Thesis presented for the degree of Doctor of Science by

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Studies in the Morphology, Anatomy and Physiology of the Mango Inflorescence and Flowers.

Introduction:

Our present knowledge of the inflorescence and flowers of the mango (Mangifera indica, Linn.) is not extensive. Engler, J.D.Hooker, Cooke, Talbot and others have devoted short spaces to these subjects in their systematic works. Horticultural writers such as Woodrow and Firminger in India, and, later, other writers in America have given little that is precise on the question. The anatomy of the inflorescence as distinct from that of the vegetative axis does not appear to have received special attention, and details regarding the biological phenomena of the inflorescence and flowers are wanting.

It seems, then, that the mango inflorescence and flowers are very fit subjects for more accurate investigation.

The work here described has been done on cultivated varieties of Mangifera indica, and on unnamed "country" trees of that species. The varieties referred to differ mainly in the shape, size and flavour of the fruit. These need not be gone into in detail here. Where differences in the inflorescense and flowers of different varieties exist they have been mentioned.

The paper has been called "Studies" because it ~~makes no pretence of completeness~~ does not profess to be complete. It is, indeed, merely a breaking of ground for more definite knowledge.

The practical aspects of the questions here discussed are important. We cannot devise rational systems of pruning or forcing until we know more of the positions and times of appearance of the inflorescences. We cannot be successful in crossing the flowers till we know more of their behaviour in natural pollination. Fruits fetch higher prices at unusual seasons , and the investigation of untimely flowering comes into this research. From the point of view of the plant breeder the matter is also important. As Piper in his retiring presidential address in 1910 to the Botanical Society of Washington said " One must at least know all the botany possible of the plants one is immediately concerned in breeding, lest one be lured into needless error." (Science, June 10,1910)

The inflorescence and flowers of the mango have an Indian mythology of their own. I need not go into this here. It is summarised in Pharmacographia Indica Vol. 1, p.382.

Morphology of the Inflorescence.

The normal inflorescence (Herbarium specimen 1, photo (1)+(2) 3&4) consists of a straight or slightly curved main axis , from which secondary axes arise in acropetal succession. The secondary axes are longest at the base of the main axis , and the general form of the inflorescence is that of a pyramidal panicle. Each secondary axis bears on it tertiary axes in acropetal succession. Each of these tertiaries is a repeated biparous cyme, each successive branching being in a plane at right angles to the ~~previous~~ below one. At the very top of the main axis even the secondaries become simply biparous cymes. Finally the tip of the main axis and the tips of the secondaries each terminate in a flower. The main and secondary axes go on elongating for some time, and the terminal flowers do not appear till the end of this growth. While growth is proceeding the tips of the main and secondary axes are covered with small unopened flower buds within their bracts.

With the exception of the main axis in a terminal inflorescence, each grade of axis has its bracts, which are normally caducous . There is a transition from the budscales to the bracts in shape. The lower bracts of the main axis being spathulate , the upper linear lanceolate , decreasing in size.

On axes of still ~~lower~~ higher grade the bracts become mere linear scales . Occasionally the bracts become foliar; this is referred to later .

Wester in "The Mango"(Bulletin 18, Bureau of Agriculture, Philippine Islands, 1911, p_17) erroneously speaks of "the small ~~terminal~~ racemes that make up the terminal panicle". If he is referring to the secondary axes he should call them racems of biparous cymes and not simply racemes.

The folowing are actual details of a typical terminal inflorescence from tree Alphonse 37 in the Ganeshkhind Botanical Garden, Kirkee :

Main axis 27cm.long,1 cm.thick at the base and 1 mm_ at the top, roughly ~~circular~~ terete with three indefinitely marked faces, glabrous for the lowest 11 cm., hairy for the rest of the length, most hairy just at the apex. Colour yellowish - green with a wine-red tinge on the surface that was nearest to the light. Scars of budscales at base, and some ovate - acuminate shrivelled budscales still persisting. The diverg- ence of the secondary axes 3/7. The number of the secondary axes 51, of which the last ten are very crowded and minute. Secondary axes hairy especially in the upper halves. The ~~long lengths~~ lengths of the secondary axes and distances between them are as follows :

Sec.axis.	Length.	Distance between secondaries
1	2.5 cm_	
		2 mm
2	4.0	
		2
3	9.5	
		2
4	12.0	
		1.8 cm.
5	12.0	
		1.0
6	15.5	
		2.0
7	4.8	
		2.4

The divergence of the secondary axes in the above example was 3/7. The divergence of 2/5 is also found in other cases, and sometimes the divergence cannot be classified.

Development of the Inflorescence.

The normal inflorescence is at first a small bud of the average size of 0.5 cm. broad and long, completely covered by bud scales. The outer 4 or 5 scales are triangular, elongated, blunt-tipped and hard, about 0.5 cm.long. The inner ones are triangular to ovate - acuminate, about 7 x 7 mm. and with a midrib. These scales fall off soon after the extension of the axis. Figures 1,2,3,4, and 5, and photos 1,2,and 3 represent stages in the development of the inflorescence. The figures are all of the same inflorescence, the photos of more than one . The following are descriptions of the stages represented in the photos.

Photo.3. Length 5 cm, 4 brown scale leaves remaining ,27 bracts on main axis , 26 with secondaries in the axil, all green, at tip a mass of buds and bracts. No red colour yet developed in the axes.

Photo.4. Length 19 cm, scale leaves off, bracts fallen save at the very apex of the main axis, 28 secondary axes visible and then a terminal mass of buds and bracts. Red colour now developed on exposed sides of secondary and main axes. The first node of each secondary axis much elongated, other nodes still condensed.

Photo.1. Length 28 cm, no scale leaves, a few small bracts at upper nodes of main axis , 53 secondary axes, and then a terminal mass of buds and bracts, upper parts of secondaries much elongated, many flowers open, red colour on exposed sides of main and secondary axes.

The three photos. were from inflorescences taken on Jan.9,1913 from one tree, Alphonse 36, in Ganeshkhind Garden.

The following figures summarise observations as to the time required for an inflorescence to develop:

Tree examined, Alphonse 34.

Bud terminal or axillary, T stands for terminal, and A for axillary.

Length in cm.

Bud.	Date Jan9.	Jan.16.	Jan.28.	Feb.6	Mar.3.		Branch
T.	Bud scales expanded	8 cm	20	32	33	7 fruits	1.
A.	"	8	22	32	34	3 "	
A	"	7	19	31	32	2	
A	"	7	18	29	30	0	
A	"	3	14	19	19	0	

Opening of flowers began on Feb. 6 & ended on Feb. 21. i.e. no flowers opened after that date

Bud.	Date Jan9.	Jan.16.	Jan.28.	Feb.6	Mar.3.		Branch
T	Bud swollen. scales not expanded.	5	17	Feb.5. 30	33	?	2.

Flowering began on Feb 5. No flowers opened after Feb.21.

Bud.	Date Jan9.	Jan.16.	Jan.28.	Feb.6	Mar.3.		Branch
T	Opened: bracts seen.	5	18	Feb 5. 32	34	7	3
A	swollen: unopened	3	12	22 fell off			
A	dormant	1	5	10	12		
A.	dormant.		2	fell off			

Opening of flowers began on Feb. 5.

Bud.	Date Jan9.	Jan.16.	Jan.28.	Feb.6	Mar.3.		Branch
T	swollen: unopened	5	17	Feb 5. 30	32	9	4
T	"	2	8	Feb 8. 22 (6 fls. open.)	26	3	5.

Bud.	Date Jan9.	Jan.16.	Jan.28.	Feb.6	Mar.3.		Branch
T.	opening.	3	10	Feb 5. 26	31	7	
A.	"	3	11	28	31	5	6
A	"	2	8	22	24	0	
A	dormant	1	6	19x	22	0	
A	opening	3	14	29	34	0	
A	~~dormant~~ "	2	8	14	fell off		

Flowers opened on Feb 5 except in case of x. which was late

Bud.	Date Jan9.	Jan.16.	Jan.28.	Feb.6	Mar.3.		Branch
T	opened	3	10	Feb 7. 26	30	17	
A	"	3	11	24x	28		7
A	"	2	10	27	30		
A	"	2	9	25	26		
A	"	2.5	9	24	24		

Flowers opened on Feb 7 except in case of x which was late

Bud.	Date Jan9.	Jan.16.	Jan.28.	Feb.6	Mar.3.		Branch
T	"	2	8	Feb 6. 23	26	2	8.

Flowers opened on Feb. 6.

			Feb.	Feb 8.	
T	opened	11	23	26	1
A	"	9	18	20	
A	"	9	21	25	
A	"	11	23	27	1
A	dormant	5	14	fell off	

9

Flowers opened on Feb 8.

T	opened	6	12	12

10

Flowers opened on Feb 8.

We thus see thatthe time from the beginning of the swelling of the inflorescence till the ~~development of the fruit~~ opening of the flowers is from 27-30 days and the time until the flowering stops in an inflorescence is 43 days in the two cases in which this latter observation was made. These observations were made in 1913. It is interesting to compare with them the observations made on the inflorescence drawn in the figures, in 1910. These observations were.

	Length				
T.	Dec.20	Dec.26,	Dec. 29.	Jan 4	Jan 18.
T.	1 cm.	3	4	7	31

that is, the time from the bud attaining 3cm to it attaining its flowering period was 24 days., approximately the same time as in 1913.

Position of the Inflorescence.

In the majority of cases the inflorescence is terminal on a vegetative shoot. Axillary inflorescences however are common, as the following table will show :

Date.1913.	Tree.		Terminal	Axillary.
Feb.15-17	Pairi	152	685	22
Jan. 26-28	"	196	1624	371
Jan. 29-31	"	238	1086	313
			3395	706

that is , in these three trees 17.3 per cent of the inflorescences were axillary. A considerable proportion of axillary inflorescences is commonly noticed in ~~casual~~ casual observations of any plantation.

plantation, and yet all the books that describe the mango, state that the inflorescences are terminal!

The production of ~~terminal~~ axillary inflorescences is stimulated by the ablation of the terminal bud of a branch or by damage to the terminal inflorescence after it has developed. Axillary inflorescences however frequently arise at the same time as and just below a terminal inflorescence. They may arise also just below a terminal inflorescence but much later than it. This was specially observed in February 1913 in a garden at Trombay. In this garden terminal inflorescences occured in September 1912. Many of these were labelled for future observation. When the garden was revisited in Jan .1913 these were found to be bearing fruit, and axillary inflorescences had arisen from near their bases.

Similar cases were observed in the Ganeshkhind and Empress Gardens Poona, and the photos of these are nos. (6) and (5). The explanations of the photos are on pp 37.-38.

The age of the vegetative shoots on which the inflorescences, both terminal and axillary, occur, varies considerably, and so far there appears to be no law in the matter. A mango tree of middle age, say 20 years, in normal conditions produces new vegetative growths three times in the year , viz. the cold weather growth (October, November), the hot weather growth (March-May,) and the rains growth (July-August). These growths do not necessarily succed one another on the same branch. One branch may develop its growth in the cold weather , another in the hot weather and another in the rains. Inflorescences have been found to occur on every one of these growths.; that is, the inflorescence , which in Poona usually appears in December, may be on wood that is only one or two months old, or on wood of any of the older growths, or even on branches that have ceased growing in length for some time. Axillary inflorescences may even arise on thick bark-covered branches, especially if the end of the branch has been removed, or if the branch is decaying. For example, in 1911 a tree in Ganeshkhind Garden of the Shahabuddin variety produced an axillary inflorescence on a branch 10 cm in diameter. The production of this inflorescence was stimulated by the complete pruning off of the end of the branch six months previously. At, Pashan, a village near Poona, I noted a similar case in Feb.1913. In this case an axillary inflorescence arose from a moribund branch 7 cm in diameter. In the Bassein Botanical Garden in the same month I noted a parallel case on another dying branch, and other examples have been noticed. The following table gives an idea of the proportion of inflorescences borne by the various growths.

Tree Kavasji Patel 66. Labelled at 114 places on March 14,1911/on vegetative growths bearing inflorescences of 1911. Growth followed in April - May 1911 (hot weather growth,) in the cold weather of 1911 also, none in 1912,and in Feb.1913. Inflorescences in 1913 occurred as follows :

On cold weather growth of November 1911.	73	in 1913 (T = terminal inflorescences)
On axillary cold weather growth of Nov.1911 produced below site of inflorescences of 1911	2	T in 1912
Vegetative growths	28	
Axillary inflorescence of 1913 below site of inflorescence of 1911	1	A = axillary "
Branches off	10.	

Here we have a year of comparative rest in reproduction followed by the appearance of inflorescences on the wood that was matured about a year before. The wood of the same age however in two cases produced inflorescences in the preceding season, and in one case the wood that produced the 1911 inflorescence also produced the 1913 inflorescence.

Tree Shahbuddin 41.

Labelled at 27 places in April,5, 1911, on branches that had borne inflorescences in Jan. of that year.the only succeeding growth was that of the hot weather of 1911(May) The following were the observations :

Inflorescences of 1913 on hot weather growth of 1911	13
Terminal Vegetative growth of 1913 on hot weather growth of 1911	1
no growth of any kind	6

Hot weather growth of 1911 followed by no other growth	6
Branches off	1

Here in this tree the inflorescences of 1913 appeared on wood that was six months older than that on which the majority of the inflorescences in the last tree appeared.

Tree ~~Raiar Raiar~~ Pairi 414.

Labelled on April 27, 1911 at 33 places. This tree produced hot weather and cold weather growths in 1911. The following were the observations :

Inflorescences of 1913 on hot weather growths of 1911	~~2~~ 7
Inflorescences of 1913 occurring just below the inflorescences of 1911	3
Inflorescences of 1911 followed by no growth	2
" " " " vegetative growth only	8
Branches withered	13

This is in the main similar to the last tree.

Tree Pairi 303.

Labelled in rains of 1912 at 139 places on rainy season growth. Observations :

~~Rainy season growth~~

Inflorescences of 1913 on rainy season growth of 1912	60
" " " cold weather growth succeeding the rainy season growth of 1912 (see Photo. ~~62B~~ (4))	1
No growth	78

In this case, with only one exception, the inflorescences appeared on the rains growth. In the exception a vegetative cold weather growth was interpolated.

Tree Pairi 305.

Labelled in the rains of 1912 in 207 places.

Observations :

Inflorescences of 1913 on rainy season growth of 1912	63
Vegetative growth of 1913 on rainy season growth of 1912	2
No growth	142

There was no cold weather growth on this tree and the tree had borne no inflorescencesin 1912. The rainy season growth was in this case the only one that bore inflorescences at all.

Tree Shahabuddin 64.

Labelled in the rains of 1912 at 243 places .

Observations :

Inflorescences of 1913 on rainy season growth of 1912	40
No growth	203

Here again the only growth producing inflorescences was the rainy season growth.

The cases given above are only a few to show that the inflorescences may be borne on the growth of any of the seasons and on ~~considerably old wood~~ wood of considerable age. It would seem that the age of the wood on which the inflorescence is to be borne is entirely a question of the individuality of the tree or even the branch. What determines the production of growth at one season and not at another on any given branch is a thing yet to be investigated. (See Schimper. Plant Geography. p.350.)

