BUDDING IN THE FIELD.

By C. E. T. MANN.

1. Introduction.

In present plantation practice it is recognised that the budding of Hevea may be carried out either in nurseries or in the field. It is not intended in the present paper to discuss the rival merits of the two methods; it is sufficient to state that in Malaya at least field budding is carried on to a great extent. It is therefore important to gain more detailed knowledge of the factors affecting the success of the operation under field conditions. Clearly, there will be some factors to be considered which are common to both field and nursery practice and in these instances any information obtained may prove of equal value in both cases.

2. Field Work.

In April of this year the writer was afforded an opportunity to carry out a budding programme on an area of 50 acres. The results obtained and observations made during the course of the work form the subject of the present account.

3. Stocks.

The clearing was planted in February 1927 with basket plants alternating with stumps, the whole of the planting material being raised from seed collected from a recorded, high yielding area on the estate. Planting was on the square system, the planting distances being 20 ft. x 10 ft. Where the original basket plants had failed "stumped" plants had been used as supplies.

4. Budwood.

Budwood was obtained from an adjoining area of vigorous young budded trees planted as "stumps" in late 1924. Test tapping experiments were in progress on this area and the three most promising clones were selected for use in the new clearing. Sufficient budwood was cut in the early morning for each day's work and any excess was used on the following day before a fresh supply

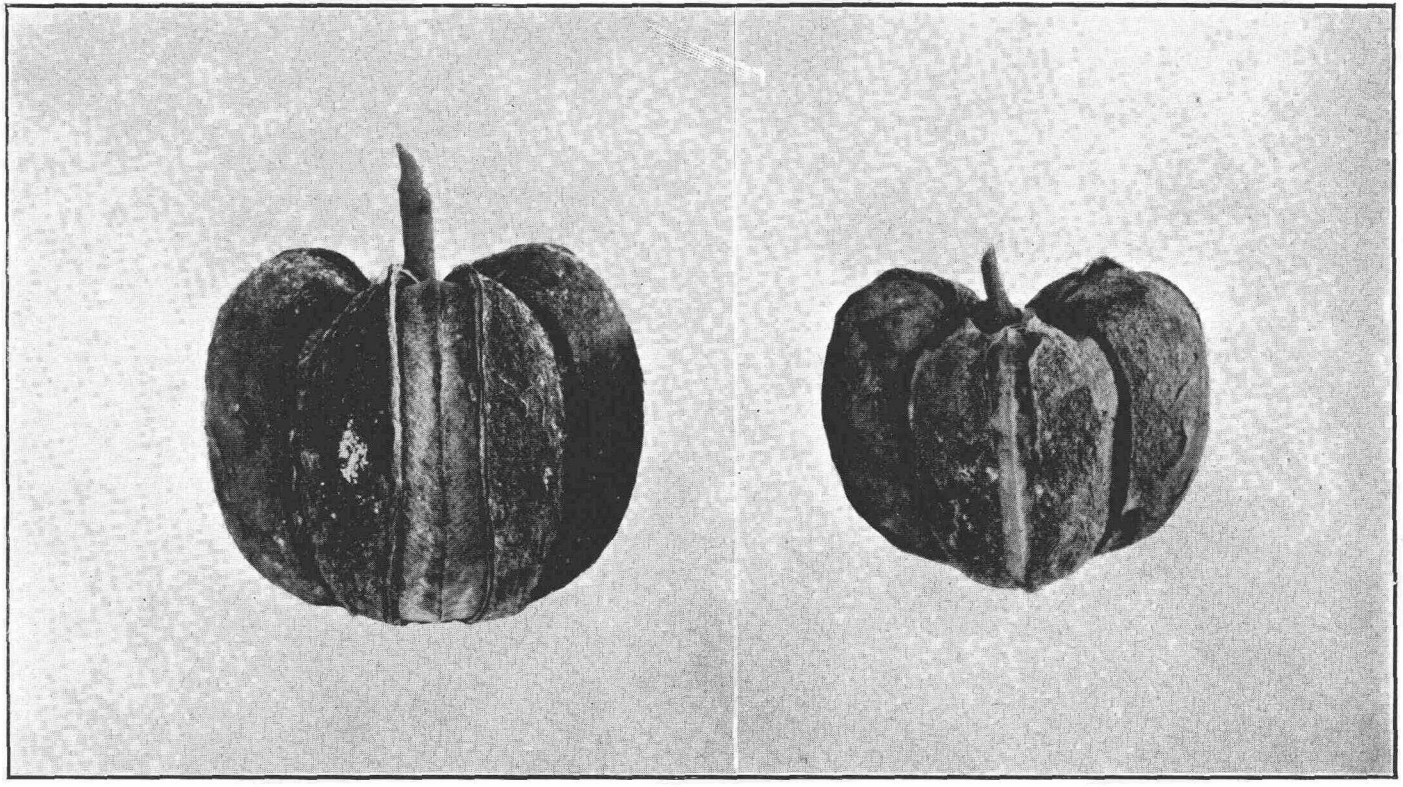

PLATE I.

RIPE FRUITS FROM 1928 ARTIFICIAL POLLINATIONS

A44 FEMALE X B58 MALE

B50 FEMALE X A44 MALE

was cut. In this way material in the best possible condition for use was obtained and the risk of failure due to dry or bruised budwood was minimised. Having been sawn into convenient lengths the sticks of budwood were rolled in damp sacking for removal to the clearing where care was taken to protect the bundles from exposure to the sun.

