HAWAII AGRICULTURAL EXPERIMENT STATION
E. V. WILCOX, *Special Agent in Charge.*

BULLETIN NO. 20

SHIELD BUDDING THE MANGO

BY

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LETTER OF TRANSMITTAL

HONOLULU, HAWAII, *December 3, 1909.*

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 20 of this station a manuscript on Shield Budding the Mango, by J. E. Higgins, Horticulturist. For some time urgent need has been felt for a practical method of budding mango trees in order to multiply rapidly the excellent varieties which have been introduced in small numbers. It is believed that the methods described in the bulletin are readily practicable.

Respectfully,

E. V. WILCOX,
Special Agent in Charge.

DR. A. C. TRUE,
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Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON, *Secretary of Agriculture.*

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SHIELD BUDDING THE MANGO.

INTRODUCTION.

The possibilities of the mango as a tropical fruit for the world's markets are gradually being appreciated. Since it has been demonstrated that the fruit can be successfully shipped long distances in refrigeration, and since the fine varieties have become more widely known, a new interest is being awakened in the fruit. Already the Agricultural Departments of several tropical countries are devoting attention to the development of the mango as a fruit industry and commercial orchards are being planted. It is confidently expected that the next decade will be marked by a large increase in plantings.

One of the most pressing problems that presents itself for solution at the beginning of this development is to find an expeditious method of propagation, seeds being no more reliable in the reproduction of excellent varieties than in the case of most other tree fruits. Very considerable progress has been made in the working-out of this problem. In very early years, before the commercial side was seriously considered, the first step was taken in India by the application of inarching to the mango. This consists essentially in grafting scion to stock while each continues to be supported by its own root system. It is cumbersome and, except for special purposes, is too slow for commercial use. A great step in advance was made by Oliver[a] and by Knight[b] in adapting patch budding to the mango. By this means it became possible to plant seedling trees in orchard form and later bud them to desired varieties. The method, however, requires considerable dexterity and can be successfully applied only when both bud-wood[c] and stock[d] are in flush, a condition which frequently does not exist in both members at the same time. It is in the hope of adding some small increment to the knowledge of mango propagation that the following results are offered.

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a. U. S. Dept. of Agr., Bur. of Plant Industry Bul. No. 46.
b. Queensland Agr. Journal (1900), Nos. 1, p. 41; 2, p. 149.
c. The wood from which the buds of the desired variety are taken.
d. The tree into which the buds are to be placed.

DESCRIPTION OF METHOD.

The proposed method is new only in its modifications and in its application to the mango. It is merely shield budding with an inverted "T," adapted to the peculiarities of the mango. Shield budding is probably one of the oldest, and certainly the most widely practiced, of all methods of budding. Ordinary shield budding had been tried on the mango long ago, following the general practice in the selection of bud-wood and stock that govern in the shield budding of citrus fruits, peach, or plum. In this case young bud-wood was used with the leaf still attached, and it was inserted in young wood. It soon became apparent, however, that this method would not work successfully, and it was abandoned, giving place to the patch bud, spoken of above, which was practiced with more mature bud-wood and stock. The present method consists in using wood of the same maturity as in patch budding, but adopts the simpler device for bringing the bud shield into contact with the stock, known as "shield budding" with an inverted "T" incision.

Materials and Tools Necessary. The materials and tools which will be found most convenient in performing this work are the following: (1) budding-knife with bone handle to raise the bark; (2) raffia; (3) grafting wax; and (4) waxed cotton bandage. The budding-knife will be necessary to make the incisions, and the bone handle to raise the bark. The raffia has a special advantage as a tying material in that it holds firmly for the few weeks necessary, and without cutting the bark. It will also decay or be broken by the expansion of the stock under the waxed bandage. It can be obtained from dealers in gardeners' supplies. If only a few buds are to be applied, other soft but strong tying material may be used. The wax may be prepared according to the following formula: beeswax 2 parts, resin 4 parts, beef tallow 1 part, by weight; break these into small pieces, place them in any pot or tin container and melt them over a slow fire. When they have become thoroughly liquified, remove from the fire and pour into a bucket of cold water. When sufficiently cool to be handled, apply tallow to the hands and pull the wax like candy until it has acquired a good grain and light color. The bandage may be made by dipping strips of cotton in bees-wax liquified over a slow fire. These strips of cotton are usually made as wide

as can conveniently be placed in the vessel containing the wax. When removed and cooled, the cotton may be rolled and cut off in pieces of any desired width. Strips about three-quarters of an inch to one inch wide are found convenient for this work.