In Bassein Botanical Garden I noted that shaded low-down ~~or~~ branches frequently produced inflorescences before higher branches. This is noticeable in photo. ~~100B~~ 29 where the fruits have set on the low branches only. Withering and wounded branches often bear inflorescences first.

It is of course not the case, as has been already demonstrated, that at the flowering season all dormant buds that grow

* The occurrence of a terminal inflorescence however by no means prevents the occurrence of axillary inflorescences next season at its base. (see photo ...)(11)

out become inflorescences. In Ganeshkhind Garden in the end of 1910 ,407 buds were labelled on one tree. They developed as follows :

Remained Dormant 12

Destroyed 57

Produced vegetative growth 51

" normal inflorescences 284

" abnormal inflorescences 3.

The percentage of inflorescences in this case is 70.5 and of vegetative growths 12.5 One cannot of course say what the buds destroyed (by insects) would have become.

In 1912, on tree Pairi 71, 47 buds were similarly labelled All these became inflorescences. In 1913, three more trees were similarly labelled . Results

Tree.	Veg. Growths	Normal Infls.	Abnormal Infls.
Pairi 152	193	707	61
" 196	457	1995	
" 278	282	1399	
	932	4162	

The percentage of inflorescences is here 81.8 and of the vegetative growths 18.2

It Is worth noting that buds side by side on the same branch may develop some into vegetative and some into flowering growths. In Pairi 306 in 1912 five consecutive buds on one branch developed simultaneously , 3 becoming vegetative, and 2 flowering. (Photo 8) (to 9) / 10 shows a "transition form" (see p. 31) in addition

In a country tree in Bassein Garden in 1911 the bud at the tip of the shoot had been somehow spoiled. Five axillary buds behind the tip developed . Nos 1_2_3_ and 5 in order of nearness to the tip were inflorescences, but no.4 was vegetative. Many similar cases have since been observed.

The habit of the mango tree is largely determined by the fact that the terminal growth of all shoots is periodically stopped by the formation of a flowering growth, which afterwards disappears. The axillary buds are then stimulated into

* The occurrence of a terminal inflorescence however by no means prevents the occurrence of axillary inflorescences next season at its base. (see photo. 11)

growth. A repetition of this gives the characteristic dome shaped crown. (See ~~sketches~~ Figures 6, 7, and 8) *

While grafted trees do not ~~usually~~ usually flower till the third year at least after planting , flowers occasionally occur on the scion shortly after union. Thus in Ganeshkhind Garden a Pairi scion was tongue-grafted by approach on a 2½ year old country stock in a pot on Aug.12,1911. The scion produced inflorescences in January 1912. In Bassein Garden an Alphonse scion was whip-grafted on a country stock in June 1912. Flowers appeared in February 1913. A Sakharia scion behaved similarly. In no case was there any growth of the scion before the production of the inflorescences. These are only a few cases. Others are shown in photos. 12, and 13

It would seem then that the nature of the bud is determined at a very early stage of its formation. Once formed any stimulus to grow will result in the production of what is formed already even though the production of the inflorescence at that stage would be to the disadvantage of the tree, as it certainly is in the case of a newly grafted plant.

Relation of the Inflorescence to Light.

Illumination has no effect on the actual number of inflorescences on any given side of a tree, but it affects the time of their appearance. In the Ganeshkhind Garden the shaded side of any mango tree was the last to flower, and in trees standing free of shade the north side was the last to flower. For example, in Alphonse 36 the first appearance of the inflorescences was on Jan.5,1913 the last on that tree for that season was on Feb.6 on the north side.

The terminal inflorescences are positively heliotropic and soon take up a fixed light position with ~~regard~~ to the main axis parallel to the rays of strongest incident light. The inflorescence axis is usually parallel in one of the vertical planes to the vegetative shoot on which it arises, but it bends up where necessary. In the Empress Gardens, Poona, in a plantation of tall trees, the inflorescences on the lower branches bent up much more steeply than in plantations of shorter trees in Ganeshkhind Garden. (See figures 9 and 10) When the inflorescences grow long and heavy they tend to droop, and the positive heliotropism disappears. Finally when the inflorescences are weighed down by heavy fruits they point to the ground.

Light affects the colouration of the axes in certain varieties. Pairi and Alphonse both become red on the exposed sides of the axes. The Alphonse has somewhat the deeper colour. Shahabuddin becomes deep red on all sides of the axes. Salghat and Kavasji Patel show no red colouration whatever. These differences are in some degree correlated with the amount of blush on the fruits of these varieties.

Time of Flowering.

In the neighbourhood of Poona inflorescences begin to appear annually about the end of December. In Trombay on the coast near Bombay, they appear as a rule in the end of November. In Ratnigiri, farther south, also on the coast they are quite as early. Mango fruits from Madras come into the Bombay Market practically all the year round, which connotes an equally extended flowering season. There is a variety of mango termed Baramashi -"The Twelve Month"-signifying its character of flowering all the year round. The main flowering season however is round about the beginning of the year. This is the time observed also in the United States and the Philippines.

On Jan 22, 1913 the Acting Agricultural Explorer in Charge United States Department of Agriculture wrote me as follows:

"The period at which the mango flowers in Florida varies more or less with the seasonal conditions. This year a few trees were in bloom in December. However under normal conditions the first blooms appear some time in January, the last some time in March. Very often there is a second flowering season in June. The mango appears to be very erratic in regard to its time of blooming. A protracted drought followed by a soaking rain, or, in fact anything that causes a severe check to the growth of the tree is apt to force it to bloom "

The Horticulturist, Bureau of Agriculture, Philippine Islands wrote me on Feb.19 1913 as follows "

"I take pleasure in informing you that the earliest varieties that I have seen come into flower late in December and early in January. I have not noted when the first flowers of late varieties appear. In Florida I have never noticed untimely flowering of the mango i.e. any flowers coming later than early in May. In the Philippines however it seems that very rarely mango trees will burst into bloom suddenly almost any time of the year. This of course provides for a few mangoes during the better part of the year also. I have unfortunately not had the opportunity to note whether this habit of flowering at unusual times is a regular feature of such trees ".

In the Bombay Presidency, besides the January flowering one other well marked flowering season is sometimes observed. Attention to this matter has been drawn by one of my ex-students, Mr. K.V.Tamhankar, B.Ag., in a note in the Agricultural Journal of India Vol.7,4,p.399-402. He suggests a classification of trees into (1) those that flower every alternate year (2) those that flower every year (3) Those that flower in September - October, or both in January and September - October. His first class is based on the belief that each alternate year the crop of mangoes is small. While there seems to be some likelihood that this is the case, there are as yet not sufficient reliable figures to make a positive statement. September flowering moreover is not entirely conditioned by variety. In

September, 1912 , an unusually large number of mango trees in various parts of the Presidency produced flowers. The climate of the previous months was as follows :

Rains 1911: Poor rains with a great burst in October-November

Cold weather 1911-2 : Normal, Mango flowering poor.

Hot weather 1912. : Very hot and dry.

Rains 1912. Rains delayed, they burst in the end of July, then a break, then heavy rains in August again.

We have here conditions similar to those cited in the letter from the United states Agricultural Explorer, viz., poor flowering previously, considerable check by heat, and then sudden moisture in excess.

One tree in the Basin taluka of Ratnigiri district blossomed in the first week of Sept.1911 and produced fruit in November. It was a seedling tree. This tree blossoms every year at this time.

Near Dharwar, in 1911 , I saw a mango tree flowering in September, It had never before been known to flower at that time of the year.

In a garden at Trombay many inflorescences appeared in September 1912 and formed fruits.Quite close to them , new inflorescences, both axillary and terminal, occurred in January 1913. Similar cases have been observed in the Ganeshkhind Garden. (See photo 64B) In the same Trombay Garden it was remarkable to see that many individual Pairi and Alphonse trees went on flowering from the beginning of December 1912 till the end of February 1913. On the same tree all stages from unopened flower buds to fruits of the size of a pea were observed. The owner of the garden stated that the flowering sometimes goes on till the end of March. Fruits are thus available in this plantation from end of March to end of June.

Inflorescences may be formed even as late as April, and that in close proximity to fruiting inflorescences. see photo ~~89 B~~. 5.

That this phenomenon of the double flowering season is not confined to India is shown by the following extract from the Annual Report of the Hawaii Agricultural Experiment Station for 1908, p. 47.

"The season of the flowering of the mango~~xhas~~ in Honolulu has been noted with interest for several years. A record has been kept of the first flowers.observed which appeared to be the beginning of a general blooming season, disregarding the few flowers that may appear at almost any time. The record of the beginning of the season has been as follows: January 1 to 10, 1906;December 10 to 12,1906;November 15 to 20,1907; and February 15 to 25,1908. Attention is called to the fact that for three successive years ~~the~~ each season of flowering has been nearly one month earlier than in ~~h~~ the preceding year. For the mango crop of 1908 there were two seasons of quite general blooming among the mango trees of Honolulu , the first being in November and the second in February. It will be observed that a period of three months is thus covered which is in marked contrast to the seasons of flowering where climatic conditions are more sharply defined. "

In the Deccan the pomegranate , guava, and all the citrus species and varieties have three flowering seasons, termed <u>bahars</u> . These are the Amba Bahar (~~Xm~~ January), the Mrig Bahar (June) and the Hatti Bahar (September). Trees can be forced to flower at any one of these seasons by stopping water for some time and exposing the roots of the trees, at the same time pruning off some of the side roots. A similar treatment was given to some mango trees in 1911. The roots were exposed as in photo. 表 14. The result of the treatment was negative. Very few inflorescences followed and these were not early. On one tree they appeared in Jan.26,1912 and on the other on Feb.6. In the trees used as controls the inflorescences appeared on Feb.6.

Woodrow (The Mango p.14) says

"The mango growers near Mazagaon, Bombay, who produced such famous fruit before the land was occupied with cotton mills, applied ten pounds of salt to each tree at the end of September, this would arrest growth during October and November, and encourage the formation of flower buds. In a moist climate and the intervening ground occupied with irrigated crops, this system is highly commendable, but with a dry climate is unnecessary."

To test the effect of salt manuring at Poona, experiments were made in the seasons 1911-2, and 1912-3 at the Ganeshkhind Garden. Four trees each received ten pounds of salt and four were kept as controls. The salt manured ones showed no advantage either as to early flowering or early ripening. The number of fruits from the salt manured was, in 1913, 576 and from the controls 606. In both cases the countings were done after severe windfalls. The application of salt in Poona has therefore so far had no effect. It is ~~probable~~ necessary that Woodrow's explanation of the action of the salt ~~is mere theory.~~ should be tested on plantations near the coast.

Morphology of the flowers.

The flowers of Mangifera genus and of Mangifera indica have been described by Engler in Monographiae Phanerogamarum vol.4, p.125, and by many other botanists. There is no need therefore to go into a very detailed description of them, but it is desirable to recall the features of the normal flowers for comparison with the variations that will be cited later.

In Mangifera indica the flowers are male and hermaphrodite. Sepals five, polysepalous, green, hairy; petals five, polypetalous alternating with the sepals, white with a trifid yellow stripe; stamen one, staminodes indefinite, stamens and staminodes attached to the inner face of a five lobed nectarial disc; ovary one-carpelled with simple style attached slightly to one side of the ovary, stigma simple; ovule anatropous attached to the side of the ovary. Figure 01 shows the floral diagram of a normal flower. The male flower is the same as the hermaphrodite, without the ovary, or rather with only a rudimentary papilla in its place.(See tubes N.1 to N4)

The following are , I believe, new facts concerning the flowers :

There is a distinct tendency for the corolla to become zygomorphic due to the formation of a wider angle between the two anterior petals. This has been observed in a great number of flowers. (See floral diagram O2)

The male flower always has a reduced ovary represnted by a ~~pap~~ papilla (See tube N3)

The variation in number of parts per whorl is very considerable In tables 1, 3 & 4 this is clearly shown. From January 24, 1913 observations were made of the number of flowers with unusual numbers in the whorls. This was done because on that date several four-petalled flowers were noted in the inflorescences under examination. In the inflorescence examined in Pairi 196 the percentage of four petalled flowers (in four and five petalled flowers taken together) was no less than 37.8 in the dates Jan 24 to Feb.3. In the inflorescence examined in Alphonse 37 the percentage for a similar period was 43.7. It ~~appears~~ appears that in the axes of the higher grades 4 petalled flowers are common. These 4 petalled flowers have four sepals in most cases(See tube V1)

It should be explained that the above cited tables were got in this way : An inflorescence of Pairi 196 and one of Alphonse 37 were chosen. Each day all the flowers open were cut off and their character noted. The flowers on the lower grades of the cymose axes were therefore the first to be removed. It was only after the higher grade axes were reached that the four-petalled flowers began to appear.

Increase in the number of petals is also common. In the inflorescence of Pairi 196 above examined five 6-petalled flowers were found, but none in the Alphonse inflorescence , though such flowers do occur in the Alphonse variety. In the Alphonse inflorescence however two flowers were found with only three petals each. In the Bassein Garden there is a country tree in which 6-petalled flowers are the rule, and on which there are many with seven petals. Table 1 shows the actual variations found and their frequency. Many of these have been preserved in tubes V, N, and T, all numbers.

The twin-forms are specially interesting. Some are undoubtedly due to the fusion of two adjacent flower rudiments (nos. 30, 31, 32, 34, 35. See tubes T1, T4) In others, (nos. ~~25~~ 8, ~~26~~ 9 and ~~27~~ 10 in the table, and tubes T6, T11) it may be assumed that we have a reversion to the larger number of carpels in an otherwise normal flower, as in the more primitive Anacardiaceae. It is noticeable that in these there is only one fertile stamen, whereas in all the other twin forms but one there are more than one fertile. The inference that the two twin types are essentially different in nature is thus strengthened. The first type is two flowers joined, the second is a primitive flower.

A phenomenon which I have termed that of <u>intrusive petals</u> is also fairly common. This consists in the development of one or more extra petals between the lobes of the disc, or at least to the inside of the line of the petals. (See tube V2) These intrusive petals may be variously situated with regard to the symmetry of the flower. Diagrams 03 and 04 show actual cases.

The number of members in the androeceum is very variable. As a rule there is one fertile stamen, <u>always the anterior</u>, but the number and degree of development of the staminodes varies enormously. Additional fertile stamens occasionally occur. In Pairi 196, in the inflorescence recorded in the table two cases of flowers with two stamens each were found. Many such cases will be seen in table 1

The staminodes vary in shape from the merest papilla to a full grown antheriferous stamen. Table 2 gives some idea of their variation.

Certain country trees have a large proportion of staminodes with coloured though sterile anthers. Considering the structure of the androeceum in the Anacardiaceae, especially in Anacardium itself, it seems probable that we have in such trees a less evolved androeceum, near the ten stamen ancestral type.
The pollen grain is oval in outline. Fig 11. The size of the grains is 40µ x 30µ. The walls are without thickenings or spikes. The contents are grey and granular. What look like two germpores appear on the two longer sides of the grain. The colour of the unripe anther is deep crimson and of the ripe anther blue.

The nectarial disc is divided into five lobes by deep grooves. Smaller grooves occur partially subdividing some of these lobes, and there are irregular indentations on the outer faces of these lobes in which the honey collects. It is noteworthy that in abnormal inflorescences the disc is always swollen. In some inflorescences this swelling of the disc is the only sign of abnormality.