5. Budding.

The original basket plants or the "stumps" supplied if these were well established, were budded. In the first period of the work two experienced men were employed; later a third man of similar experience and a fourth who had received a short training were also employed. The usual "patch and tongue" method was used throughout. Each budder was followed by a cooly who tied a shade of leaves in position over each completed budding and also fixed around the base of the plant a wire hoop bearing a metal label stamped with the clone number (and the number of the tree in the clone from which the budwood had been taken). It may be mentioned that this method allows a skilled man to carry on his work without interruption and the man who does the incidental work is able to learn a good deal by observation. In this way an efficient gang may be built up from a small nucleus of skilled budders.

It should be stated that the work was not continuous, the four men being employed for short intervals as they became available. Budding was therefore carried out under varying conditions.

6. Recording.

To facilitate the work of recording and supervision the area was divided into smaller blocks of about ten acres each. Buddings in each block were made from two clones and the combination was changed for each successive block to obtain the desired distribution of the three clones used. A permanent stake bearing a board on which was stencilled in correct order the numbers of the clones used was placed opposite the first tree of each block. This method of subdivision simplifies the work of recording and labelling and avoids the confusion which attends the use of unwieldy numbers. A small plan of the area showing subdivisions and the numbers of the clones used in each small area can be used both for quick reference during the actual budding operations and at later stages.

During the progress of the work the following observations and records were made:—

1. Source of budwood, clone number and the number of the tree from which the wood was taken, with observations on on its condition.
2. Notes on growth condition of individual stocks whether stumps or basket plants, at the time of budding and later when the buddings were opened.
3. Individual records of the work of each man.
4. The complete record of successes and failures at "opening", at"ringing" and again at the first pruning of the stock about ten days after ringing.
5. The daily rainfall observations over the whole period obtained from the estate records.

7. Results.

For the purpose of this account the men employed in budding will be referred to as A, B, C and D, and the clones used as Clone No. 1, No. 2 and No. 3. As the results are to a great extent numerical they are best presented in tabular form.

Table 1. Summary of the results obtained in a field budding experiment with three clones.

Clone.	Number of Buddings Made.	Successes at Opening		Successes at Ringing		Successes Final.	
		No.	%	No.	%	No.	%
1	1518	1404	92	1125	74	1101	72
2	1257	944	75	666	53	664	53
3	779	574	74	472	61	471	60
Total and mean percentages.	3554	2922	82	2263	64	2236	63

The figures summarised above show to what extent the success obtained varied for the three clones used. Clone 1 appears to bud more successfully than either of the other clones. A second point of special note is the very serious loss which occurred between the opening and ringing operations. Budding was carried on during