The Stock. Budding by this method has been successfully performed on stocks from an inch to three inches in diameter. What the limitations are, on either side of these dimensions, is not known at present. Wood of this size, in seedling trees, may be from two to five years old. It is essential that the stocks be in a thrifty condition, and, still more important, that they should be in "flush." If not in this condition, the bark will not readily separate from the stock. It has been found that the best time is when the terminal buds are just opening. Unless the trees are watched carefully they will pass this stage before the flush is observed. When the young, brown leaves have appared it is often too late to bud, and the operation must be postponed until the next flush.

The Bud-wood. The bud-wood which has been most successfully used is that which has lost most of its leaves and is turning brown or gray in color. Such wood is usually about an inch in diameter. It is not necessary in this method of budding that the bud-wood shall be in a flushing condition, although it may be an advantage to have it so. It should, however, be healthy wood of normal growth.

The incisions should be made in the stock about six inches in length. At the lower end of this make an incision at right-angles to it, with the knife edge pointing upwards at an angle of about forty-five degrees with the stock, thus making a curved incision as shown in Plate I. Insert the sharpened end of the handle of the budding-knife beneath the bark at the junction of these incisions, and push it gently upward, raising the bark so as to make a place for the bud. It is not necessary to push the handle far, but, by gently prying, the bark may be separated from the stock, if the latter is in proper condition, without injuring the delicate cells against which the bud shield is to be placed.

The Bud is now to be removed from the bud-wood. With a rather heavier knife than is generally used for budding, in the right hand, and the bud-wood held firmly in the left, place the blade against the bud-wood with a very slight inclination, and cut so as to make as flat a surface as possible under the bud shield. This bud shield should be about 3 to 3½ inches

long, with the bud in the center. The small portion of wood, which will thus be taken off with the bud shield, may be removed if it slips readily. If not, it should be left in place. The lower end of the shield is then taken between the thumb and finger and gently inserted in the incision prepared for it, pushing it up until it is held firmly in place by the surrounding bark.

Tying and Wrapping. The stock must then be tied with raffia or some other soft, but strong, tying material, so as to prevent drying out. The cut surfaces below the actual bud are usually covered with grafting wax, and the whole is then wrapped with a waxed cotton bandage, beginning at the lower part and winding spirally to the top, exposing only the actual bud. This method of wrapping protects the bud and the wound from the access of water. The bud is shaded by a short piece of bandage hung over it and held in place by being laid under the upper strands of the spirally wound bandage.

After-Treatment. In about three or four weeks, if the bud remains green, the stock should be lopped at a point about seven inches above the bud. Care should be taken in thus cutting the stock partly off to avoid splitting downward. It should be made to split upward into that portion of the stock which is to be destroyed. This lopping will serve to force the bud into growth. Many other buds, on the sides of the stock, will start into growth before the new bud. These must all be cut off. It has not been found necessary to remove the tying and wrapping material until the bud has made two flushes, and often it is not necessary at all, since the raffia usually decays beneath the waxed cloth and the latter naturally expands with the growth of the stock. When the bud has started into growth the top of the tree may be completely cut off and destroyed. The stump remaining above the bud may be cut off with a sloping cut close to the bud, after the latter has made three or four flushes.

FIG. 1.—Mango shield bud in an early stage of growth.

ADVANTAGES OF THE METHOD.

Speed. It has been found that buds can be set quite rapidly by this method. In the experience of the writer, five or six buds could be set by this means to one by the patch bud method. Speed may be increased also by the use of unskilled labor in the tying and binding operations. The operator can set the bud and pass on to the next without any danger of it getting out of place before the helper, who immediately follows, ties it.

Perhaps the most important advantage in this method of budding lies in the fact that it may be used successfully when the bud-wood is not in an active growing condition. The most tedious part of patch budding is in removing the bud, and frequently in doing so it will be broken. Further, it is frequently impossible to get bud-wood of a desired variety in active condition when the stocks are ready to be operated upon.

