts. Survival of the treated grafts was slightly better than the controls, 38% versus 34%. Thus it appears that the application of growth regulators might be beneficial.

Table 1 Nut graft survival

Location of frame	Year	Number of grafts	Number with roots	Percent survival
Greenhouse	1964	469	246[1]	50
Greenhouse	1965	439	211[2]	48
Greenhouse	1966	283	164[1]	58
Outside	1965	862	185[3]	22
Outside	1966	2331	859[1]	37
Outside	1967	1300	[4]	—

[1]Recorded 1-2 months after grafting

[2]Recorded 2 months after grafting

[3]Recorded 6-9 months after grafting

[4]Not tabulated, but results poor due to adverse conditions developing in frame during callus and root formation

Outdoor Frame

Three years experience using an enclosed, heated, outdoor bed demonstrates that an outdoor frame can work as well as a bed in the greenhouse (Figure 2). For instance, of 378 grafts of the Nanking clone on Nanking nuts 48 percent were rooted and alive at the end of the first growing season. At that time they were up to 40 inches high and averaged 12 to 18 inches in height.

One of the reasons for the lower average of successful grafts in the outside frames was the difficulty in maintaining adequate temperature and humidity control. The humidity needs to be high, although a saturated atmosphere may not be necessary. Grafts in an open greenhouse bench were unsuccessful as were grafts in an enclosed but unheated outdoor bed. Poor results in one frame in 1967 were attributed partly to high and near lethal temperatures which inadvertently built up in spite of two layers of shade cloth. Maintenance of proper conditions is important during rooting as well as during the hardening off period immediately after rooting. The second cause for disappointing results in 1967 was attributed to poor scion wood. As with any grafting procedure the scion and stock material must be in excellent condition.

Compatibility

In a comparison of 30 grafts each of 9 hybrids, 7 of the 9 clones unexpectedly had higher survival on Chinese nuts than on their own respective nuts—for each hybrid 15 grafts were on Chinese (Hemming) nuts and 15 were on nuts of the respective hybrid. Other comparisons also indicate that species or hybrids do not necessarily graft best on their own nuts. Among the most successful combinations, e.g. 84% survival from 31 grafts after the first growing season, were Chinese-seguin hybrids on Chinese or Chinese-hybrid nuts. Hybrid clones with seguin parentage grafted better than other scion sources regardless of the nut source. In spite of the large number of combinations tested it is not possible to recommend specific scion-nut combinations.

Translocation of Root Promoting Substance

To test the theory that the nut might transmit a root promoting substance to the scion, 70 scions consisting of two different clones were grafted with the nut on top of the scion. The graft was made as described in Figure 1, except that the wedge-shaped cut was made just above a bud on the scion, and the nut was placed on top of the scion. The nut and upper portion of the scion were wrapped in aluminum foil. The base of the scion was cut on a slight slant and placed in the medium. It was hoped that a root inducing substance might be translocated from the nut, down to the base of the scion where it would accumulate and stimulate rooting. Good union and callus formation occurred between the nut and scion, but no roots formed on the scions. The results were the same in another trial where scions were grafted into the cotyledon tissue of nuts at points other than where the petioles emerge—none of the scions formed roots.

Transplanting and Field Survival

Transplanting of rooted grafts during the growing season was generally not practical because of transplanting "shock" and limited subsequent growth. An attempt to root grafts in individual paper containers to facilitate moving them was without notable success. Grafts started in an outdoor frame could be left in place for at least one full growing season; however, their survival through the first winter has been a problem. The scions appear to be highly susceptible to winter damage, and often have loose, split bark in the spring. This problem is not unique to nut grafts, but has been reported on grafts of citrus and other nut trees (1) when the graft union is low. Presumably the scion wood from a "mature" tree does not become conditioned to the extreme temperature fluctuations near the ground as readily as "juvenile" wood. Yet there is no doubt that these nut grafts can be over-wintered, for we