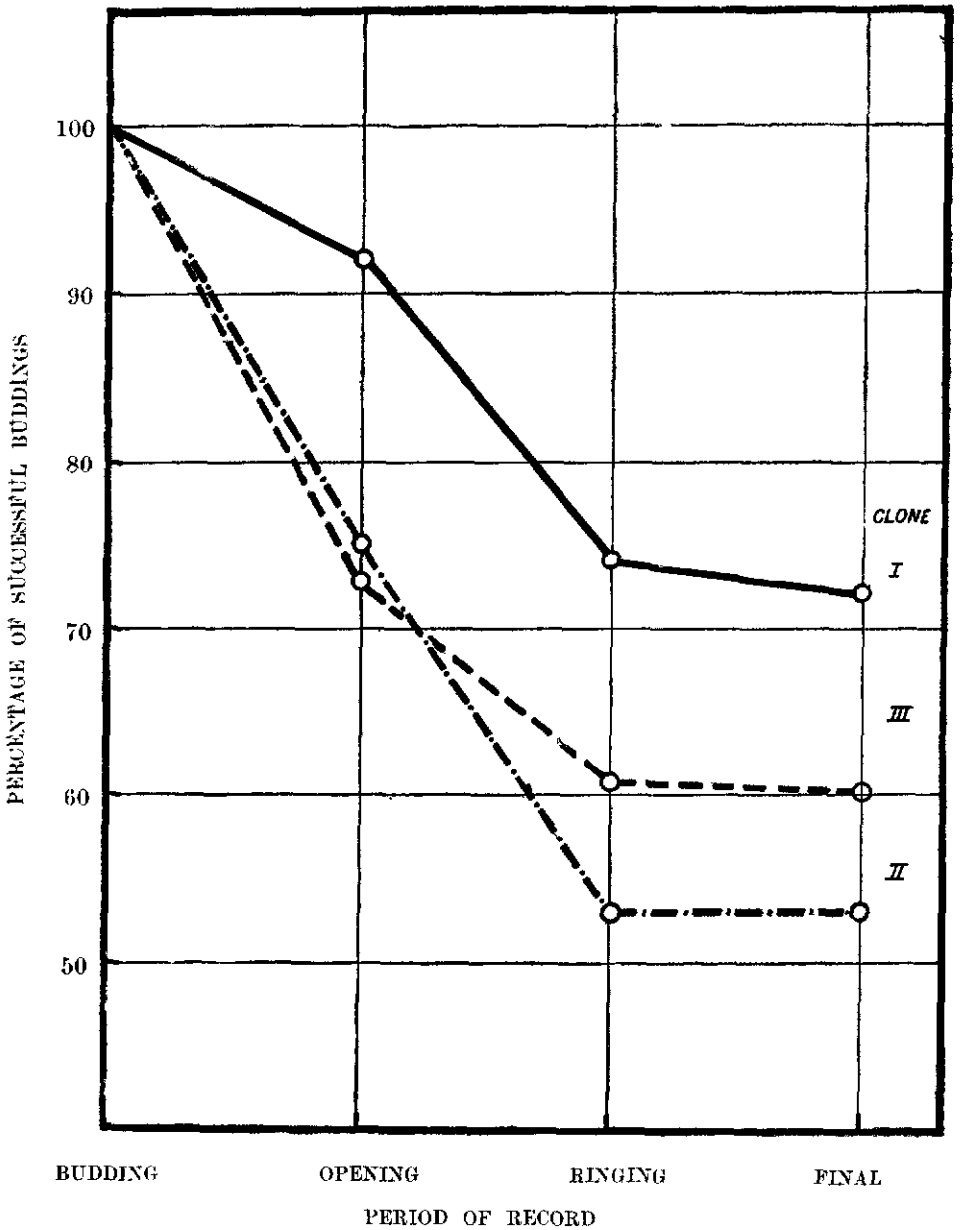

FIGURE I.—A comparison of the results obtained in budding with three different clones under field conditions (Based on data given in Table I.)

part of April, May and June and the losses varied greatly in different periods. This point will be further discussed when the effects of weather conditions and growth of the stock are considered in more detail.

8. Factors Affecting Success.

(1) *The Personal Factor.*

In such an operation as budding the personal factor, the skill of the operator, is of the first importance. In the work under review, A, B and C were all skilled men of considerable experience. It is therefore interesting to compare individual results where work was carried out with analogous material under the same general conditions. Examples of such comparisons, (Table 2) taken from the complete records, show that even with skilled men the variation in success attained may be considerable. It is likely that the variation will be even greater with less experienced budders. The examples quoted show that the quality of the work varies from day to day but this may be due partly to differences in the material used or to different working conditions, or to a combination of both. The work of B is consistently better than that of A and B's superiority is most marked in work with Clone 2, the one which was most difficult to bud successfully.

(2) *The Condition of the Stock and the relation between growth and success in budding.*

It is generally stated that with suitable budwood best results are obtained when the plants budded (stocks) are in active growth or when there is a "strong flow of sap". The growth of a young rubber plant in the first two or three years is somewhat peculiar. Extension growth is carried on by a vigorous terminal bud which passes through phases of very vigorous activity, each active period being followed by a period of rest or dormancy. During the vigorous phase young leaves are formed, the intervals between them becoming smaller as growth slows down until with the cessation of terminal activity the leaves are crowded together forming the typical "whorl" which marks the close of a single growth phase. The terminal bud becomes dormant some time before the leaves reach their full size and the reddish green drooping foliage of the "new storey" or growth phase, is a characteristic feature of vigorous young seedlings at this stage.

In the present work notes were taken on the individual growth condition of about two thousand stocks, both seedlings and stumps, at the date of budding and again when the buddings were opened from seventeen to twenty-one days later. From these observations

TABLE II. *A comparison of the results obtained in budding by different operators under comparable conditions.*

Example No.	Date.	Clone.	Tree Number.	A.		B.		C.		D.	
				% Success at opening.	% Final success.	% Success at opening.	% Final success.	% Success at opening.	% Final success.	% Success at opening.	% Final success.
I	17.4.28	1	29	80	20	95	24				
	17.4.28	,,	30	97	80	97	88				
	18.4.28	,,	116	77	61	86	75				
	19.4.28	,,	157	91	63	90	74				
	23.4.28	,,	45	85	73	92	77				
	23.4.28	,,	115	63	47	92	73				
	24.4.28	,,	115	76	65	84	63				
	...	,,	Average	81	59	91	68				
II	20.4.28	2	370	30	26	75	54				
	21.4.28	2	358	42	39	85	81				
	...	,,	Average	36	32	80	66				

III	25.4.28	3	276	81	65	91	88	81	75	...	...
	25.4 28	,,	287	80	70	84	70	77	54	...	...
	...	,,	Average	81	68	88	79	79	65	...	...
IV	26.4.28	3	395	62	50	...	...	81	81	...	..
	27.4.28	,,	291	56	42	...	..	65	53	...	...
	28.4.28	,,	315	68	58	...	...	83	69	...	...
	,,	...	Average	62	50	...	...	76	68	...	...
V	12.5.28	1	145 137	...	...	100	96	...	...	98	93
	14.5.28	1	138		...	100	95	...	...	100	89
	,,	...	Average	...	..	100	96	..	...	99	91
VI	10.5.28	2	364	...	...	93	91	78	74	93	90
VII	11.6.28	2	350	84	50	..	...	...	...	92	60
	12.6.28	2	368	92	29	...	...	...	...	87	35
	,,	..	Average	88	40	...	...	...	...	90	48

the stocks have been divided into five main groups or growth classes, and the number of successful buddings made in each class have been recorded. The results are summarised in Table 3.

Table 3. Results obtained in budding of stocks in varying stages of growth activity. (Success is based on the final number of growing buddings).

Class.	Growth Condition of Stocks.		Results.			
	At Budding.	At Opening.	No. Budded	Successes.	Failures.	% Success.
I.	Dormant	Dormant	437	174	263	40
II.	Dormant	Terminal growth beginning	321	198	123	61
III.	Dormant	Vigorous	413	296	117	72
IV.	Vigorous	Vigorous	252	184	68	73
V.	Vigorous	Dormant	427	269	158	63

The figures presented in Table 3 show that the best results were obtained on vigorously growing stocks. The comparatively poor results obtained on stocks in a dormant condition are of particular interest and a further reference to this observation will be made when the influence of weather conditions is considered.

In the accompanying figure (Fig. 2) the normal growth curve of a young rubber plant between two periods of rest is diagrammatically represented. This curve may be divided into sections corresponding with the growth classification given above. (Table 3).* The results obtained in budding plants falling within each class are shown in the diagram and the striking relationships between the vigour of the stock and the success of the operation is clearly shown.