Adaptability. The method may be applied most advantageously to seedling trees in orchard form when they have become large enough to be operated upon, when the buds should be set only a few inches above the ground. It may also be used in top-working old trees to new varieties. For this purpose, the main branches of the trees must be cut down to a point about two feet from the trunk. The cut surface of the wound should be painted with ordinary lead and oil paint to prevent drying out and checking. The remaining stumps will send out numerous young shoots, and from these a few may be selected for budding. The others should be broken off before they have made much growth, so as to throw the vigor of the tree into the selected shoots. When these new branches have arrived at the condition described above, buds may be inserted in them to form the new head for the tree. It is better not to cut off all the large branches the same year.

It is too early to report the results of this method as applied to nursery trees, but from the experience at this Station it seems highly probable that the method would be applicable in the nursery also. Seedling nursery trees, of several years' growth, have been successfully transplanted by severe cutting back. In all probability, nursery trees budded as early in their growth as possible, and near to the ground, could be successfully removed a year or two after budding. Nevertheless, it is recom-

mended as better practice to plant out young pot-grown seedlings, budding them as soon as they have become of sufficient size.

STUDY OF THE BUD UNION.

The region of union. It may seem unnecessary to point out the region of union between the bud and the stock, but from

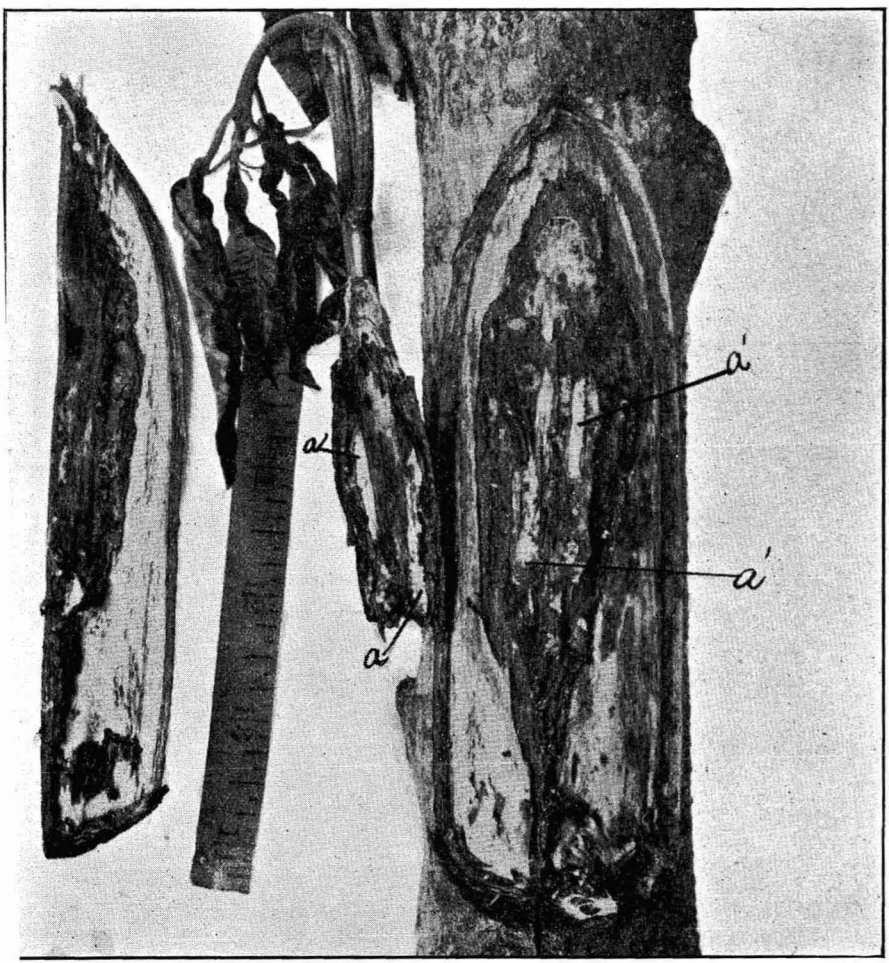

FIG. 2.—A mango bud shield separated from its stock, showing the elliptical line of attachment *a a a' a'*.