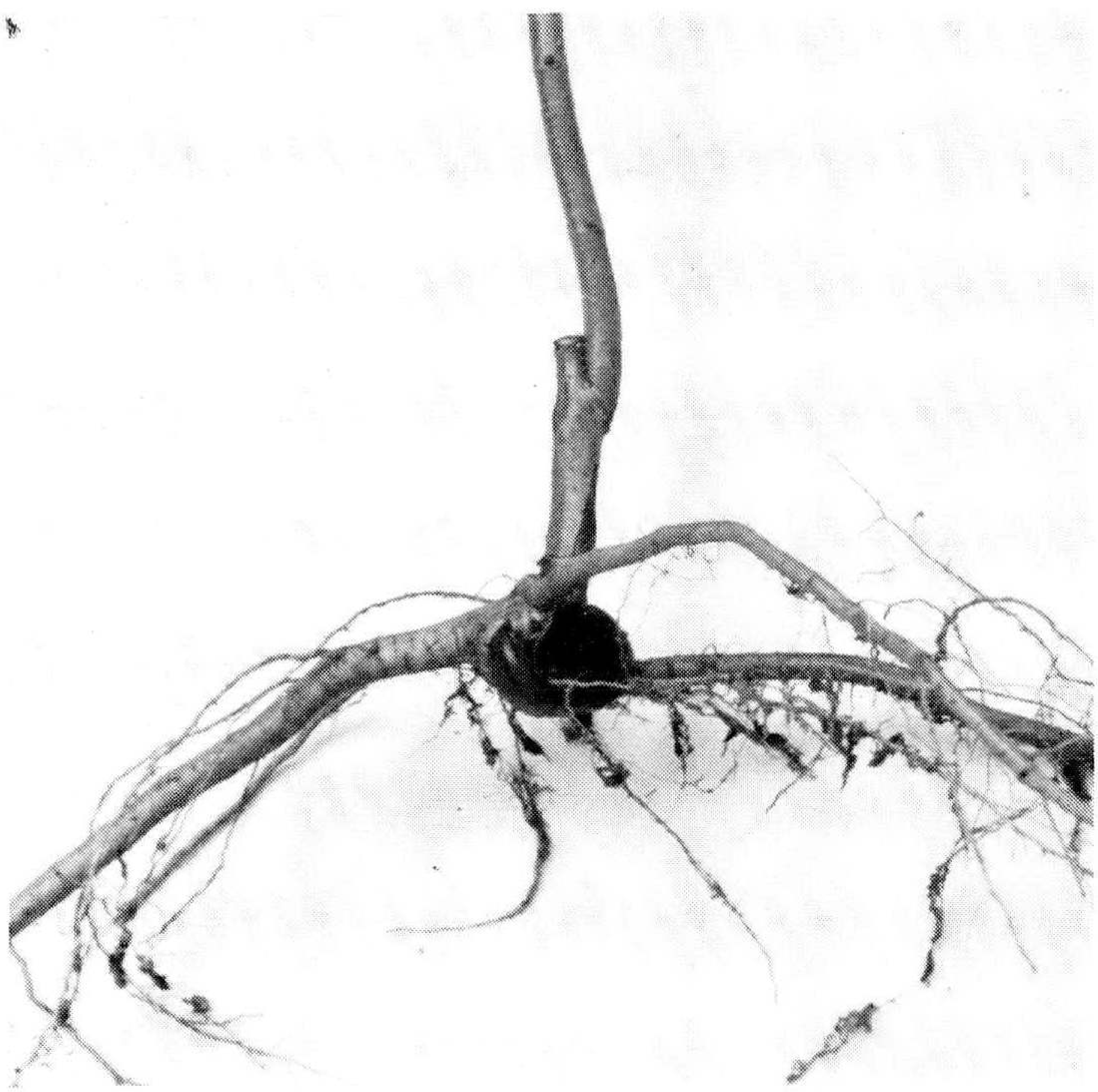

Figure 2. Nut graft of Crane variety of Chinese chestnut on a Heming nut at the end of the first growing season. Total height of shoot was 30 inches.

now have several of bearing age; but the percent surviving has been very low due to insufficient protection.