(3) *Type of Stock.*

Where stump supplies had made good growth they were budded at the same time as the original basket planted stocks. Approximately six hundred stump supply plants were budded in the first

*For the purpose of diagrammatic presentation Classes III and IV in Table 3 have been combined.

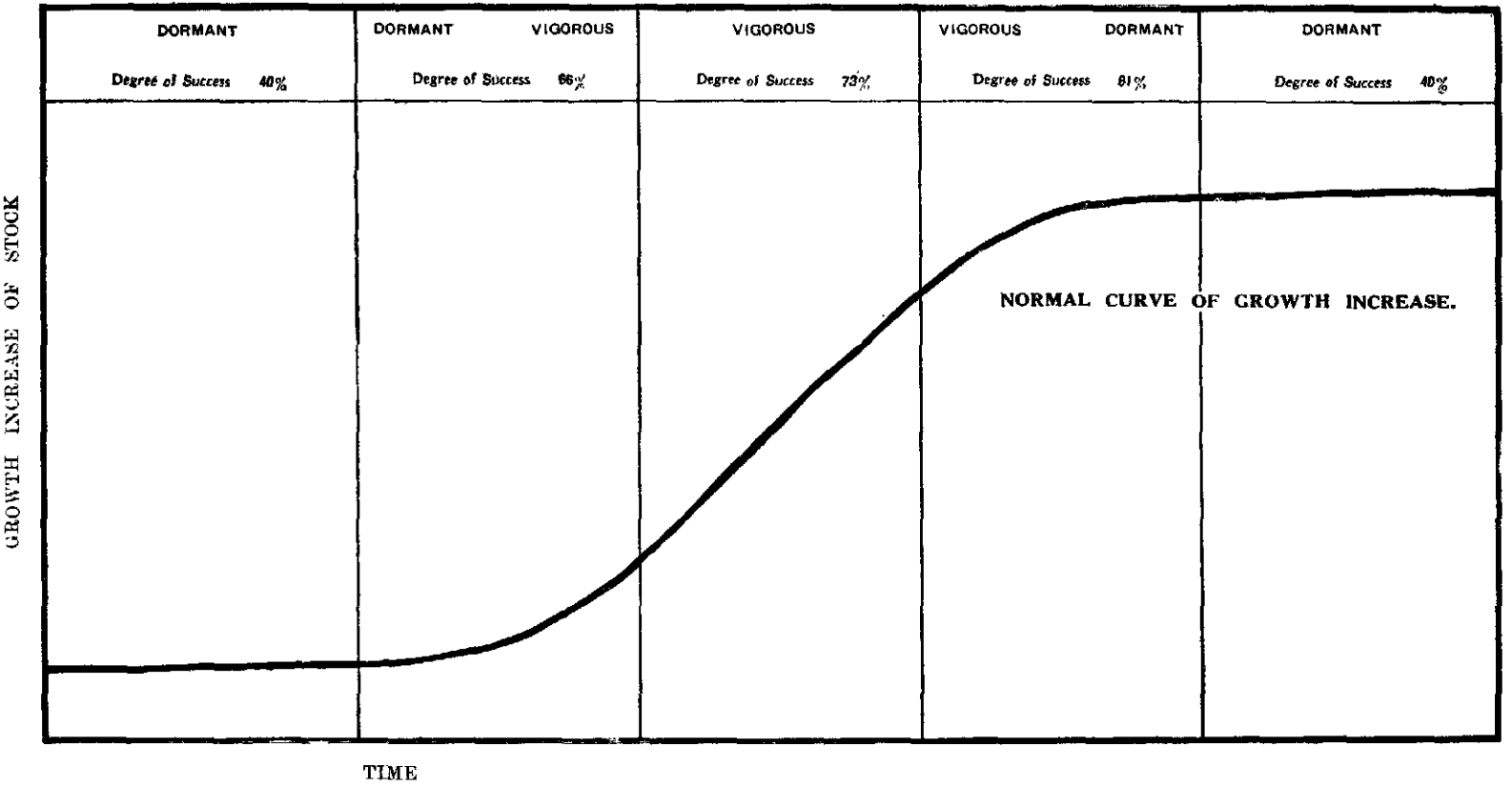

FIGURE II.—Showing the relation between the vigour of growth of the stock and success attained in the budding operation. It will be noted that the best results were obtained on stocks which showed vigorous growth throughout the period from budding to opening.

three blocks (28 acres) and a comparison of the results obtained with those obtained on seedling stocks is made in Table 4.

Table 4. Comparison of the results obtained in budding with three clones on "stumps" and seedling stocks.

Stocks.	Stumps.					Seedlings.				
Clone.	Number Budded.	Success on Opening	%	Successes Final.	%	Number Budded.	Success on Opening.	%	Successes Final.	%
No. 1	190	161	85	127	67	467	402	86	308	66
No. 2	183	127	69	112	61	569	407	71	376	65
No. 3	212	152	72	124	59	565	418	74	342	61
Totals & mean %ages.	585	440	75	363	62	1601	1227	77	1026	64

Examination of the results summarised in Table 4 shows that *in the present experiments there is little significant difference in* the results obtained on the two different types of stock. The small apparent superiority of seedlings over "stumps", amounting to about two per cent., cannot be regarded as sufficiently large to be significant.