the widespread misconception of this subject, it is believed to be necessary to draw attention to some facts in this connection. For example, in budding with a patch of bark inserted into

an opening of the same size in the bark of the stock, it is quite commonly misconceived that the union takes place along the edges of the bud patch, uniting the latter with the bark of the stock. As will be seen from a study of the figures showing the sections of the bud, this is not the case. By reference to figure 2, it will be seen that union is effected in a more or less broken ellipse, corresponding to the line between the bark and the small portion of wood adhering to the bud shield. A moment's reflection should serve to show that this is the only region where it is possible for a union to be effected. The cells of the wood are too old and inactive to take any part in a coalition with any plant substance with which it could be placed in contact. Likewise, the cells of the bark are too old to unite with other plant substance. It will be recalled that the region of growth lies just between the bark and the wood, and that this thin layer of cells is known as the cambium. The cells in this part are thin-walled, tender, and in process of subdivision. When this cambium layer, lying between the bark and the small piece of wood, is placed in contact with the cambium of the stock, and is held there for a considerable period, the new cells forming by the subdivision of the cells placed in contact constitute a continuous layer through stock and bud. The small portion of wood, held within the bud shield, dies and becomes dried up.

When the incisions are made in the stock to prepare a place for the insertion of the bud shield the bark of the stock separates from the wood along the line of the cambium zone. When this bark is again pressed down upon the bud shield at its edges and into place against its own cambium, union again takes place more or less completely along the zone where it has been separated. The bud shield, however, will prevent the wings of the bark of the stock from returning perfectly into position. A region will, therefore, be left surrounding the bud shield where no union can be effected between the two layers which were in contact before the budding operation was begun. This leaves a zone in the form of an ellipse surrounding the bud shield and on which all the surface cells have become dry. (See figure 3.)

Since, however, the bud shield which is united with the stock is in vital contact with it and is drawing its sustenance from this source, there must be a continuous layer of active cells beneath those that have become dried; otherwise there

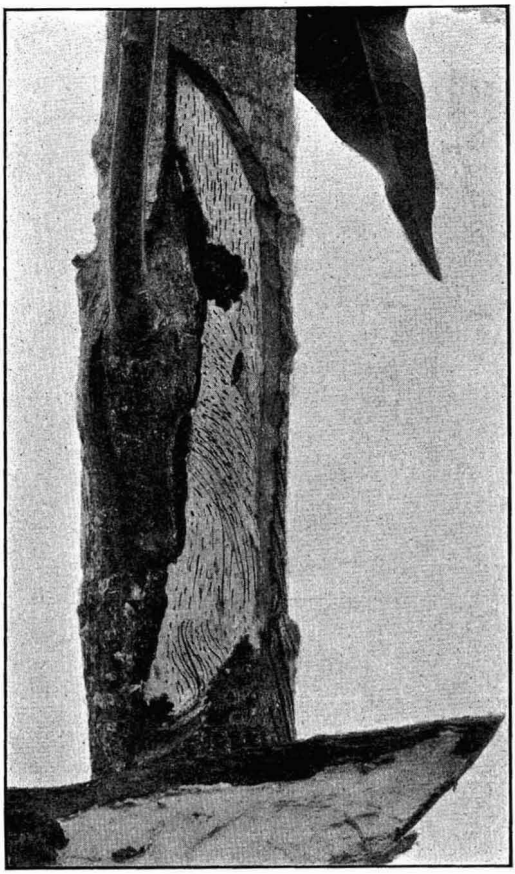

FIG. 3.—Mango shield bud from which one wing of bark has been removed.

would be no possible means of communication between the bud branch and the stock. For example, in figure 2, at points á á, the elliptical line of union may be distinctly traced. Surrounding this may be seen the darker portion, showing where the surface cells have become dried up, and beyond this, again, the region where a new layer of wood is being formed and where the wings of the bark have united with the stock.

Modification of cells due to the bud. If a mango branch be examined it will be observed that numerous buds are to be found,—one in the axil of each leaf, and one above each scar where the leaf has been dropped. Nearly all of these buds remain dormant. If the branch is split through the center, it will be found that the bud, as in the case of most dicotyledons,

is connected with the center of the branch by a thin line of pith. As shown in the drawing, nearly all the elongation of cells takes place in the direction of the growth of the main branch, but a few bundles are elongated toward the dormant bud. If this branch is cut off just above one of these buds, the