Position of Male and Hermaphrodite Flowers on the Tertiary Axes.

In the Alphonse and Pairi varieties the terminal flower of a tertiary axis is always hermaphrodite. The proportion of male flowers increases as the axes of the cyme subdivide. Take the following actual example of a tertiary axis from an inflorescence of Alphonse, as far as it could be examined. (Figure 15)

The following is an analysis of the ratio of ☿ and ♂ present in seven such tertiaries from two different secondary axes of the same inflorescence.

	Axes.		
	1st. Grade.	2nd.Grade.	3rd.Grade.
☿	4	9	9
♂	0	4	21
missing.	4	3	2
Percentage of ♂	9	30.8	70

The same fact is borne out by a study of the figures given in tables 3 and 4. On the first day the ♂ were 24.8 per cent of the total flowers. On no succeeding day were the ♂ flowers fewer than the ☿, and the average percentage for the succeeding days is 74.2

In the Alphonse inflorescence similarly studied, the percentage of ♂ on the first day was 21.2, and for the rest of the time averaged curiously enough again 74.2.

In the diagram given in Fig 15. I have traced the sex of the flowers only to axes of the third degree. This was the furthest extent to which I could be sure of the sex of the flowers. As shown in slides 035/0 (7), 042/13 (8) 138b (17) the anther develops early, but the ovary is so small in the young flower that it is easy to confound the sexes at an early stage. I traced the branching in some tertiaries to see to what extent the cymes subdivided and found that they went as far as axes of the sixth degree.

The proportion of ♂ and ☿ does not seem to be the same in all varieties. In Pairi and Alphonse it is nearly the same. Kavasji Patel however seems to have an even greater percentage of ♂ flowers but I have not confirmed this by numerical tests.

We can now calculate roughly the number of flowers on a tree of middle age, say 20 years old. From my statistics we can calculate on an average of 1000 inflorescences on such a treeand 2800 flowers per inflorescence of which 2000 would be ♂ . This makes a total of 2,800,000 flowers per tree of which 2,000,000 are ♂ and 800,000 ☿ . In this connection it is worth referring to Curtis ' Botanical Magazine, vol.6, 3rd series, 1859 in which the following statement is quoted from the Gardeners' Chronicle ofApril 6,1850 :

" The Gardeners' Chronicle of this day April 6,1850 gives the number of heads or panicles of flowers on a plant at Sir George Haunton's, Leigh Park, namely 108: the number of flowers on each panicle is on an average 2100, and the whole number of flowers was estimated at a quarter of a million, of which(as is usual even in tropical countries) only a very few ripen fruit. "

The number of flowers per panicle estimated independently in the two cases(mine and the Gardeners' Chronicle) is sufficiently close to be remarkable.

The number of fruits produced from the 800,000 flowers is according to my experience only about 1500 at the outside. This can be accounted for by taking into account the facts that (1) many flowers are knocked off ,
(2) many flowers do not set
(3) the tree can only nourish a limited amount of fruit and probably naturally prunes and thins its own fruits.

POLLINATION.

In Knuth's Handbook of Flower Pollination Vol.2,p.258 under Anacardiaceae only a few notes on Rhus are given. Engler in Die Naturliche Pflanzenfamilien vol.5,p.142 gives the following short note on the pollination of the Anacardiaceae as a whole.

" Schon der Umstand , dass es bei den meisten A. zur Bildung von ♂ und ♀ Bl. gekommen ist und dass zwischen den eingeschlechtlichen die ☿ wohl auch als morphologische Übergangsstufen existieren (man vergleich. z.B. die Bl. von Cotinus coggygria Scop. x x) aber nicht geschlechtlich functionieren, weist darauf hin, dass

Selbstbestäubung in dieser Familie jedenfalls nur eine untergeordnete Rolle spielt. Ferner kommt hierzu , dass wir in den Bl. mehrerer Gattungen eine entschiedene Begünstigung der nach vorn gelegenen Teile finden. ....Bei Mangifera jedoch entwickelt sich das vorn stehende Stb. allein kräftig und nahert hierbei seine A. der N. Wahrscheinlich findet hier Dichogamie statt und wahrscheinlich erfolgt die Bestaubung durch Insekten, die mit demselben Körperteile in der einen Bl. die N. berühren, mit welchem sie in der anderen den Pollen abgestreift haben. Dies muss in den Tropen festgestellt werden. "

The following are my own observations and conclusions. The flower is undoubtedly entomophilous, designed for short-tongued insects. Honey is secreted in considerable quantity from the disc and there is a peculiar odour the source of which I have not yet discovered. The honey is often spread all over the surface of the petals, showing that secretion begins before the flower opens. Flies (Psychonosma and Pyrellia spp) are the chief visitors and a tree in full flower fairly hums with them. Ants crawl over the flowers and steal the honey to some extent but probably do not assist pollination much.

Self pollination is possible. In many cases I have noted flowers with the stigma and anther very close together or in actual contact. This is not by any means the rule . The anther and stigma generally stick out away from each other in the open flower. In some cases where contact was noticed pollen grains had actually been deposited on the stigma and style. In 1911 inflorescences of Kavasji Patel were enclosed in bags while in bud and kept so during the whole of the flowering time . Several fruits set, showing that pollination of some kind takes place without the intervention of insects.

As to the question of dichogamy: the hermaphrodite flowers are protogynous . The flowers open and remain open some time with the nectary actively secreting and the stigma fully exposed before the anther bursts. In several cases I have seen this condition of the flowers with the pollen grains on the stigma and in one case with the stigma withering and the ovary fertilised, though the anther was still unburst.

There are no scientific data as to whether crossing takes place between varieties or not. It is believed in this part of India that one can never be sure of the produce of a seedling mango though it is raised from the fruit of a first class variety. It is assumed that this is due to crossing with inferior varieties.

During 1911,1912, and 1913 ~~myself~~ I and my assistants did several crossings between varieties using the methods described in Bulletin 167, Bureau of Plant Industry , U.S. Dept. of Agriculture, " New Methods in Plant Breeding " by Oliver. In this method one cleans the pollen out of the flower by a fine jet of water instead of mutilating the bud by emasculation with scissors. The following are the results :

1911 : 142 crosses made between different varieties. The severe frost of February ,1911 wrecked this experiment. 23 crosses set, but none finally survived.

1912. Inflorescences few so crossing on a smaller scale, 17 only done. 3produced fruit of 25 mm. diameter each. These all dropped later.

1913 : 120 flowers crossed in February 1913. Of these 15 developed into fruits the size of a grain of millet but later these dropped.

All attempts at artificial crossing have so far been unsuccessful. This is not to be wondered at considering the few flowers that set in the ordinary way of fertilisation and the lavish pruning of these that goes on in nature.

The slides referred to have two numbers, one on the label in ink, and one on the glass in yellow crayon. The latter number is given in red throughout this MS. and the former number is typed or is in black ink.

Anatomy of the Inflorescence.

Engler and Prantl in Die Naturliche Pflanzenfamilien III Teil ,V Abteilung, pp.138 et seq. , and Solereder in his Anatomy of the Dicotyledons, English edition Vol.8, p.245 give a general account of the internal structure of the axis of the Anacardiaceae but make no special mention of the inflorescence. Goris in his Contribution a l'étude des Anacardiaceae de la Tribu des Mangiférées (Annales des Science Naturelles, neuvième série, Botanique*) describes the axis also , but again without mention of the inflorescence. I am not aware if the anatomy of the inflorescence has been accurately described or not. The following are descriptions from the material I have sectioned. Selected slides accompany this thesis and I shall refer to these , and to the drawings I have made with the camera lucida.

*undated "Extrait"

The structure of the inflorescences of all grades is that of a normal dicotyledonous stem. The outline of the transverse section is roughly circular. In those inflorescences which I call abnormal and which are dealt with in ~~the next~~ a later section of this paper, there often occur marked rugae in the cortex. See slide 183.(9) & figure 12

The pith is always present, sometimes circular in outline , sometimes star shaped , if the xylem bundles project deep into it. The cortex is well marked. Resin ducts appear in the phloem, pith , and cortex, never in the wood. The following are details of the tissues of the main axis of a fully developed inflorescence in flower.

Epidermis.

The epidermis is one layer thick, with straight side walls to each cell and arched outer walls. See slide Baramashi (10) and drawings Figures 12 and 13.

The size of each cell is about 10μ x 15μ. There is a lenticular nucleus visible especially in the early stages of the inflorescence

The outer wall of the epidermis cells is thick and cutinised. ~~Pointed thick walled hairs arise here and there from~~ between ~~the cells of the epidermis.~~ These hairs are from one to four celledand contain granular contents. (Here and there an epidermal cell grows out radially to form a pointed thick-walled hair.)

Cortex.

This is parenchymatous, small and close celled near the epidermis , larger and looser celled near the phloem. The former cells are up to 20μ in diameter , and the latter up to 30μ . The former stain more permanently with haematoxylin, and in the early stages of growth contain a good deal of tannin. Lenticular chloroplasts occcur throughout the cells of the cortex, and crystals of calcium oxalate are common.

Starch is often found especially in the cells immediately surrounding the crescents of sclerenchyma ~~rings~~ that protect the resin ducts. In varieties of mango that develop a red colour in the axis , this colour appears as a sap pigment in the cortical cells.

Resin Ducts. (Fig. 13 & 14)

These vary much in diameter. The main ducts are constant in position, namely just outside the phloem, one to each original vascular bundle. It may be that other ducts are afterwards intercalated in this row but the evidence for this is incomplete. Ducts are very common in the pith , as slides 189(12) , 158(27) , and 183(9) will show.

The ducts branch (slide 036/1 (13)) longitudinally.

They vary a great deal in diameter. They are lined with an epithelium of small ~~granular~~ cells with granular contents, entire and complete in very young axes, often broken and incomplete in old axes. The epithelium is surrounded with 2-5 concentric layers of quadrangular , close set , thin walled cells . In the phloem ducts these are surrounded on the outer side by a crescent of sclerenchyma. These crescents join up with each other to form a cylinder of protective tissue.

Phloem.

In transvesse section the phloem appears to consist of polygonal cells of irregular size, averaging about 10μ in diameter. It is traversed by larger celled uniseriate medullary rays which broaden towards the cortical side. see ~~St.~~ slide 160 (26) + Fig. 16.

Cambium.

Usually three cells across in transverse section, and consisting of cells of the usual brick shaped type. Slide Baramashi (10) + Fig ~~15~~. 13

XYlem.

The main water carying elements are scalariform or ~~spix~~ annular vessels, of somewhat oval transverse section, and diameter of about 40μ . Between these are numerous close set tracheids. The medullary rays and wood parenchyma are often packed full of large starch grains. See slides. 189 (12), 160 (26) Fig ~~16~~. 17

The protoxylem is usually visible near the pith ~~with a few parenchymatous cells between it and the xylem proper. See slides~~

Pith.

This consists of irregularly sized ~~xxxx~~ round parenchymatous cells varying from 20μ to 50μ in diameter. These cells often contain starch . see slides 189 (12) 160 (26) Fig 18.

So far for the description of the adult axis in flower. To compare wihh it let us take the very young axis and the axis whan bearing ripe fruit.

The Young Axis (Inflorescence)

The pith and cottex occupy a relatively large part of the cross section (slide 132 (29)), the vascular bundles are far apart, and no starch appears in the cells anywhere. Slide 036/7 (13) shows a longitudinal section of a young inflorescence. Note the large pith and cortex, the bundles of scarcely differentiated vascular elements, and the rudimentary flowers.

The Axis bearing Fruit.

There are two marked changes. The first is the increase in the xylem and the second is the increase in the sclerenchyma. The extent of the xylem is seen in slides 189 (12), 158 (27). As to the sclerenchyma, we find in the fruit bearing axis that all sclerenchyma such as that round the resin ducts becomes thicker walled. In addition, sclerotic cells (slides above mentioned also 06/4 (32)) appear in the cortex four or five cells in from the epidermis. These cortical sclerotic cells are never seen in the early stages of the inflorescence and are, like the thickening of the existing sclerenchyma, an adaptation to the strain of the weight of the fruit. These cells will be referred to again in comparing the inflorescence axis with the vegetative axis. The epidermis remains unchanged, but in axes that persist for an unusually long time there develops a cork cambium a little deeper than the epidermis. It and the cork formed therefrom may be seen in slide 013/1 (14).

The Effect of Wounds on the Inflorescence.

The inflorescences are frequently bored by various insects. In slide 136 (15) will be seen the transverse section of one bored by a Chalcyd insect. The response of the wounded pith has been the formation of a squarish celled callus that cuts off the cavity from the living tissues inside. The cells on the cavity side of the callus are dead and the filaments and spores of a Cladosporium may be seen among them, and detached from them.

In slide 036/7 (13) callus production is seen in the places where the bud scales have fallen off. The callus here consists of large x rounded cells which project from the sound tissue.

Comparison of the Vegetative and Inflorescence axis.

There is little difference in the general appearance of the internal structure of the vegetative and flowering shoots, but careful study of a large number of sections has brought out the following facts.

1. The epidermis of the vegetative shoot and of the flowering shoot are different . This is well seen in the slides Baramashi (10)(11) and in the drawings Fig. 13 & 14. of the Baramashi mango shoots. This difference is constant. Where one finds a doubtful case one may look for some abnormal factor such as the fact that the inflorescence is not a pure inflorescence but a transition strusture . This labile character ofthe inflorescence will be referred to later.

The difference between the two kinds of epidermis may be expressed thus : Thatx of the inflorescence has cells that are nearly equal in length and breadth when seen in transverse x section, and the outer wall is arched and moderately thickened. That of the vegetative axis has cells that are longer than broad, the outer wall is not arched, and thx it is much thickened.

2. In the vegetative axis (see slides 173(16), 188 (1) the sclerotic cells of the cortex referred to on p.29 of this MS. are present from a very early stage. In the pure normal inflorescence thay appear when the need for extra strength on account of the develpoing fruit begins to be felt.These sclerotic cells may become very thick indeed and have branched pits (slide 04/4 (32) Fig.19.). They occur in one line only however and in the infloresc ence in a usually broken line.

3. Hairs are present on the early stages of the flowering shoot and never on the vegetative shoot.

Transition stages between Vegetative and Flowering Growths, their morphology and Anatomy.

As previously remarked , the inflorescence of the mango is a most labile structure.

By this term I mean that it does not seem to be at all fixed in the reproductive character of its organs but may and often does become wholly or in part vegetative. The first sign of this vegetative character of the axis is when instead of producing caducous small bracts it produces foliar persistent bracts. Such a case is shown in specimens no. 2, 5. and again in photographs no. 15, 16, ~~8, 63B~~. The flowers that occur on such an inflorescence are perfectly normal and may set fruit. The extreme case is where the axis is in every respect like a vegetative axis but has one small secondary flowering branch. I have seen such cases ~~Photo 65B, 2A, 66B.,~~ Herb. Specimen 6. Photos. 17, 18, 19. Between these two extremes all kinds of variations exist, and one of the most interesting is that in which one side of the axis is vegetative and the other reproductive Photo ~~[illegible]~~ 20. A case of this kind is recorded in the Journal and Proceedings of the Asiatic Society of Bengal New Series Vol III. p427. in an article entitled " An Abnormal Branch of the Mango (Mangifera indica, Linn.) " by I.H. Burkill , and G.C.Bhose This is so far as I know the only published record of such a phenomenon, and the writers evidently thought it rare. It is however not so rare as they imagined , as every year I have come across more than one example. The writers of the article above cited after dealing with the phyllotaxy, devote most of their attention to the correlation of external morphology and internal structure, and show that in their case the vascular tissue was thicker on the foliage side than on the flowering side of the axis, and that this was mostly due to the great development of the xylem. The vessels were moreover wider and there was a greater development of the wood fibres.