(4) *Condition of Budwood.*

It has already been shown (Table 1) that the success obtained varied with the three clones from which budwood was taken. Further, the results summarised in Table 2 indicate that within a single clone the degree of success attained may vary with individual trees from which budwood is obtained. Although in many respects budded trees of the same clone show much greater uniformity than seedling trees of mixed parentage yet both buddings and seedlings are equally subject to environmental influences. Thus in an area planted with trees of a single clone differences in vigour due to soil differences or special advantages of position will be encountered. It has been noted that trees of the same clone growing under apparently uniform conditions do not flower at the same time neither do they all go through the wintering stage together. Both flowering and leaf fall are the outward evidences of changes in internal condition. Such differences will affect the quality of the budwood obtained from different trees.

Examples have been selected from the full records illustrating this possible variable factor. In the cases summarised in Table 5 each set of buddings was made by the same man working under the same conditions with budwood obtained from different trees of the clone specified.

Table 5. Variation in the success obtained in budding under uniform conditions with budwood from different trees of the same clone.

Clone.	Tree Number	Date.	Number of Buddings made.	% Initial success.	% Final success.
1	29	17.4.28	38	87	24
	30	,,	83	97	83
	116	19.4.28	20	95	90
	157	,,	42	90	74
	45	23.4.28	122	89	75
	115	,,	69	78	60
	145	12.5.28	42	100	95
	137	,,	62	98	94
3	276	25.4.28	93	85	77
	287	,,	119	82	64
2	370	20.4.28	176	52	40
		28.6.28*	131	51	40
	358	21.4.28	90	67	62
		29.6.28*	44	77	77

*Rebudding. Results obtained with budwood from the same two trees.

In the examples given above those given for Clone 2 need a further word of explanation. Failures and supply plants not suitable for budding in April, were budded in late June with buds

obtained from the same two trees. The budwood from tree 370 gave consistently poorer results than that from tree 358.

(5) *The Influence of Weather Conditions.*

It is common knowledge that the success of the budding operation depends to a certain extent on weather conditions. For example, during rain or heavy morning mists it is impossible to ensure the degree of cleanliness in the actual operation which is essential for success. During the heat of midday, the physical discomfort of the operator makes for poor work and it is often advisable when budding under field conditions, to stop work early and start again in the cooler hours of the afternoon. But these are conditions affecting the actual budding operation and further information is required on the conditions which make for success or failure between the time of budding and the commencement of growth of the grafted bud.

In the present work it has been shown that the margin of failure varies considerably with the skill of the operator, and the quality of the material used. It is therefore impossible to make a close comparison between success and daily weather conditions. The whole period over which the work was carried out is divisible into two well defined showery and drought periods. From the middle of April to the middle of May there were fourteen rainy days and the total rainfall was 11.23 inches. From the middle of May to the middle of June a total of 1.29 inches of rain fell on seven days. In the whole month of June rain fell on only 5 days and totalled 0.88 inches. It is of interest in view of these records to examine the results obtained in budding in the two periods April—May:—showery; May—June:—drought. (Table 6).

Table 6. Influence of weather conditions on budding in the field.

Clone.	Period of Budding.	No. of Buddings.	Percentage Initial Success	Percentage Final Success.	Losses after opening as a percentage of initial success.
No. 1	Showery	493	98	84	14
	Drought	190	99	70	29
No. 2	Showery	361	88	85	3
	Drought	502	80	35	56

Caution must be exercised in any attempt to separate one factor from the complex of factors which influence the success of such

an operation as budding but the results obtained under the diverse weather conditions described above are very suggestive. The high initial success at the first examination (success at opening) shows that the quality of the actual technique did not change very appreciably. The greatest losses occurred between the first and second examination (at ringing) and point to the influence of some external factor or complex of factors.

(6) *Losses After Opening.*

In field budding it is the usual practice to protect the completed budding from exposure to sun and rain by tying a shade of leaves around the freshly budded stock immediately above the waxed binding. As a further precaution, in exposed situations this protective shade is renewed after the budding is opened and the bud-patch proves to be alive. In all the buddings made in April the first of these precautions was made the rule and the second, shading after opening, was practiced where the exposure seemed to warrant extra protection. When the first buddings were ringed on May 21st a large percentage of losses was recorded. More attention was subsequently paid to shading after opening, more leaves were used to make a thick shade, the "tongue" was not cut or broken off but allowed to cover the bud lightly, and in addition a split bamboo, about eighteen inches long and semi-circular in cross-section, was forced into the soil close to the stock and opposite the point of budding. By this means losses after opening were considerably reduced which is shown by the results summarised in Table 7.

Table 7. The effect of shading young buddings at "opening" on the final success obtained....(Figures do not include buddings made under drought conditions of June).

Clones.	Extent of Shading.	Number of Buddings Made.	Percentage of Initial Success.	Percentage of Final Success.	Losses after Opening as a Percentage of Initial success
Nos. 1, 2, & 3.	Light or none	1659	76	62	19
No. 1 & 2.	Heavy	960	90	81	10
No. 1.	Light or none	348	91	70	23
	Heavy	283	99	87	12
No. 2.	Light or none	266	57	48	17
	Heavy	302	88	84	4