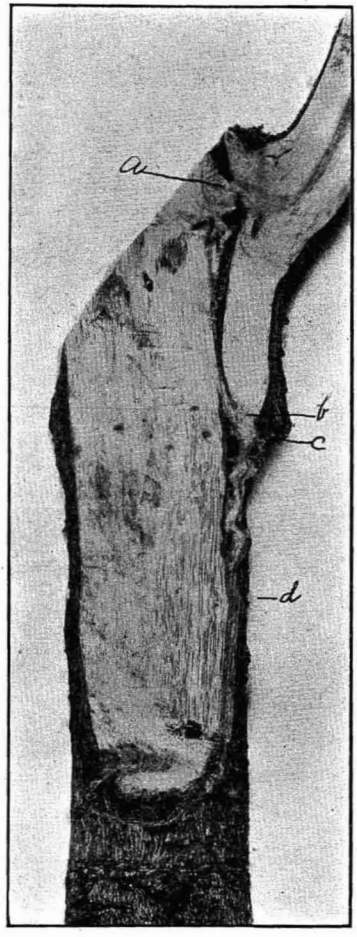

FIG. 4.—Section through a mango bud union after several flushes had been made.

latter will be forced into growth. The flow of sap toward the newly developing bud will cause the elongation of the cells toward the new bud. In other words, the grain of the wood will be changed in direction.

If a new bud from some other tree be inserted under the

bark of this branch, and if union takes place, a corresponding change in the direction of the grain will take place. There will be this difference, however, that there will be no central pith connecting the new bud with the center of the main branch. When union is first effected, as pointed out above, it is in a more or less broken ellipse along the line of the cambium zone, lying between the bark of the bud shield and the small portion of wood beneath it. At this point of union it may often be seen, as in Plate II, fig. 2 a, that the elongation of cells takes place in a direction at right angles to the natural grain of the wood of the main branch. As growth continues the newly forming cells become less and less sharply angled at, or near, the point of union, and gradually assume the direction of the new branch. If a budded branch of a few months' growth be cut through longitudinally, the old line showing where the bud was applied may readily be seen, covered by new layers of wood (Fig. 4). These layers are continuous between the new branch and the stock. It will be understood that they are also continuous in the circumference of the stock and branch. Each year, as new layers are added, the line between the bud and the stock becomes the more deeply embedded in the tree. In this way the new growth completely surrounds the old, and the new tree top becomes as firmly attached to the stock as one of its own branches would have been. A careful study of these mango bud-unions leads to the belief that no fear need be entertained as to their strength. In figure 4, at the points a and b, may be seen the place where union was effected between bud and stock. At these points may be seen the cross-grain, and just outside of this, the newly forming grain which is gradually assuming a direction between that of the new branch and that of the original stock.

A similar change in the direction of the grain frequently takes place under the wings of bark which have been replaced after the insertion of the bud. (Figure 3.)

An Adaptation of Inarching.[a] In relation to the matter of propagation it may be well to mention here an adaptation of inarching which has been found very useful. It has been stated above that inarching is a cumbersome and tedious process for the multiplication of a variety. Nevertheless, there are cases

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a. The process of inarching is described in Hawaii Experiment Station Bulletin No. 12, page 13.

in which it can be made to serve a valuable purpose. Frequently this station has received inarched potted plants. It has been found that these often fail to do well when planted out. Sometimes the root-system has been too long confined to the pot, or long transportation has reduced the vitality of the tree. Such trees are no longer planted in the station orchards on their own roots, but are grafted by inarching to the side of a strong seedling already in the orchard row. For this purpose the pot is sunk in the soil close to the seedling and only a small portion of the potted tree need be grafted to the new trunk. After the union has been effected the pot plant may be taken to another tree if desired, and the process repeated. By this simple adaptation a shoot only a few inches in length has been made to produce a tree top of 5 feet spread and 4½ feet height in less than a year.

DESCRIPTION OF PLATES.