Rooting of Scions

In contrast to observations by Moore (4) and Goggans and Moore (1) no root formation on the scion proper has been observed on any of our grafts during the first growing season. Twenty-five 2-to 4-year old grafts were examined and only one of them had any roots from the scion.

Summary

Nut grafting has met with qualified success in enclosed, heated, outdoor frames. Survival of 45-80 percent has been obtained for several scion-nut combinations. A nut graft is a conventional graft made in an unconventional way. Roots arise from the stock nut, seldom from the scion. There is need for further refinement of conditions required for consistent success with the nut grafting technique. Young grafts are susceptible to winter injury and will require protection.

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MODERATOR CANNON: The program now calls for a discussion period of the three papers which you have just heard.

ROBERT FARMER: Have you tried the nut grafting on oak?

RICHARD JAYNES: We have tried the nut grafting on oak and have had very limited success. I know it can work, but I question its ultimate practicability.

JAMES WELLS: I would like to ask Mr. Girouard about the origin of a root from callus. I did not know that roots would originate in callus. We have often been told to remove a large amount of callus when it forms at the base of a cutting and I would like to know whether this is an advantage or a disadvantage?

RON GIROUARD: My experiences are limited to the adult form of the English ivy and to spruce, with which I am working now. For those two plants callus seems to be beneficial. What happens is a group of cells within a portion of the callus become meristematic. Then vascular tissues begin to grow out from the original stem and link up with the developing meristem.

DICK FILLMORE: I would like to ask Dr. Jaynes what tissues form the graft union in his nut-grafting technique?

RICHARD JAYNES: We obtain a union at both the cotyledon petioles or the extensor tissues which connect the cotyledons with the developing seedling and also directly with the cotyledonary tissue itself. The most rapid union formation and the place where the roots initiate is the cotyledon petioles or stubs which remain after the young seedling is cut away.

MARTIN VANHOF: I would like to ask Dr. Jaynes if he has planted the chestnuts and then grafted on the young seedlings during the normal growing season?

RICHARD JAYNES: Yes, we have tried that but have met with very varied degrees of success. We seem to have more success grafting and top working Chinese chestnut and in southern areas such as Georgia, and Maryland. However, in our area in Connecticut, we have not had good success. Conventional grafting has not proven feasible for any commercial nurseryman as yet.

MODERATOR CANNON: To start off the second portion of this morning's program we have Dr. Fred Lanphear who will speak on some new developments for weed control in transplant beds and field liners.

SOME NEW DEVELOPMENTS FOR WEED CONTROL IN TRANSPLANT BEDS & FIELD LINERS

F. O. LANPHEAR
Purdue University
Lafayette, Indiana

The problem of weed control in transplant beds and field liners cannot be adequately covered in a few minutes, but I would like to discuss some new concepts that are particularly relevant to the topic. Needless to say, the problem of weed control in nurseries is of great magnitude, particularly in relation to transplant beds. In fact, estimates of weed control cost have been as high as $6000/Acre/year for transplant beds where weeding was by hand. (1) Cost in field liners have ranged from $125.00 to $600.00/A/year with manual or mechanical means. It is imperative that these costs be reduced since the cost of manual labor is continuing to increase at a rapid rate. The appearance of herbicides on the scene provide some tremendous possibilities in solving this problem.

Basically, herbicides are plant poisons. Fortunately, they are selectively poisonous. This selectivity is based on a number of factors, including the ability of some plants to degrade the chemical or inactivate it in some way while others do not. One of the major factors in selectivity is the immobility in the soil once they are applied. This immobility allows the herbi-