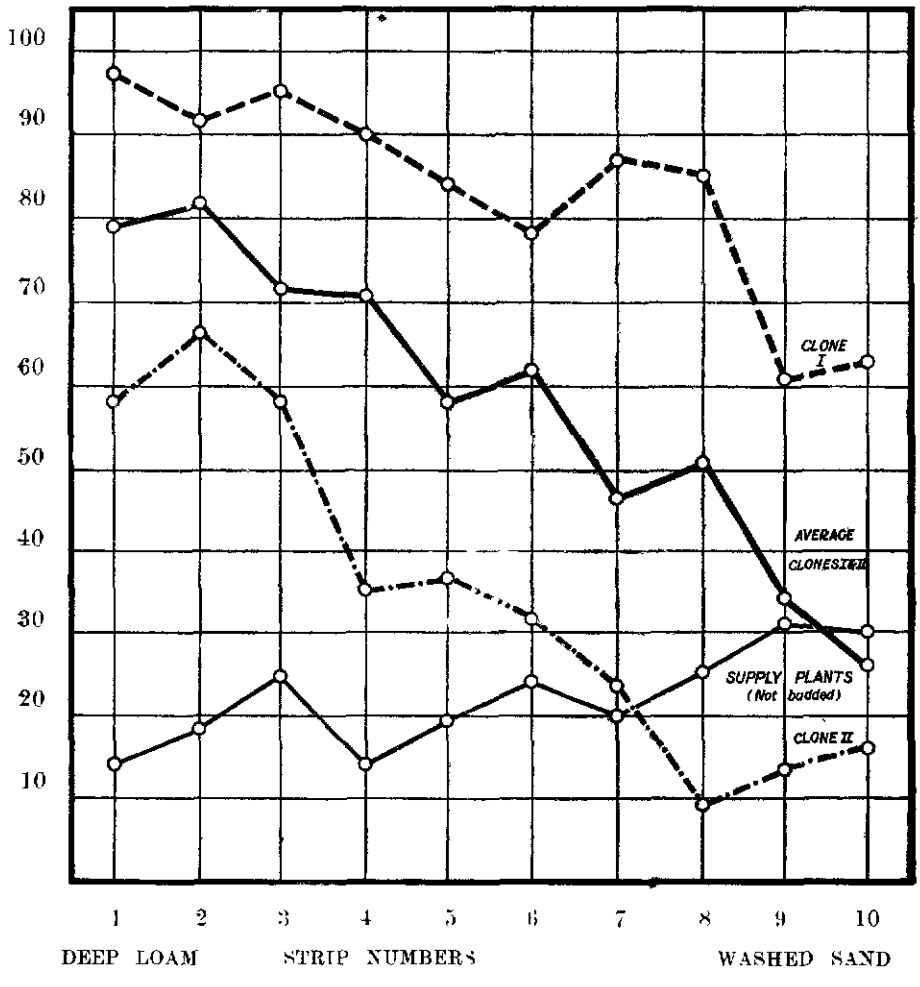

FIGURE III.—An area of 12 acres is divided into 10 strips of equal area. The character of the soil changes from a deep loam to a washed sandy soil in the direction indicated in the diagram. The percentages of successful buddings made in each strip are shown. Buddings of Clone I were made in a showery period and those of Clone II were made under drought conditions. There is a general increase in the percentage of supply plants with the change of the soil from loam to sand.

Under the severe drought conditions which obtained in June, even though the shading precautions described above were employed, heavy losses of apparently successful buddings were experienced. For example, in one block alternate rows were budded with Clone 1 in May; 493 buddings were made, 485 were alive on opening, giving finally 416 growing buddings. The remaining rows were budded in June with Clone 2; 502 buddings were made of which 411 were alive on opening but of these only 178 survived.

The effect of the drought on the growth of the stock plants during this period merits special description. In numerous instances terminal growth had just commenced early in the dry period. The subsequent growth of these plants was very different from the usual growth of a "new storey". Extension was very slow and in place of the usual, drooping reddish green foliage small dwarf leaves were produced which failed to mature and dropped in a few days. The new "storey" of growth, which under normal growing conditions would have been at least two feet in length, was represented by a slightly swollen cork-covered dwarf shoot devoid of leaves and seldom more than six inches long. On these shoots numerous small buds were present in a close spiral formation as shown in the accompanying illustrations. (Plates I and II). The close relation between the vigour of the stock growth and success in budding has already been shown. It is therefore of especial interest to note the poor results obtained under drought conditions which produce such a severe check to normal growth as that described above.

(7) *The Influence of Soil Character.*

In a block of 12 acres, which was one of the sub-divisions comprising the area budded, it was noted in passing through the area from the left to the right that the character of the soil changed markedly. The soil on the left side of the block was a deep medium loam, on the right the soil was practically a pure white quartz sand containing very little clay. The growth of the stock plants was poor in this region but improved gradually towards the left of the area with the change in the character of the soil. There had been considerable difficulty in establishing young plants in the very sandy soil as evidenced by the large number of recently planted supply plants recorded.

In budding on this block the largest number of failures was recorded in the white sand region. With Clone 1, budded in good weather conditions this was clearly shown and in budding with Clone 2 in the drought conditions of late May and June the losses in the same region were heavy. These records are graphically represented in Figure 3.

9. Discussion of Results.

In the foregoing account of results and observations it has been possible to analyse and compare the results obtained in budding in the field under a variety of different conditions.

Given good technique and a reasonably high standard of work on the part of the operators, success depends on two main sets of factors. The first group includes such factors as (a) the condition of the plants to be budded, their state of growth and general vigour during the early stages of the union of the bud and the stock and (b) the condition of the budwood. The second group includes those factors which are best described as environmental and the influence of weather conditions and soil characters will be considered under this head. Failure may be due to a combination of environmental factors and defective material, for example dry conditions may so curtail the growth of the stocks as to make them unsuitable for budding. The distinction between the two sets of factors is therefore not a hard one and a combination of factors of both groups may influence the results obtained.