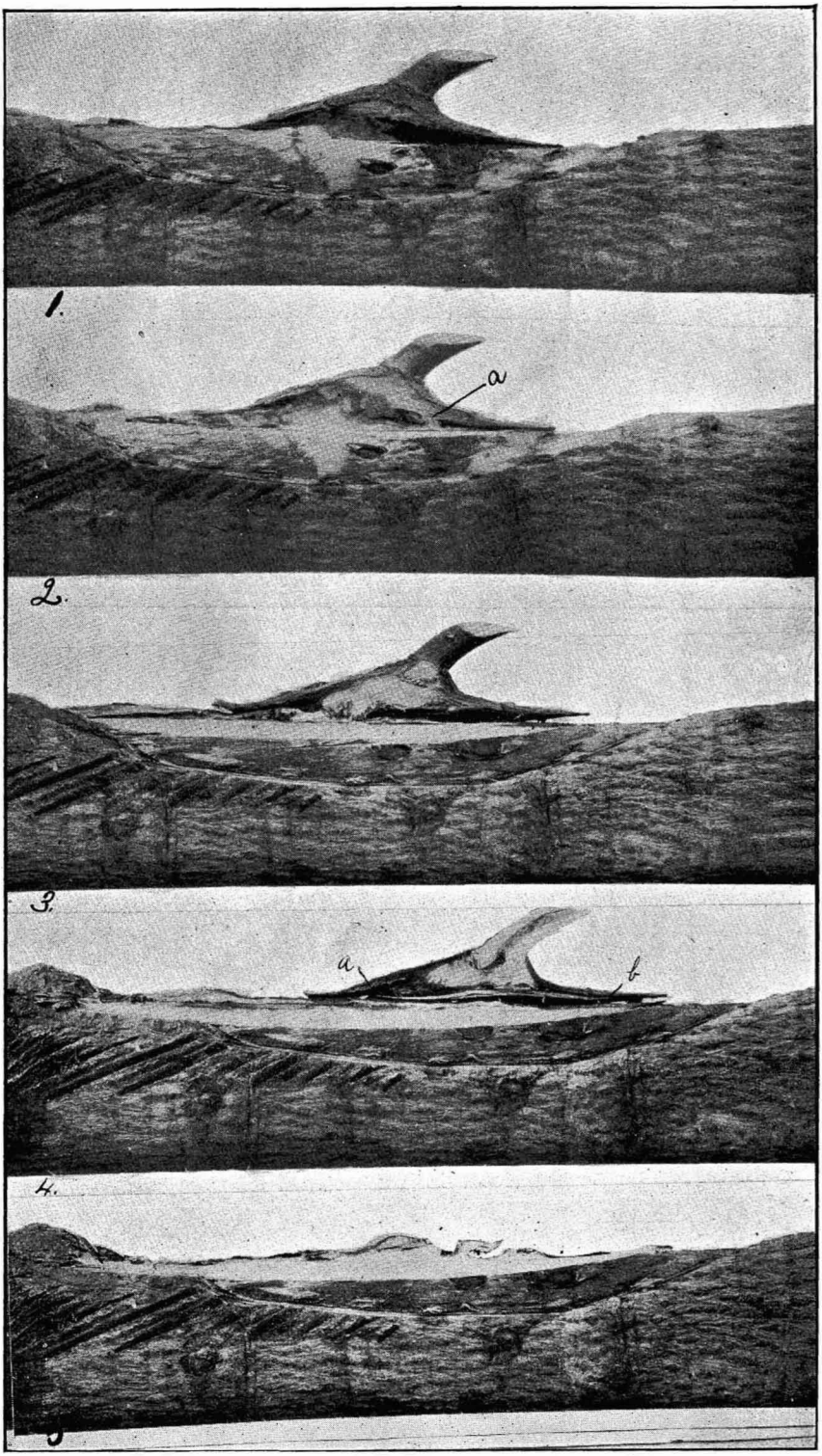
PLATE I. Shield budding adapted to the mango. a. budwood; b and b′. bud shields; c. budding knife; d. stock with bud shield inserted; e. stock wrapped and bud protected by a loose covering. Rather more than one-half natural size.

PLATE II. Series of consecutive longitudinal sections through a mango shield bud.

The sections were made after the flush of growth had been completed. Figure 1 shows a section through the outer margin of the zone of union. It has entered the elliptical line (see page 9) on one side near its lower end. The dark portion indicates the region where no union has been effected. It is outside the ellipse. In figure 2 the section passes along the line of the ellipse and shows clearly the points of union. At the point "a" the change in the direction of the grain is distinctly shown. The specimen showed all along the line a similar condition, which the camera has failed to bring out. Figure 3 passes almost beyond the zone of union. Figure 4 is completely beyond this zone and the section is practically through the major axis of the ellipse. Note from "a" to "b" the thin sliver of wood which was left in the shield when it was inserted in the stock. This wood, of course, is dead. In figure 5 the section again passes into the zone of union, but now on the opposite side of the ellipse.

PLATE I.

Shield budding adapted to the mango.


1.
a
2.
3.
a
b
4.