In my slides 187 (2) is a cross section of such an inflorescence

It will be seen that the outline of the section shows a slight sinus between the two sides of the axis. At this sinus the differences of some of the tissues are marked. The character of the epidermis changes from the vegetative to the inflorescence type. The line of sclerotic cells changes from continuous to sparse. The xylem does not show just the same regular change in breadth and character that Burkill and Bhose found but it will be noticed that leaf traces with thick walled xylem are on the foliage side of the axis. Slide 172 (3) shows however exactly what Burkill and Bhose found as to the extent and nature of xylem. This section was taken from an inflorescence that had a strong axillary vegetative growth on one side. In addition to the xylem change it will be noted in this section also that the same change in epidermis and sclerotic cells is found. We may therefore conclude that the production of bracts or of axillary vegetative growths on an inflorescence leads to changes towards the vegetative anatomy in the side showing foliage characters. Slides 176 (4), 177 (19), 190 (18) are from inflorescences that had bracts all round. They have an epidermis of distinctly vegetative type, but no sclerotic cells or any enlargement of the xylem, although the vessels are wide and well marked. It is likely that in internal structure as well as in external form there are many transition stages.

It is a curious fact that an inflorescence main axis may persist as a vegetative axis and become finally incorporated in what looks like a normal branch. The terminal bud in this case grows out into a proper vegetative growth.

Three cases of this incorporation are shown in photos. 22, 21, and 23. The last named is particularly interesting. The inflorescence of 1911 has been marked on the photo. This inflorescence bore two good fruits. Between it and the inflorescence of 1913 are three vegetative growths made in Feb. 1911, April 1911, March 1912 respectively.

Besides vegatative growth from the terminal bud of the inflorescence similar growth from an axillary bud is common. See photos. 24, 25, 26 and 27. It will be seen from these that even fruiting does not interfere with the production of these growths. The anatomy of these inflorescences that bear axillary growths on one side only has been referred to above.

It is a noteworthy point that in inflorescences that are coloured , such colour does not appear in vegetative growths produced on them either terminally or in the axils of their bracts. Moreover in the case of an inflorescence that is vegetative down one side, the colour is not developed in that side.

So far I have mentioned further growth of the inflorescence that is vegetative only, but belated floral growth may also occur as shown in photo. 28. In this case the large fruits occur on an inflorescence that was produced in Nov. 1912 An axillary bud developed in March 1913 into another structure producing flowers as seen in the photo.

Slide 17~~1~~ (5) shows the cross section of an inflorescence that was first abnormal then persistent as a vegetative growth. It will be seen that it possesses a huge xylem, an epidermis of the vegetative type and plenty of sclerotic cells in the cortex.

Slide 170 (6) shows the cro s section of the true vegetativee growth formed by the terminal bud of the above inflorescence. The section differs from the previous one only in the extent and nature of the xylem. The xylem of the vegetative growth is looser and not so broad.

~~Photograph 6 shows a case of incorporated inflorescence.~~

Internal Structure of the Anther.

Slides 035/0 (7), 042/13 (8) and 138b (17) especially the latter show the structure of the young anther. It is of the usual four chambere type, with large epidermis, small mechanical layer, and well marked tapetum. The pollen grains are formed at a fairly early stage of the bud. In these slides also the cymose nature of the branching of the axis will be clearly noticed.

The Abnormal Inflorescence. – Herbarium Specimen 4

In the two attached papers* (Preliminary Note on a Malformation of the Mango Inflorescence and Further Notes on a Malformatio of the Mango inflorescence read before the Bombay Presidency Science Association and now in the press) is contained all the information gained as to this abnormality. I do not propose in this thesis to do more than refer to this curious disease of which the cause is still obscure. During the season of 1913 buds were injected with water and with juice of abnormal inflorescences, they were also treated by bottling and by ringing the wood under them. No def~~f~~inite results as to the cause of the malformation ~~were~~ have yet been obtained. Further work will be done on this problem till it is solved. All things

* Photos for these papers not sent.

seem to point to some cause locally disturbing the metabolism of the inflorescence bud.

General Remarks regarding Variation in the Inflorescence.

Most of the variations mentioned can be put into one or other classes outlined by Masters in his Vegetable Teratology. The production of bracts that resemble leaves comes under the class of Phyllody of bracts. The continued growth of the inflorescence as a vegetative shoot comes under the heading of median foliar prolification of the inflorescence, the production of axillary vegetative growths under the heading of lateral foliar prolification. Masters does nothowever mention the Anacardiaceae as one of the orders in which prolification is frequently observed. A ~~remark on p. 164-5 of his book~~ applies to the case of flowers in the abnormal inflorescence. It runs as follows : " There remains a class of cases wherein there is a complete substitution of one structure for another it may be without the slightest indication of transition between the two , and without any admixture of leaf bud among flower buds or any absolute increase in the number of organs as in prolification".

Other Diseases of the Inflorescence.

These I shall merely mention. Insects of the natural order Jassidae suck the inflorescence and cause the flowers to abort. Cloudy weather especially in the coastal districts of the Bombay Presidency causes the inflorescences to shrivel and blacken if it occurs before the fruits are set. Insect borers, yet unidentified, perforate the inflorescence axis. Thrips are also sometimes found in the young inflorescences.

Conclusion.

In conclusion let me once more emphasise the following points.

1. The inflorescence is not a raceme as it has been often wrongly called but a raceme of repeated biparous cymes, which decrease in complexity as the apex of the main axis is reached.

2. The position of the inflorescence is by no means always terminal , although every flora repeats this error.

3. The age of the vegetative shoots on which the inflorescence appears varies from two months upwards. There is no law as to what wood will produce inflorescences. Buds side by side on the same branch may develop one into a flowering shoot and o one into a vegetative shoot.

4. Newly grafted shoots may flower. Apparently the character of the bud was decided before the grafting, and on growth occurring the floral character of the shoot had to come out.

5. Illumination affects the earliness of the appearance of the inflorescences but not their number. It also affects the colouration of such axes as can develop colour.

6. The time of flowering in the Bombay Presidency is as a rule in the end of December, but a distinct flowering in September has been recorded in a number of cases. The factors affecting this are not known, Salt manuring and the pruning of the roots do not affect the time of flowering.

7. The flowers vary enormously and present a number of interesting twin forms, which can be referred to true twins (the joining of two flowers) and to a reversion to the older type of flower of the Anacardiaceae.

8. The number of male flowers is to hermaphrodite as 5 to 2, and the position of the flowers on the cymes such that hermaphrodite flowers predominate at the ends of the tertiary and quaternary axes.

9. Pollination is by flies and other short tongues insects, but self pollination is also possible.

10. The flowers are protogynous

11. Artificial crossing has so far failed.

12. The internal structure of the inflorescence generally resembles that of the fk vegetative axis but differs in the shape of the epidermal cells, in the absence in the early stages of sclerotic cells in the cortex, in the presence of hairs

13. The inflorescence is a labile structure and many transition stages between it and the vegatative axis exist. The anatomy of these transition forms shows transitions from that of the flowering shoot to that of the foliage shoot.

14. Various diseases of the inflorescence are known of which the most obscure is that which I have termed the abnormal or malformed inflorescemce.

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Descriptions of Photographs.

1. Normal inflorescence - stage 3. ✓
2. Normal mango inflorescence. ✓
3. Normal inflorescence - stage 1. ✓
4. Normal inflorescence - stage 2. ✓
5. Three axillary inflorescences of April 1913, quite close to a terminal and axillary inflorescence (with one fruit) of January 1913. ✓
6. Terminal inflorescence of October 1912, + three axillary inflorescences of January 1913, side by side. o
7. Inflorescence of January 1913, on vegetative growth made in November 1912. o
8. Vegetative and flowering branches springing up side by side. ✓
9. Vegetative and floral growths side by side. o
10. Vegetative, flowering, and transition branches side by side. o
11. Axillary inflorescences of 1912, near terminal inflorescence of 1911. ✓
12. Tongue graft of Pairi on three year old stock in the field. o
13. Mango fruit on a scion enarched in November 1912, separated in 1913, flowered in March 1913. ✓
14. Roots of 15 year old mango tree exposed for resting the tree. ✓
15. Inflorescence with foliar bracts. ✓
16. Inflorescence with foliar bracts. The size of the big bract is 28 cm × 9 cm. o
17. Inflorescence almost entirely vegetative with one secondary flowering branch. ✓
18. Inflorescence almost entirely vegetative with two secondary flowering branches at bases. o
19. Inflorescence almost entirely vegetative with three fruits o
20. Inflorescence vegetative on one side and flowering on the other. ✓
21. Incorporated inflorescences. ✓
22. Malformed inflorescence completely incorporated into vegetative shoot. o

✓ P.38.

4 23. Terminal inflorescence 1913, and incorporated inflorescence 1911.

24. Inflorescence with one secondary branch bearing fruit, and one axillary vegetative branch. ✓

25. do. o

26. Inflorescence with two axillary vegetative branches o

27. " with one fruit & one axillary vegetative branch. ✓

28. Inflorescence of November 1912, bearing fruits with an axillary flowering growth of March 1913. ✓

3 29. Fruit set on lower branches only.

add. photos of infl. grafts

17 + (4)?

27.

Table. 1

Variations Found In the Flower.

Type.	Calyx.	Corolla.	Stamens.	Ovary.	Frequency.
1.	3	3	1	1	1
2.	4	4	2	0	1
3	4	5	1	1	3
4	4	5	2	1	1
5	4	6	1	1	1
6	5	5	2	1	3
7	5	5	2	0	2
8	5	5	1	3	1
9	5	4	1	2	1
10	5	5	1	2	2
11	5	6	1	1	12
12	5	6	1	0	6
13	5	6	2	1	1
14	5	5	3	0	1
15	6	5	2	0	1
16	6	6	1	0	2
17	6	6	1	1	16
18	6	6	2	1	2
19	6	6	2	0	1
20	6	7	1	1	2
21	6	8	2	2	1
22	7	7	2	2	1
23	7	7	1	1	1
24	7	6	2	1	1
25	7	7	0	1	1
26	8	8	2	1	1
27	8	8	2	2	3
28	8	7	2	0	1
29	8	9	1	1	1
30	9	8	2	2	1
31	9	11	2	3	1
32	9	9	2	2	2
33	9	9	2	1	1
34	10	10	2	2	3
35	10	10	3	2	1
36	7	8	1	2	1
37	9	9	2	4	1

Table 2.

Variations Found in the Number of Staminodes in the Mango Flower.

Number of Staminodes.	Frequency.
4	2
5	9
6	25
7	19
8	9
9	7
10	1

Pairi 196

(Table 3)

Date	♂ Total no.	⚥ ☿ Total no.	no of m 4	no of m 5	no of H 4	no of H 5	Total number of flowers opened & other kinds of flowers
8th January 1913	80	243					323
9 –	62	51					113
10 –	174	61					236 1 double flower
11 –	29	11					40+2 = 42 2 flowers with 2 stamens each
12 –	135	22					157
13 & 14 –	229	59					288
15 –	115	23					138
16 –	143	40					183
17 –	159	47					206
18 –	159	40					199
19 –	147	25					172
20 –	138	21					159
21 –	143	27					170
22 –	115	16					131
23 –	124	31					155
24 –	67	38	27	39	10	28	105 1 ♂ flower with 6 petals
25 –	97	48	30	66	16	32	145 1 flower with 6 petals (♂ flower)
26 –	69	33	28	38	16	16	102 1 ⚥ with 4 petals & intrusive petal; 2 ♂ with 6 petals. 1 ⚥ with 4 petals & one intrusive petal.
27 –	50	14	28	22	7	7	64
28 –	48	19	27	21	5	13	67 1 flower ☿ with 6 petals
29 –	26	12	10	16	4	8	38

Pairi 196

Date	♂ Total No.	⚥ Total No	No of M 4	No of M 5	No of H 4	No of H 5	Total number of flowers opened & other kinds of flowers
30 January 1913	12	9	3	8	4	5	21 1 flower ⚥ with 4 petals & one intrusive petal
31 "	9	4	1	8	.	4	13
1st February	4	3	1	3	.	3	7
2 "	1	.	.	1	.	.	1
3 "	1	.	.	1	.	.	1
Totals.	2336	897	145	223	62	116	3233
Percentages	72.3	27.7	4.4	6.9	1.9	3.6	

M 4 & M 5 = male flowers with 4 or 5 petals
H 4 & H 5 hermaphrodite .. ..