The results obtained and observations made on stocks of different types in varying stages of growth (Tables II and IV, Figure 2) show the most important factor which influences the success obtained is that of growth vigour. Whether the stocks budded were stumped plants or seedlings the success attained in budding varied in direct ratio with the observed vigour of growth during the important early stages of union of the tissues of the bud patch with those of the stock. In the field, where a small number of stocks are scattered over a comparatively large area, the differences in vigour of growth are far greater than those observed in a nursery established for budding. Under nursery conditions it is possible to choose stocks in the best stage of growth for the operation; under field conditions choice is much restricted and failures are more numerous in consequence.

Budwood from different clones has been shown to give varying degrees of success. This variation suggests inherent differences in the characters of the clones used. From anatomical work at present in progress it appears likely that peculiarities of bud structure may account in part for these differences. For example, examination of samples of budwood of different origin reveals differences in the character of the bud formation. In some cases there is a marked swelling of the shoot at each bud, so that when a bud patch is prepared the inner cambium surface is markedly concave with the core of the bud projecting slightly from the base of the hollow.

When such a bud patch is placed in position against the cambium of the stock this hollow must be filled with new living cells before union can be established. Further, in binding a budding of this type there is more risk of damaging the delicate cambium tissues by uneven pressure and thus reducing the chances of a successful union.

Just as the trees in the ordinary plantation show a wide range of vigour so different clones, each derived from a single mother tree, show similar wide differences. Where budwood is cut from more mature budded trees these differences will be reflected in the quality of the material obtained. Apart from this general variation between different clones differences have been shown to exist between different trees of the same clone (Table V). The reasons for this variation between individuals of the same clone require further investigation. In part they are no doubt due to the normal variation in the vigour of different trees which results from differences in soil character and position but this is probably not the complete explanation. It is well known in other branches of agriculture where budding and grafting methods are extensively employed that the growth vigour of budded plants of a single variety can be greatly modified by budding on mixed seedling stocks. Where budwood is obtained from multiplication nurseries more uniform results may be expected since the differences in vigour which characterise the trees in later years are hardly noticeable in the first year of vigorous growth.

It is evident that the success of the budding operation is dependent to a great extent on the condition of development both of the buds used and the stocks budded. Factors influencing this development will affect indirectly the success of the budding operation. For vigorous growth a plentiful, available supply of water is a first essential and where the supply is restricted, owing to unfavourable weather or soil conditions, growth will be impaired. The results obtained in budding under drought conditions, summarised in Table VI, show clearly the marked increase in the number of failures compared with the number recorded under less dry conditions. The effects of the drought were most marked in plants growing on a loose sandy soil with a low water holding capacity and it is of interest in this connection that the largest number of failures in budding was recorded in the same area (Figure 3). Little can be done in extensive field operations to counteract the effects of drought and budding is best discontinued until conditions become more favourable.

Climatic factors may have a more direct influence on the success of budding operations in the field. On opening a young bud-

ding a partially healed wound is exposed. Unless this wound is protected from direct exposure to the sun rapid drying of the newly formed, wound healing cells (callus) takes place and the bud patch frequently dies. If the operation is not carefully carried out in the first place so that wide gaps separate the edges of the patch from the cut edges of the bark of the stock the danger of loss from exposure after opening is increased. A good fit of patch and panel leaves only a small amount of wound healing tissue exposed and dangers of drying out are proportionately reduced. Careful attention to shading the freshly opened buddings has been shown to reduce the percentage of subsequent losses (Table VII). The split bamboo used in this connection is allowed to remain in position during the early stages of growth of the bud. By this means erect growth of the budding is obtained and the extra support of the bamboo in the early stages of growth prevents losses from mechanical damage.

Summary.

1. In the foregoing the results obtained in a field budding experiment are presented and discussed.

2. The percentage of successful buddings made varied with the three clones used and with the condition of the budwood obtained from different trees of the same clone.

3. Best results were obtained where the stocks budded were in a condition of vigorous growth during the period between budding and opening.

4. There was no significant difference in the degree of success obtained with basket planted seedling stocks and stumped plants where these were well established.

5. By the careful shading of buddings immediately after opening losses from exposure were greatly reduced.

6. Budding under drought conditions gave poor results.

7. The severe check to growth due to dry conditions, especially on a sandy soil, is discussed in relation to the success of the budding operation.

8. Reasons are advanced to account for the lower percentage of success attained in budding in the field as compared with budding in the nursery.

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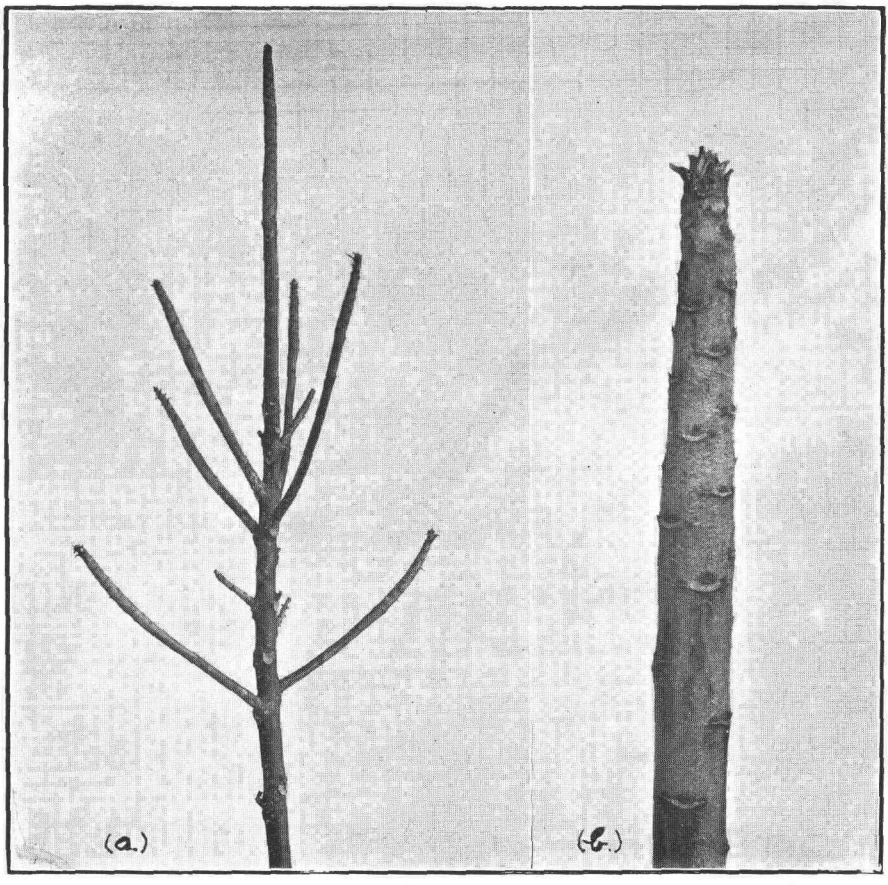
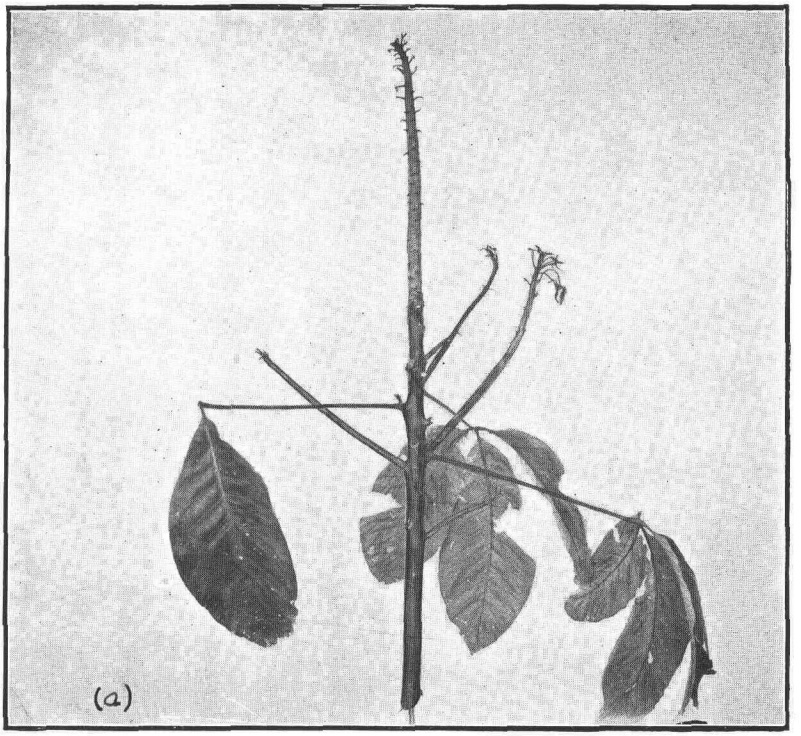


PLATE II.



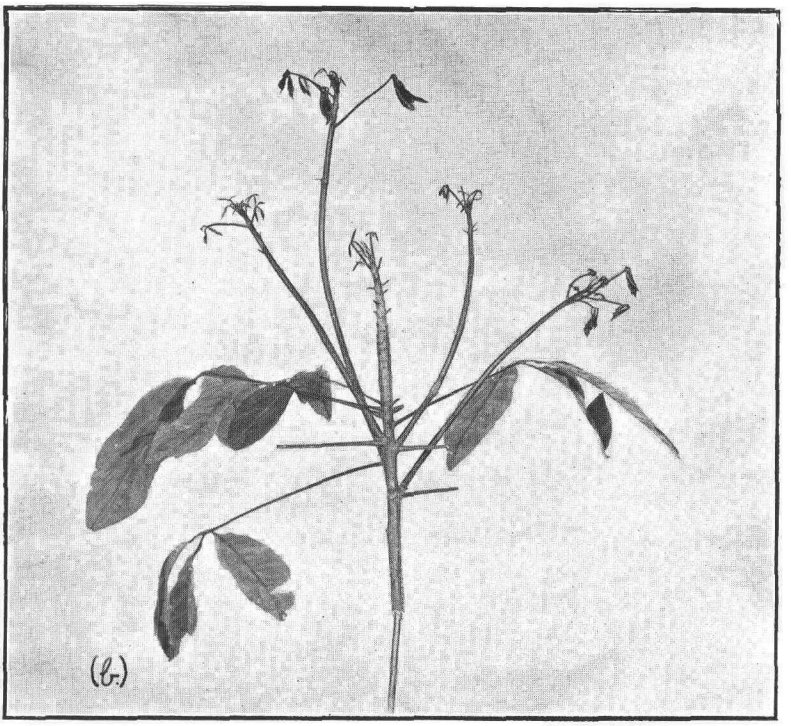


PLATE III.

DESCRIPTION OF PLATES.

Plate I.—(a) Shows the effect of drought conditions on the growth of a young rubber plant. The main shoot and lateral shoots show much restricted growth and numerous small buds in a close spiral formation are present.

(b) Detail of abnormal bud formation on the terminal shoot of the seedling shown in (a).

Plate II.—(a) Further example of the drought effect described in the text.

(b) Recommencement of growth. The terminal shoot grows slowly and vigorous young lateral branches are frequently developed.

Acknowledgment.

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