43

(Table 4)

Alphonse 37

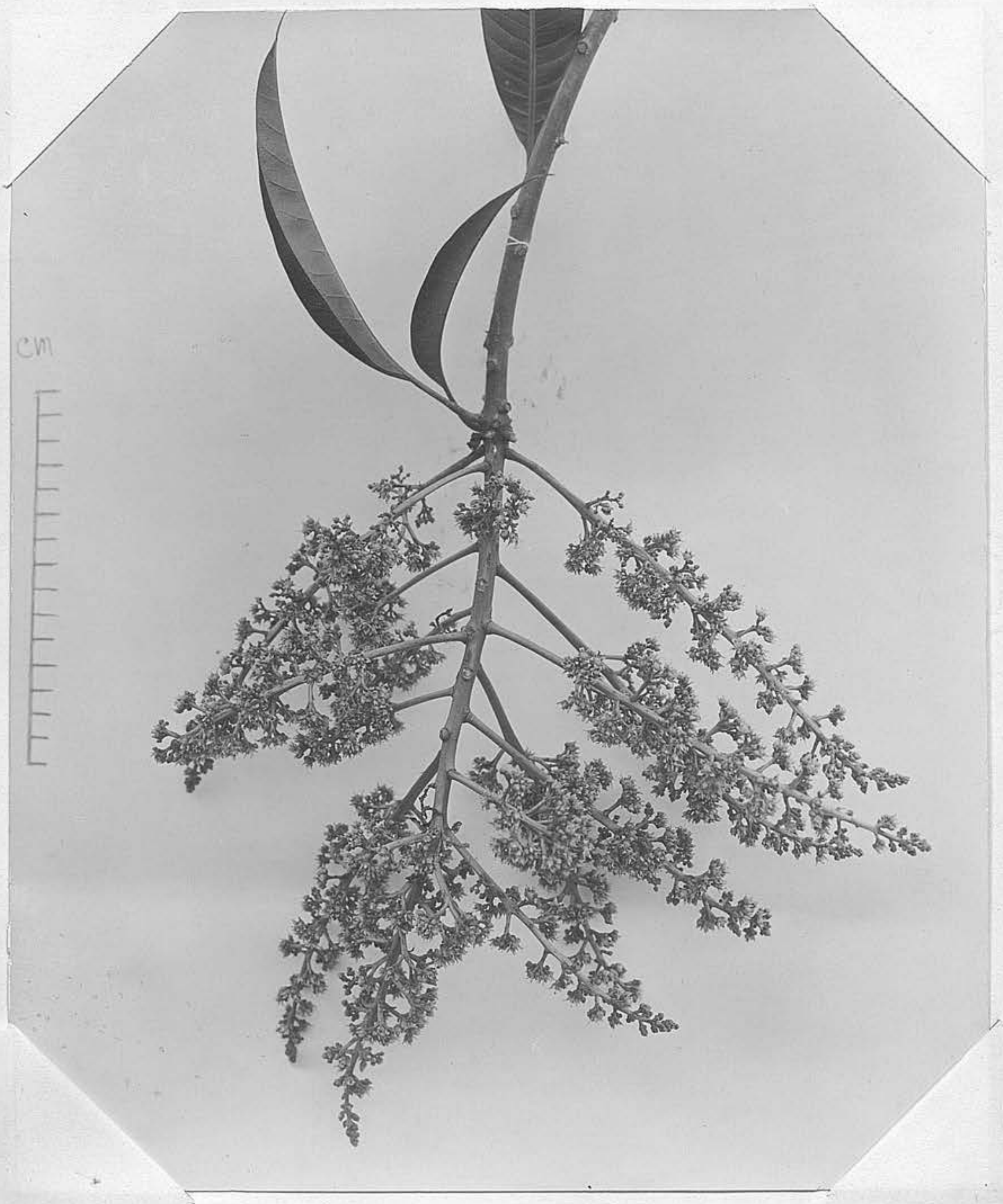
Date	♂ Total no.	☿ ⚥ Total no.	No of M 4	no. of M. 5	no. of H. 4	no. of H. 5	Other kinds of flowers & total no of flowers opened?
6th January 1913	37	138					2 flowers doubtful 177
7th "	24	32					56
8th "	11	22					33
9th "	11	30					41
10th "	33	39					72
11th "	14	21					35
12th "	34	19					53
13th & 14th "	82	44					126
15th "	41	17					58
16th "	50	29					79
17th "	61	19					80
18th "	52	19					71
19th "	57	18					75
20th "	38	13					51
21 "	60	9					69
22nd "	43	11					1(?) 55
23rd "	57	9					66
24th "	69	12	22	47	3	8	81 one flower with 3 stamens, 2 ovaries
25 "	85	17	31	54	11	6	102
26th "	64	24	26	38	8	16	88
27 "	67	17	29	37	4	13	84 one flower with 3 petals.

Table 5

Alphonse 37

Date	♂ Total No	⚥ ☿ Total No.	No of M.4	No of M.5	No of H.4	No of H.5	Other kinds of flowers & total number of flowers opened
28th January 1913	63	23	35	28	11	12	86
29th "	54	16	14	40	9	7	70
30th "	73	14	34	39	5	9	87
31st "	57	14	29	27	9	5	71 one flower with 3 petals
1st February	68	14	27	41	8	10	82
2nd "	59	20	29	30	6	14	79
3rd "	47	13	22	25	5	8	60
4th "	41	16	17	24	7	9	57
5 "	39	4	12	27	3	1	43
6 "	29	8	17	12	3	5	37
7 "	30	3	12	17	2	1	33 one flower with 4 petals & one introsive petal
8 "	21	1	12	9	1	.	22
9 "	29	1	14	15	1	.	30
10 "	20	1	8	12	1	.	21
11 "	15	.	9	6	.	.	15
12 "	11	.	7	4	.	.	11
13 "	2	.	1	1	.	.	.
14 "	3	.	3	.	.	.	3
15 "	.	.	.	.	.	.	.
16 "	4	.	3	1	.	.	4
Totals.	1665	707	413	534	97	124	2372
Percentage	70.2	29.8	17.4	22.5	3.9	5.2	

Plate 1.



Normal Mango Inflorescence.

NORMAL MANGO INFLORESCENCE.

~~Fig. 1a~~ ~~Fig. 1a~~ Photo 2

2.

Mango Inflorescence - First Stage

Plate No 3

Plate 3

(9)

Plate ~~A~~: 4

Mango Inflorescence. Second stage.

Plate 5

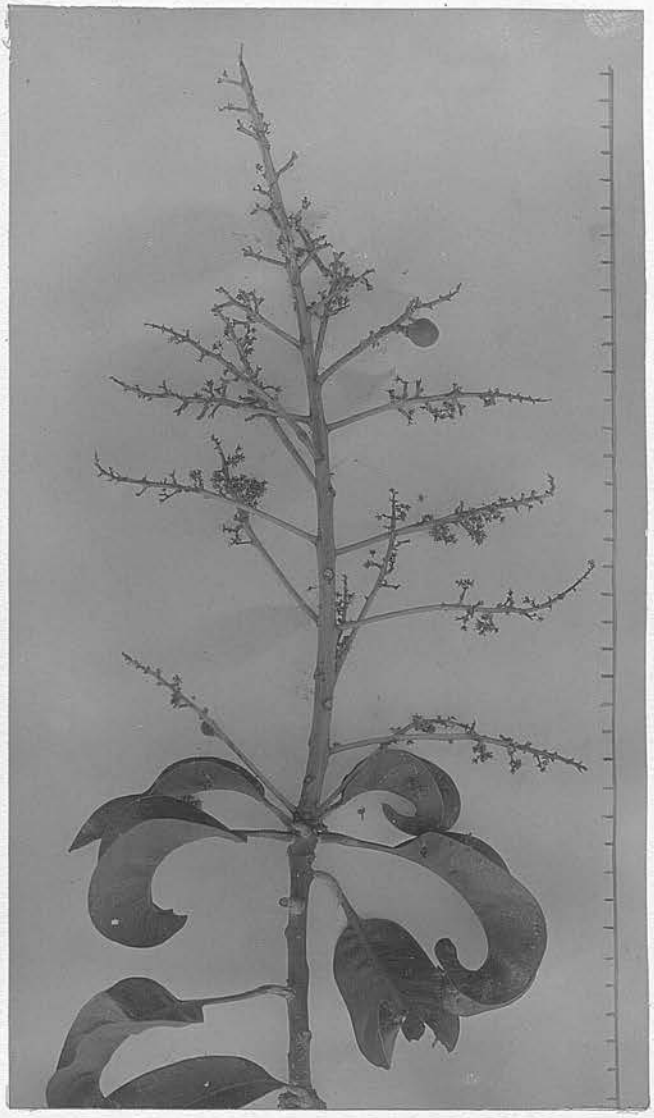
Barren terminal and fruit bearing inflorescence of Jan. 1913.
with three axillary inflorescences of April. 1913 at their base.

6.

C. 74
10.3.13

III 28

64 B. Terminal inflorescence of October 1912, and three axillary inflorescences of Jan. 1913. side by side.



7.

C.74
10.3.13

III 26.

62 B

Inflorescence of Jan. 1913 on vegetative growth made in November 1912.

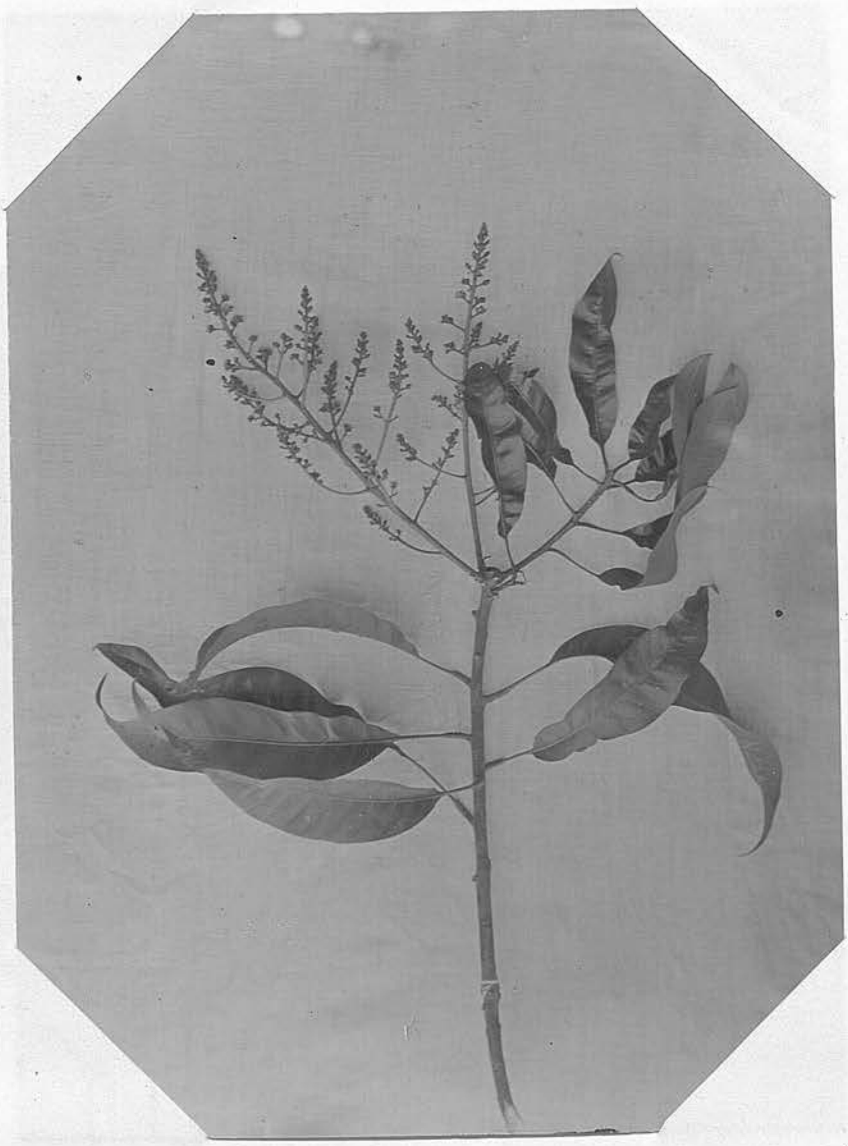
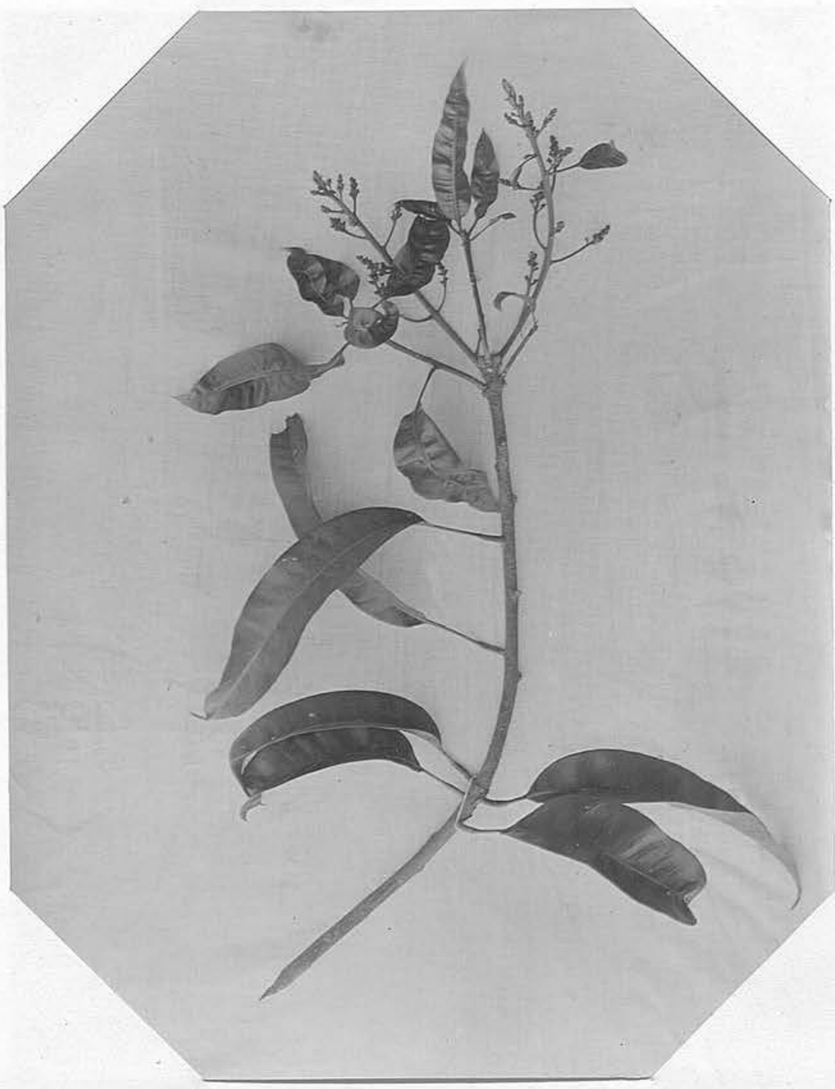


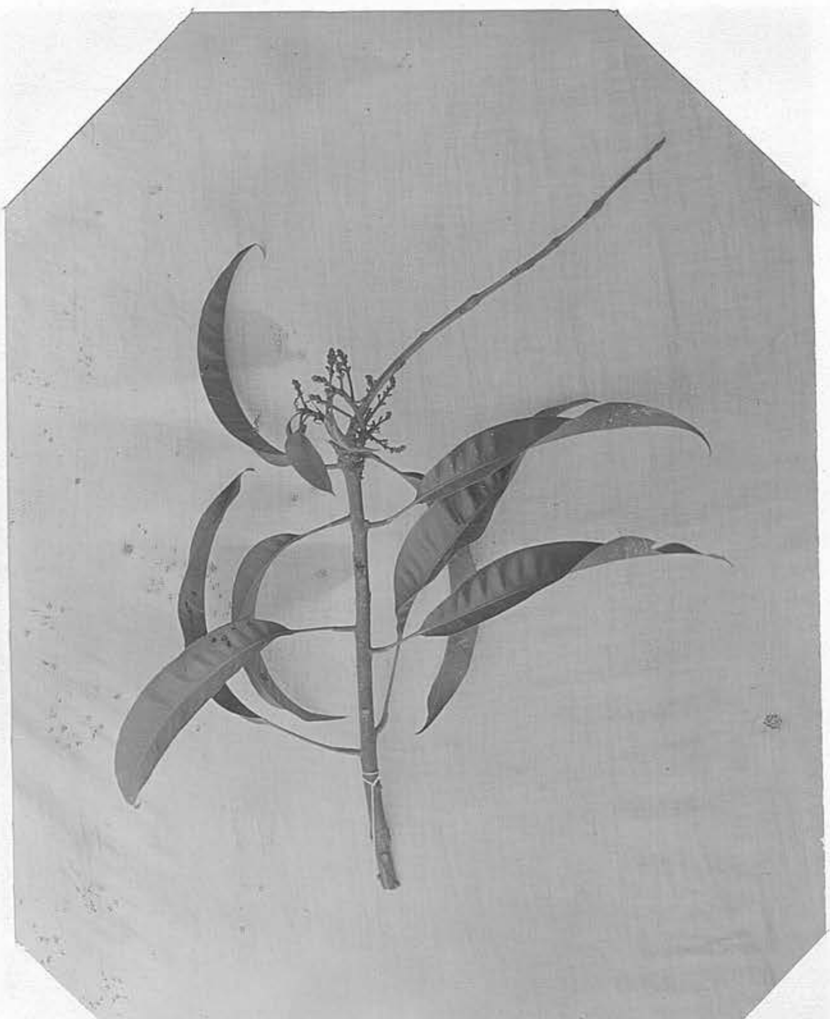
Plate 5. 8

Inflorescences and vegetative branches arising simultaneously from adjacent buds.



9.

10.



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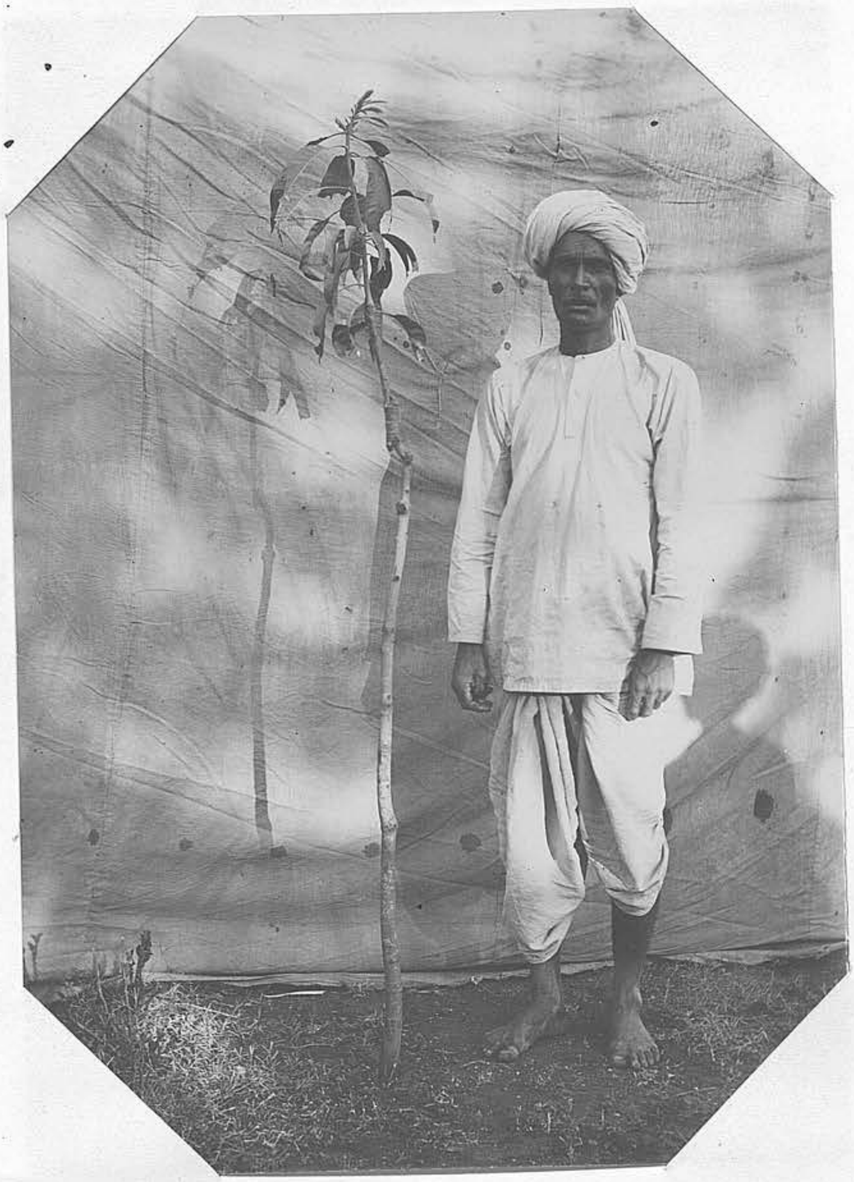

12.

(12)

~~12~~

Plate ~~12~~ 13.

Scion enarched onto 2 year old stock in Nov. 1912.
Separated from parent shoot in 1913, flowered
March 1913 & produced one fruit.

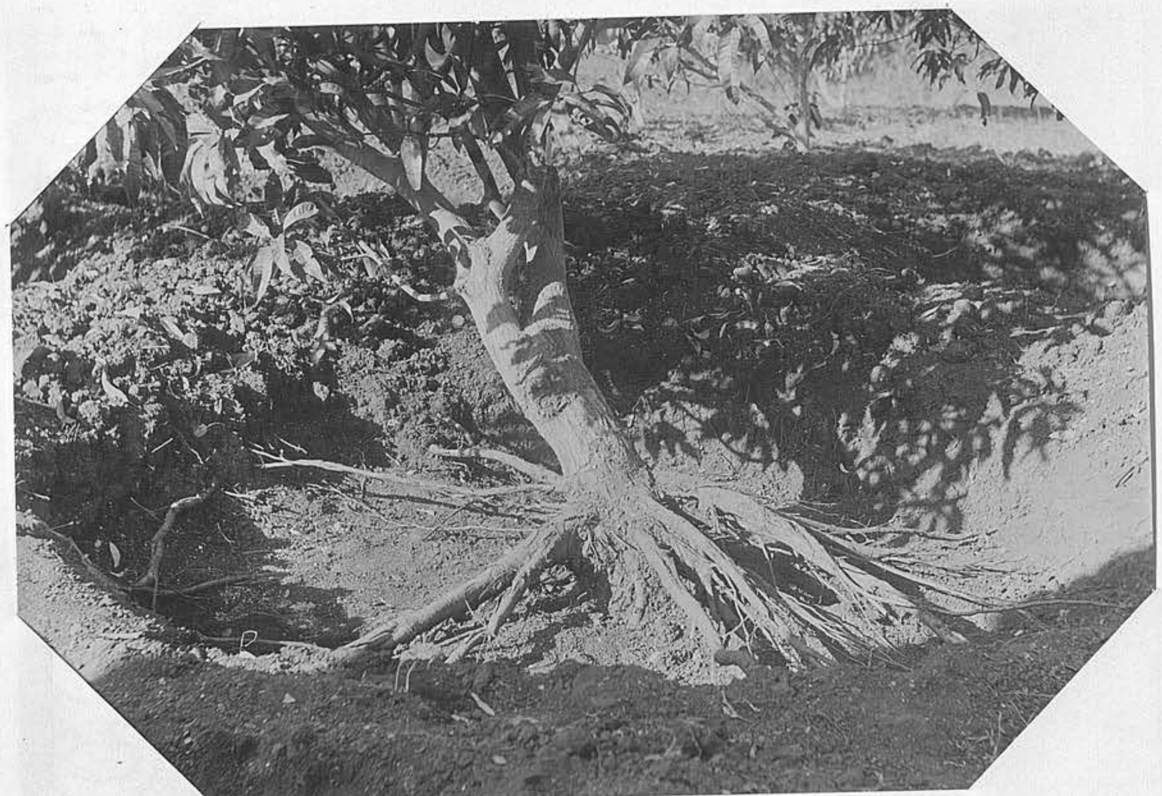

Plate No. 14

Experimental Exposure of Mango tree Roots to induce flowering.

(3)

Plate 16 ~~15.~~

Young mango Inflorescence with foliar bracts

16.

P. 305
10.3.13

63 B

Inflorescence with foliar bracts

The size of the big bract is 28 cm. × 9 cm. !

ZZ III

Plate. 17

Inflorescence almost entirely vegetative with one secondary flowering branch.

P.305
11.313

III 29.

65 B

Inflorescence almost entirely vegetative with one ~~axile~~ secondary flowering branch.

18.


C.m.

P. 249.
10.3.13

66 B

III 25

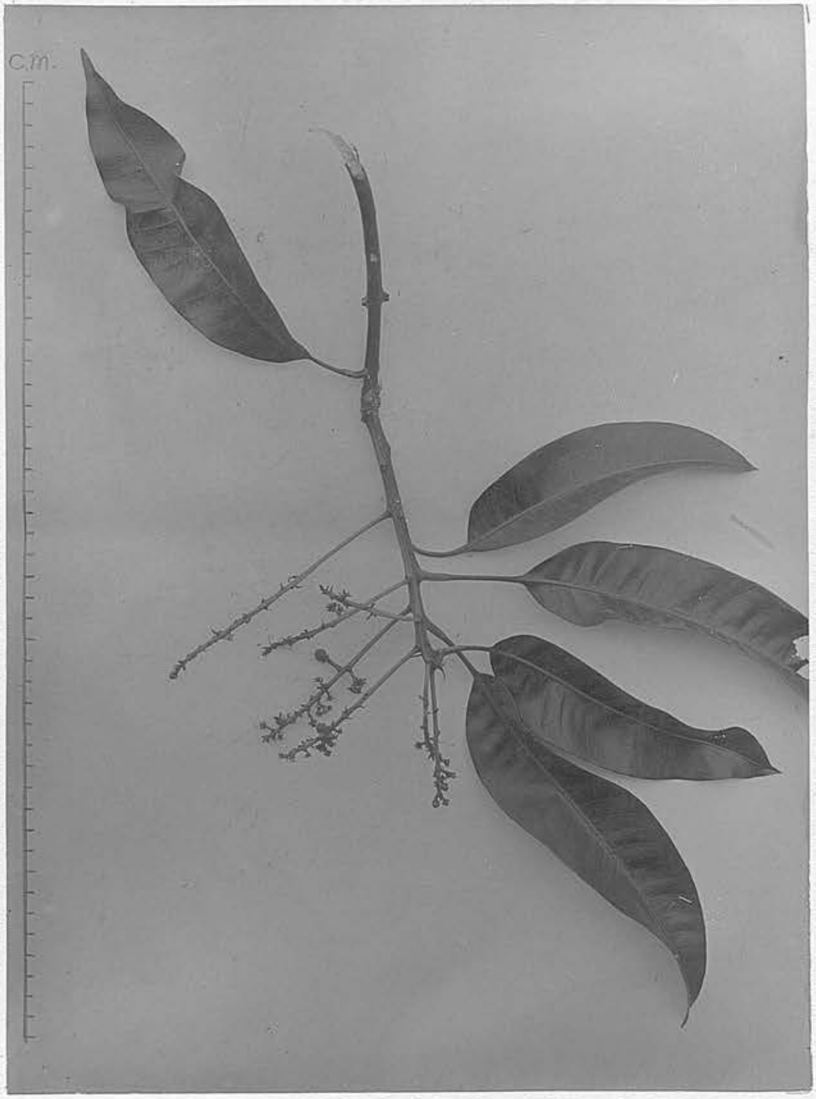

Plate 20 ~~2x~~

Mango Inflorescence vegetative on one side & flowering on the other.

67 B

Inflorescence vegetative on one side and flowering on the other

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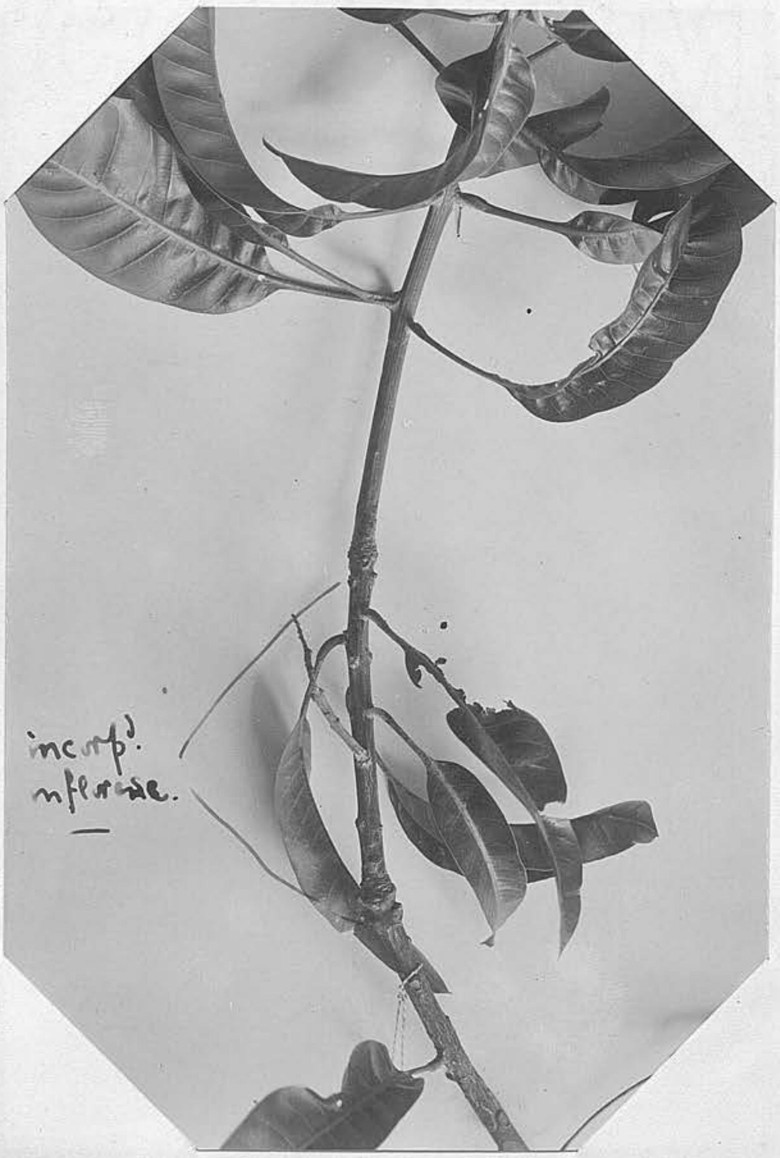


~~Photo no 11~~ ~~Photo 7.~~ 22.

Malformed inflorescence completely incorporated into vegetative shoot.

Pairi (91). G.B. Garden. 6.2.12.

22.


Terminal inflorescence
1913.
incorporated
inflorescence
1911

~~23.~~

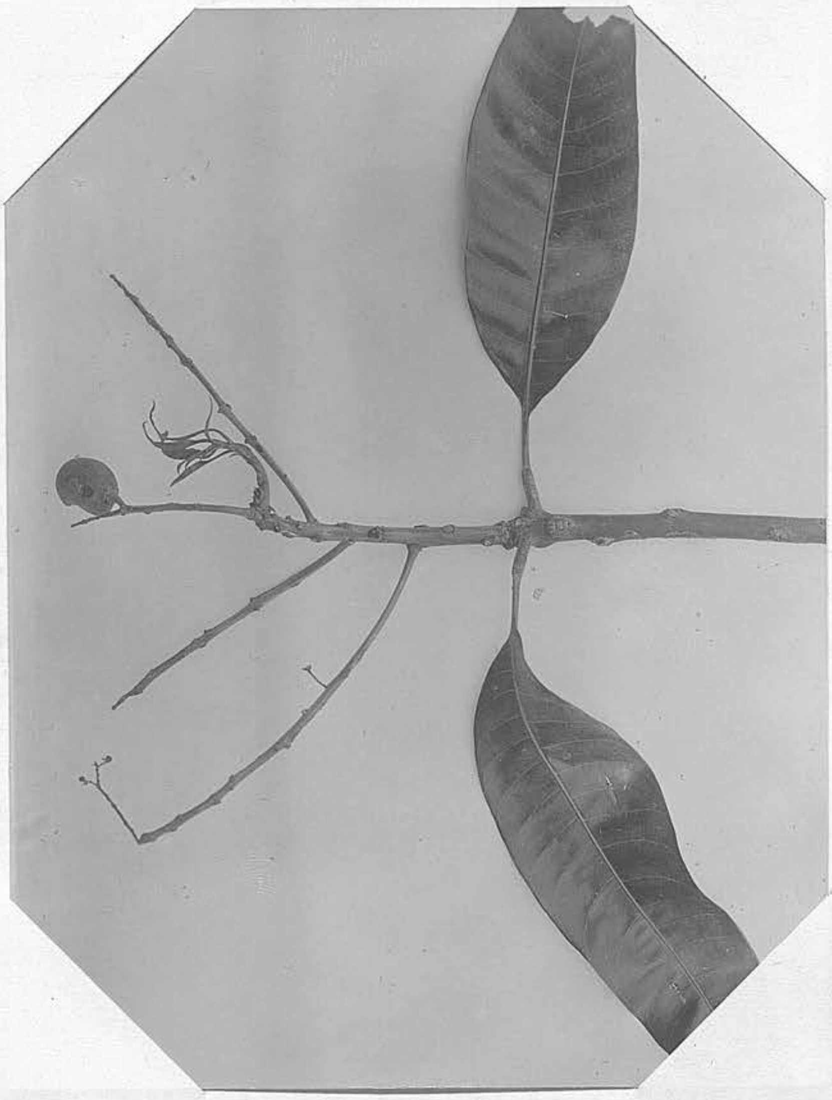
Plate. 23.

~~24.~~
Plate ~~?~~ 24

Vegetative growth of axillary bud on a fruitbearing inflorescence.

25.

26.



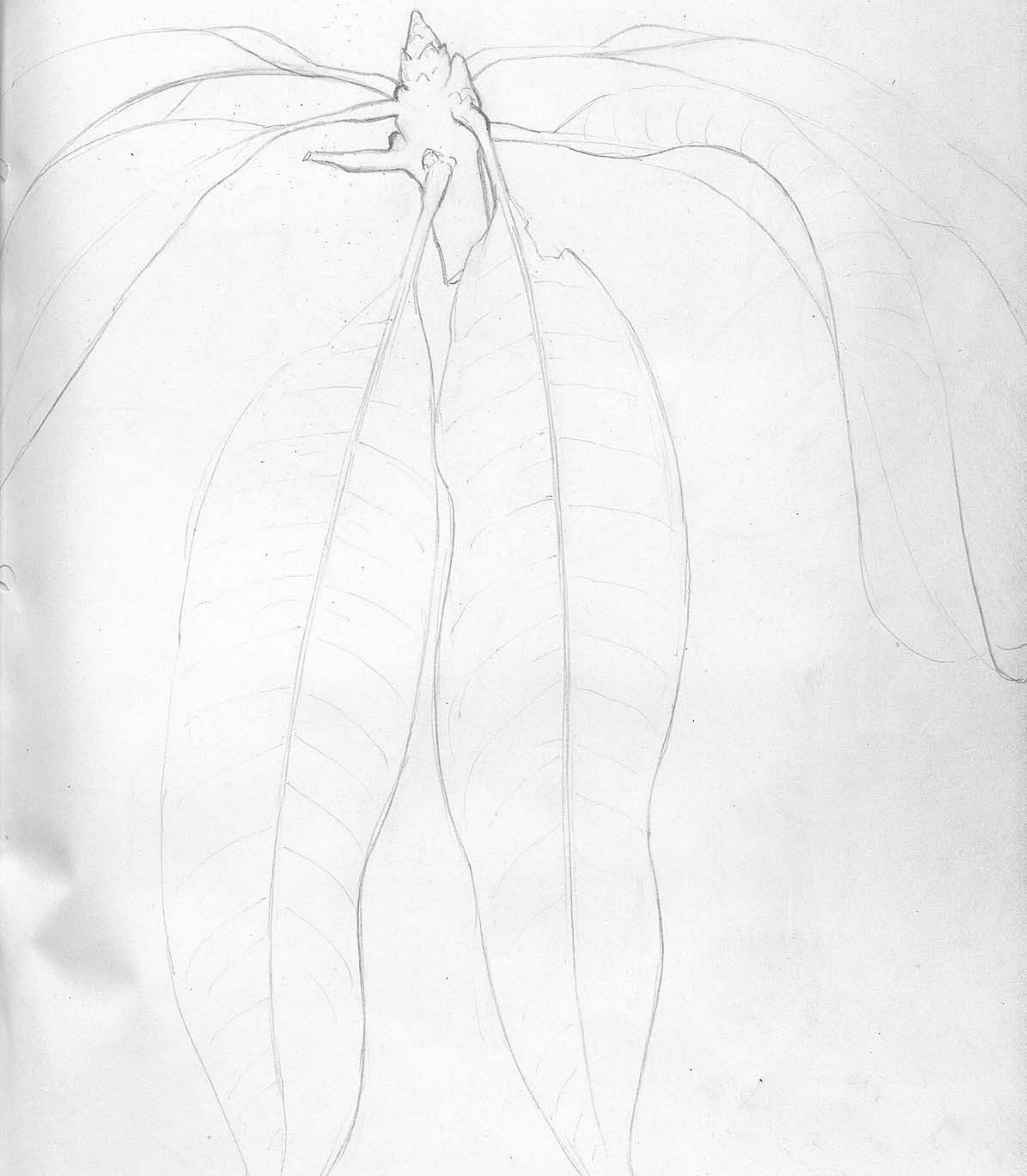
27.

28.

29.

Fig ①

Date - 20th Dec 1910
length - 1 Cm -



(Fig 2)

26th Dec 1910

Length - 3 Cm.

Fig 3

29th Dec 1910

Length 4 Cm.

(Fig 4)

4th Jan 1944

length 7 cm.

Fig 5.

18th Jan 1911

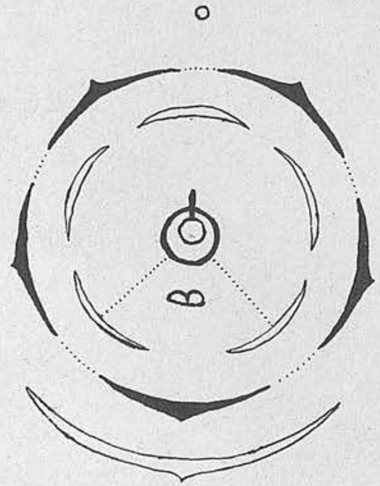
31 Cms. in length.

7 flowers opened.

1

~~Diagram 01~~

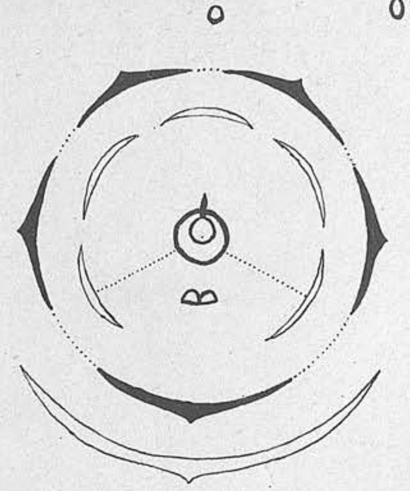
01 ~~Fig~~



2

~~Diagram 02~~

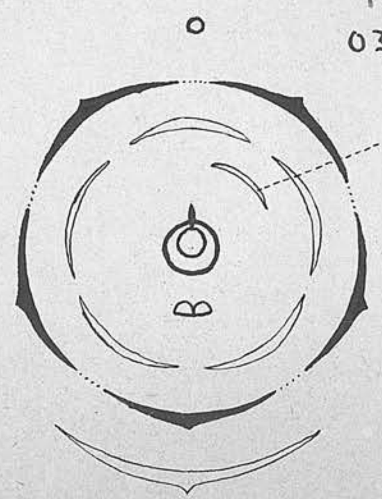
02. ~~Fig 3~~



3

~~Diagram 03~~

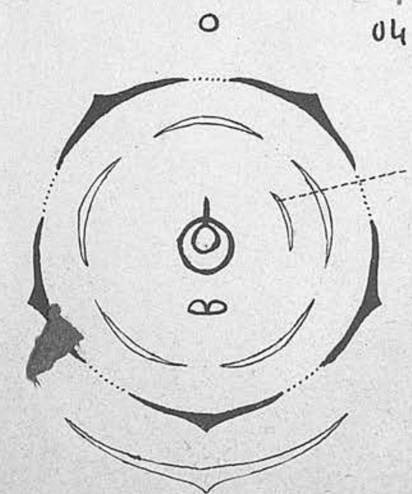
03 ~~Fig 5~~



4

~~Diagram 04~~

04 — ~~Fig 4~~



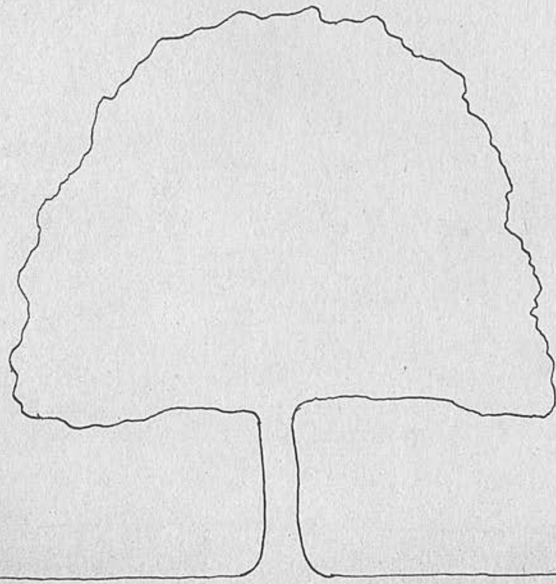
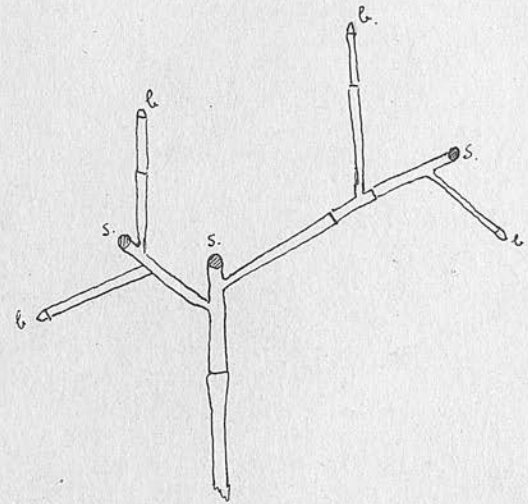


Figure 9.



s = scar of inflorescence
b = bud.

Figure 8.

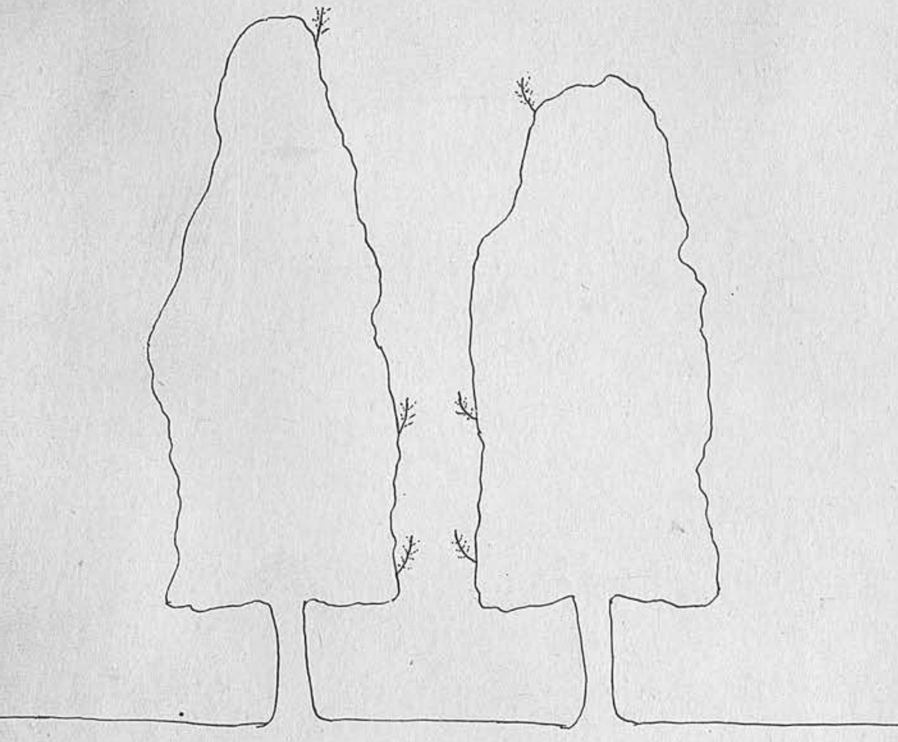


Figure 9.

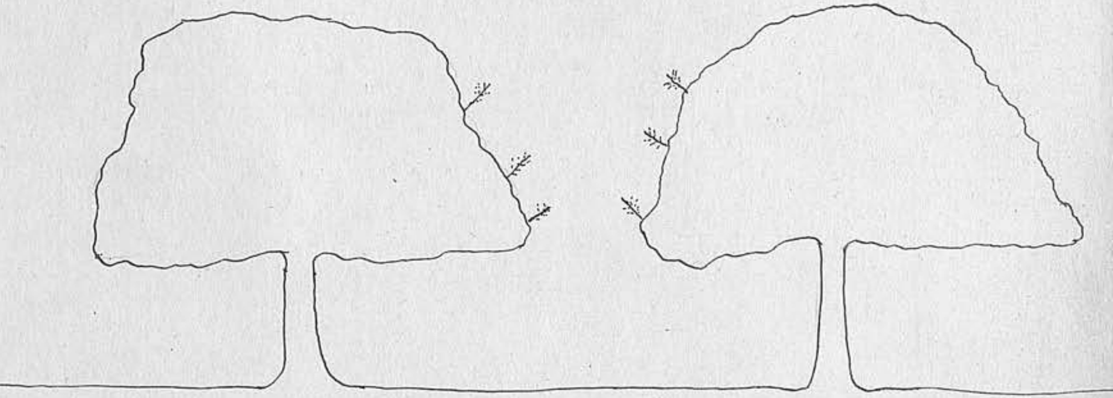


Figure 10.

Fig. 11.

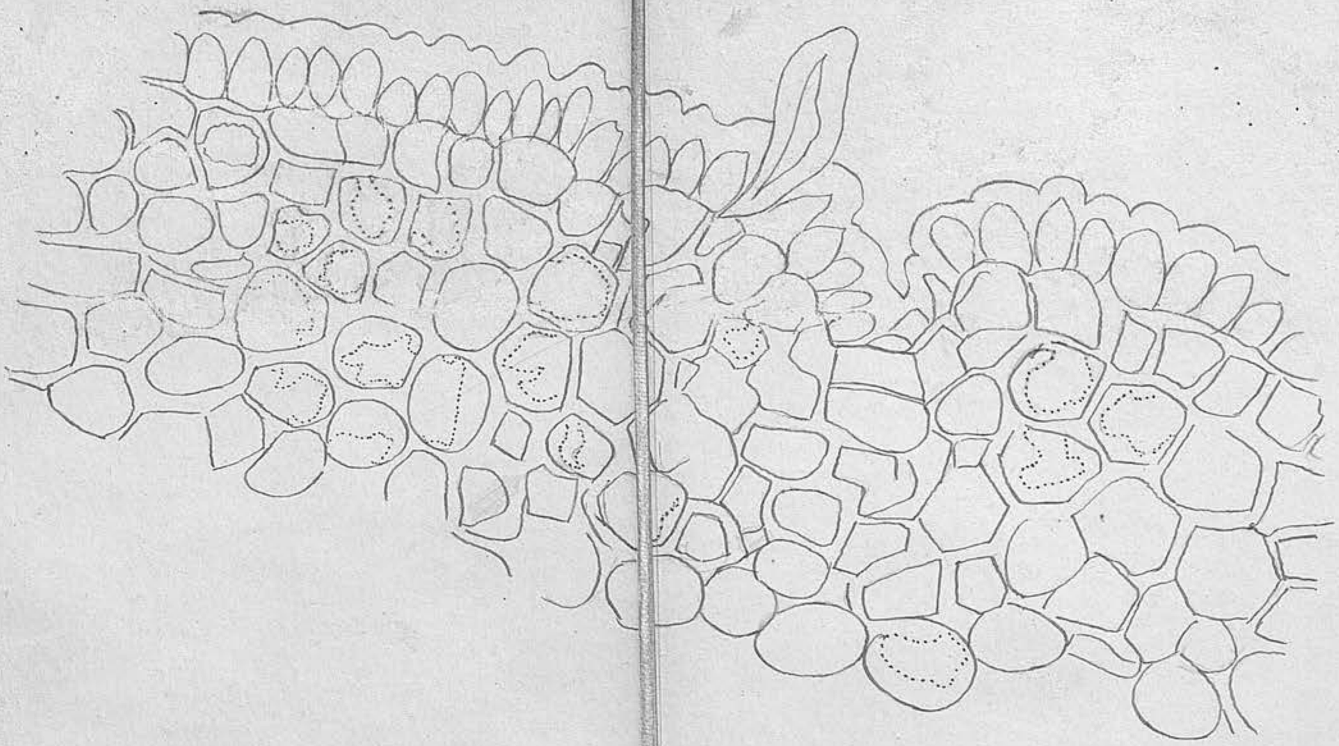
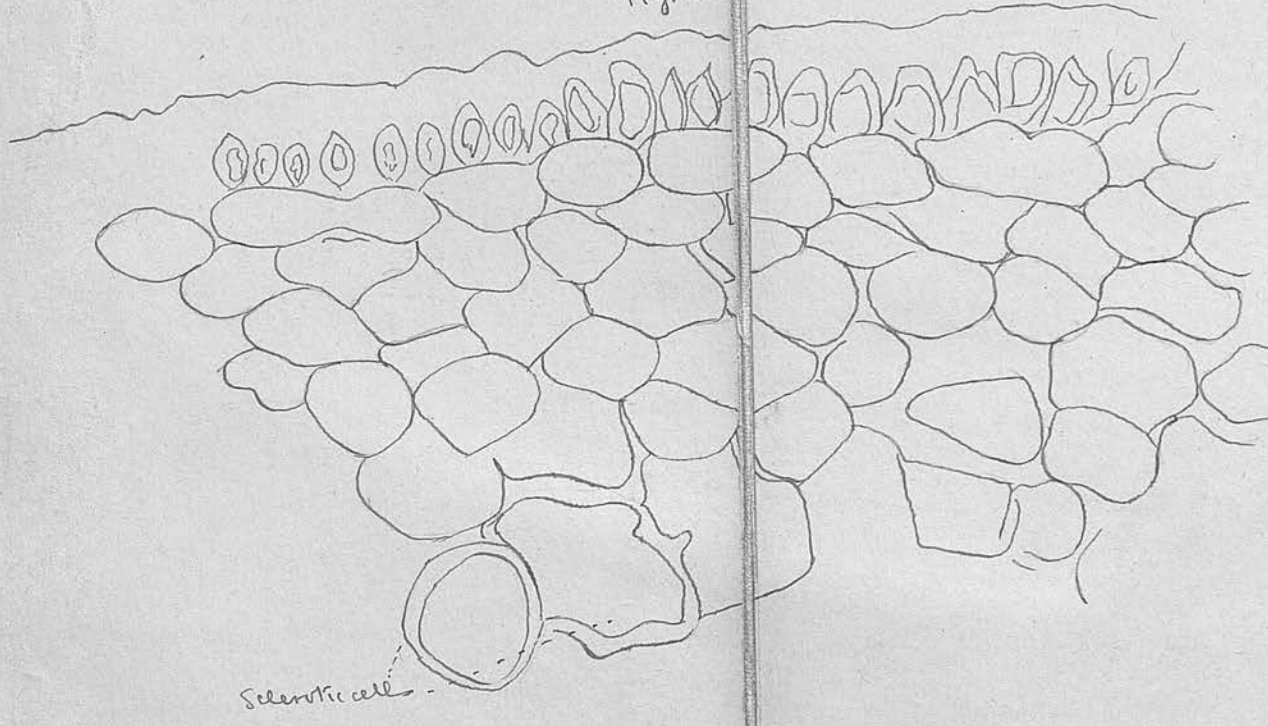
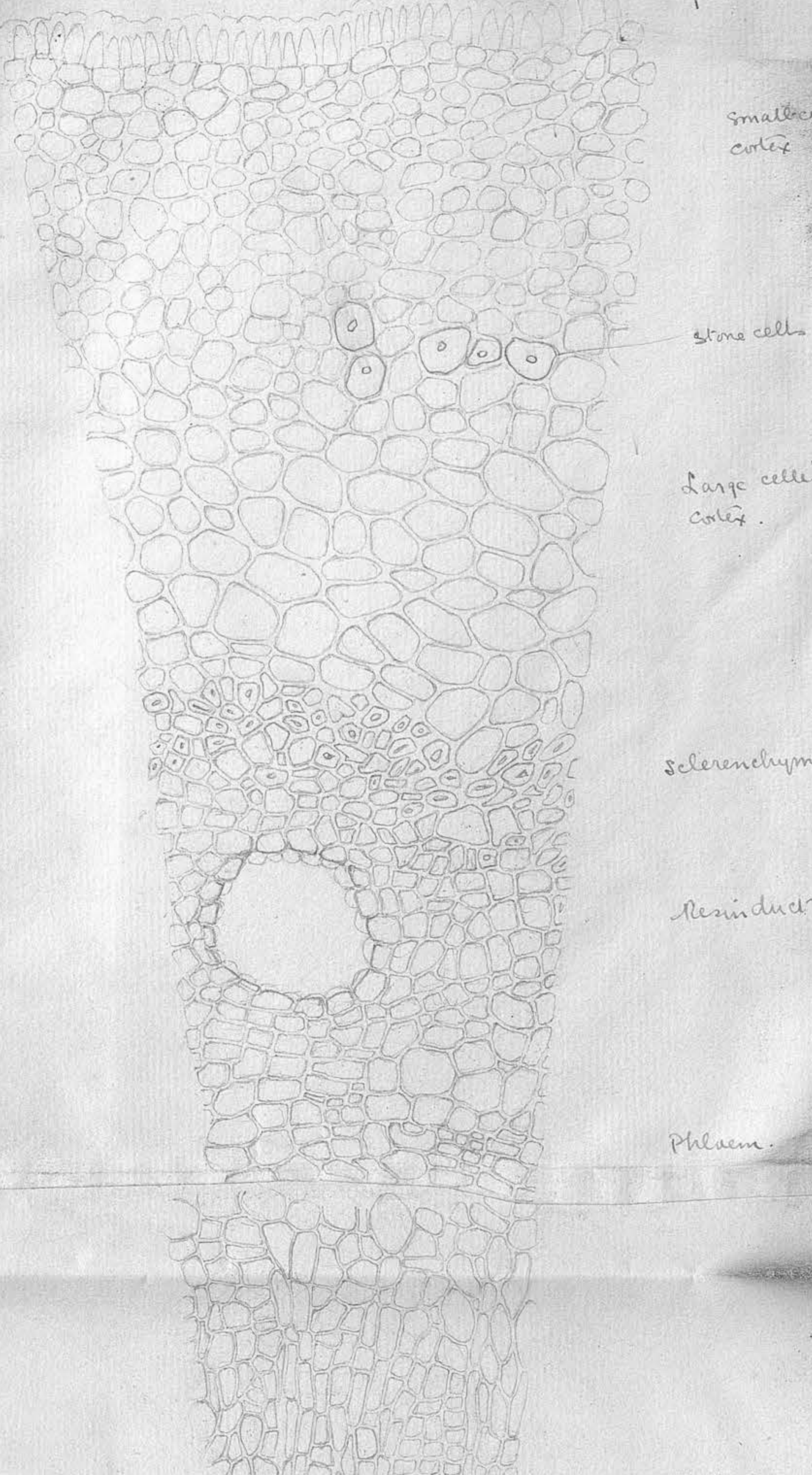


Fig. 12.



(with camera lucida)

Fig. 11 & 12. ×360. T.S. of cortex & Epidermis in (Fig 11) reproductive & (Fig 12) vegetative sides of a transition inflorescence.

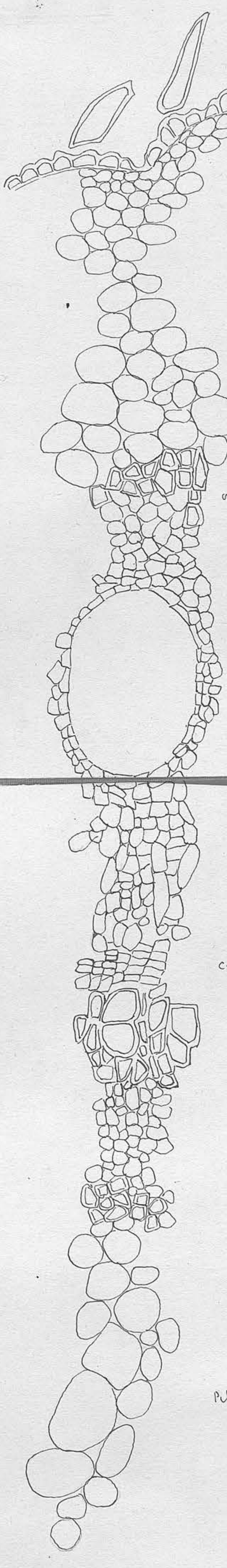


Internal Structure of Flowering shoot of Mango.

Fig. 13

Transverse section of inflorescence axis of Baramashi mango. ×200

with camera lucida



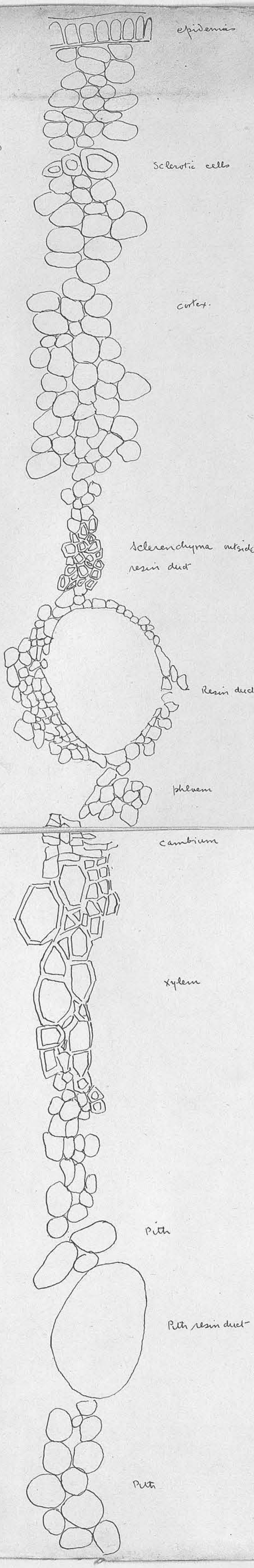
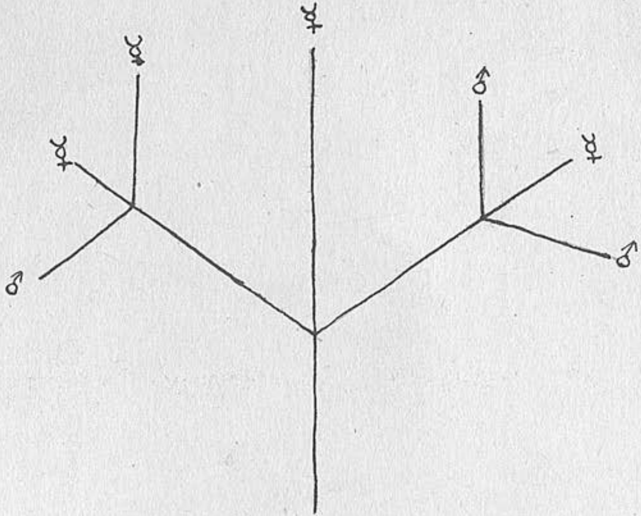


Figure. 14

Transverse section of vegetative axis of Baramashi mango.
x 200

(with camera lucida)

~~Figure 20~~ ~~Fig 6~~ Fig 15



~~Fig. 11. × 360.~~

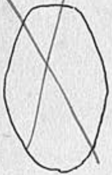


Fig. ~~16.~~ ~~8~~
16

Phloem

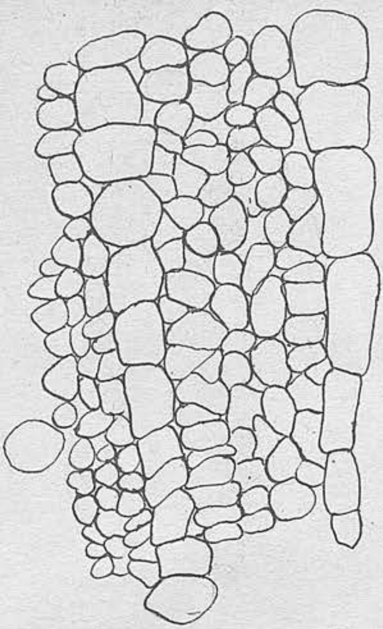


Fig. ~~17.~~ ~~9~~
17

Xylem.

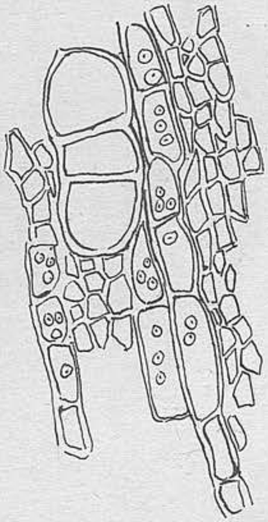
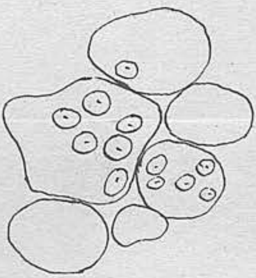


Fig. ~~18:~~ 18
~~10~~

Pith.



with camera lucida.

Fig. 19
Sclerotic cells of cortex.

× 460

(with camera lucida)