https://doi.org/10.29321/MAJ.10.A04700

Some Factors Governing Fruit-bud Formation in Mangoes (*Mangifera indica* Linn.)

II Relation Between Growth and Flowering.

By K. C. NAIK, M. Sc. (Bristol),

Fruit Specialist, Kodur.

and

M. MOHAN RAO, M. Sc.

Introduction. A correct understanding of the relationship between various growth features and productivity was shown in the previous paper* as essential in successful mango production. Productivity is the ultimate manifestation of the tree performance, from the grower's point of view. But a comparison of this ultimate phase with the growth features does not appear to be valid for the purpose of determining the most useful features of growth for ensuring high production and regular bearing in mangoes. The correct basis of study in a problem of this nature would be flowers and not fruits. Flower is undoubtedly a preliminary to fruit, but it does not follow from this that a heavy crop of flowers is always followed by a heavy crop of fruits. It is the universal experience of mango growers that, in several years flowers shed either due to environmental influences or, as is very often the case, due to a heavy attack of hoppers. A bumper crop of blossoms may be entirely lost, turning a prospective good year into one of extreme scarcity. To study the problem of the so-called periodicity or biennial bearing solely on the basis of fruit crop records in the face of these well-known disturbing factors, a good part of which is beyond human control, is naturally not the proper course. The work reported in this paper has therefore been carried out on the above-mentioned basis, viz., that of blossom.

Material and methods. The material described in the preceding paper under this series provided the basis for the study on blossom-bud formation also. The flowering performance of the various classes of shoots described therein were collected during the various flowering seasons and the data presented in the following pages relate only to these.

Importance of leader shoots. The flowering records of the six different classes of shoots selected for study are set forth in Table I. A perusal of the figures brings out the supreme importance of leader shoots in determining the future crop. There is, however, an exception to the rule in the 'current year's' shoots. It is now possible to say that, in mangoes, flowers are largely borne on the preceding year's growth which may have emerged from the leaders that had either flowered or not flowered in that year. It is true that shoots of several years of age have also been noted to produce flowers in some cases, but rarely the fruits are carried to maturity on such

* *Madras Agricultural Journal* 30, 329 (1942).

shoots. For all practical purposes, therefore, branches over two years of age may be considered to play no important part in directly increasing the flower crop.

Performance of flowered and non-flowered leader shoots. The importance of flowered leaders in any given year for the production of flowers in the following season is also found to be as great as that of the non-flowered leader shoots of the same year. The general belief that shoots that flower in one year are incapable of producing a crop of flowers in the subsequent year is erroneous, since such shoots have not been found to differ statistically from the non-flowered shoots originated in the same year.

It must however be admitted that a shoot that flowers need not necessarily carry fruits to maturity. It has also been shown in the previous paper that de-blossomed shoots have different growth features and consequently different cropping potentialities from the shoots which carried fruits to maturity. It is possible that, apart from the possible influence of earlier or later vegetative growth or of shedding of flowers on the bearing of shoots, the inability of the fruiting branches to develop new shoots and mature them sufficiently early so as to produce a crop of blossoms in the next season is also a limiting factor.

Performance of 'current year's' shoots. In the case of 'current year's' shoots, mention has already been made that no significant difference exists between leaders and laterals regarding productivity. Much reliance cannot be placed on these data because of the lower number of shoots selected for study in *Mulgoa*. However, in *Neelum* and *Bangalora* a very much higher proportion of leader shoots are noticed to bear flowers in the following year, while in *Mulgoa* though the proportion of cropping shoots is less than that of laterals, it is nevertheless fairly high. These furnish an indication that, provided a good crop of leader shoots are produced in the first flush of any year along with the development of fruits, a good crop of blossoms can be predicted during the following year.

The laterals exercise generally little influence in determining the extent of flower crop in the following year or the year after that. Notwithstanding the single exception discussed above, it may be concluded from a general review of the entire data that, proportionately the laterals are of very much lesser importance than leaders in producing flower buds. But their importance in influencing the gross flower crop cannot be determined on the above basis, as this would depend not upon the percentage of flowering laterals but upon the number of laterals produced on a tree.

Performance of shoots that carried fruits to maturity. None of the shoots under observation that carried fruits to maturity in 1939 was seen to flower in 1940. This leads to the conclusion that the effects of flowering on the future performance of the shoots is not the same as that of fruiting. As has been pointed out in the previous paper shoots that carried fruits to maturity have produced fewer laterals on a smaller

proportion of shoots and registered very much less extension growth than the shoots that flowered but shed the flowers completely. The development of the fruit possibly draws more heavily upon the food reserves of the tree than the formation of blossoms, and this fact must naturally exert a profound influence on the future shoot performance.

Dissimilar reaction of varieties to 'off-' and 'on-year' bearing tendencies. Not a single shoot of any of the six classes in *Baneshan* has borne any flower during 1940. The year appears to be an 'off' one for the variety and presumably a very good one for *Mulgoa*. *Neelum* has borne a normal crop of flowers, while *Bangalora* had a crop that almost bordered on the "poor". Incidentally, these facts relating to four main commercial varieties growing together in a plantation indicate that all varieties do not respond uniformly to the factors, known or unknown, that bring about lean and good years in a mango tract.

Performance of lateral shoots. (a) *Influence of laterals on gross flower crop and regularity of bearing.* Every leader shoot is capable of functioning not merely as a single leader but may also produce a number of laterals. Similarly, every lateral shoot is capable of producing in its turn numerous lateral growths. In as much as there are a larger number of laterals than leaders on a tree and that laterals are also found capable of producing flowers to some extent, it is to be expected that panicles borne by laterals may be far more numerous than those borne by leaders on a given tree. From this it may be inferred that, because of their large preponderance in number the laterals may influence the gross crop yield to a considerable extent.

The emergence of a high proportion of laterals during the flowering period as shown in Teble III in the first paper of this series, and the fact that a large proportion of such shoots produce blossoms in the next season are points of great interest and economic importance, in that the production of flowers and of shoots that flower in the succeeding season go hand in hand every year thus ensuring regularity of bearing. *Neelum* is known for its regularity of bearing and this variety has also shown to be capable of producing a high proportion of lateral shoots. Thus, although the importance of leader shoots in determining the crop size has to be recognised, the equally great importance of lateral shoots, especially in varieties wherein they are produced in large abundance, in influencing the gross crop-yield and in ensuring regularity of bearing cannot be under-estimated.

(b) *Performance of laterals produced in 1938.* As in the case of leaders, reference to Table I shows that no significant difference in productivity exists between flowered and non-flowered lateral shoots. Contrary to the existing belief, this fact corroborates the previously drawn inference that the shoots that flower in one year are also capable of bearing flowers in the succeeding year, provided no fruits are carried to maturity on these.

(c) *Performance of lateral shoots originating in 1939 from the flowered and non-flowered leaders and laterals.* Table II shows that a

fairly high proportion of the fresh lateral shoots produced by the flowered and non-flowered leaders and laterals in any given year are capable of flowering in the succeeding year. It is further observed that there is no significant difference in the flowering tendency of the lateral shoots originating from different classes of shoots.

(4) *Performance of lateral shoots produced in 1939 on current year's shoots.* As is natural, the leaders and laterals produced during the first flush of 1939, i. e. the 'current year's' leaders and laterals are not expected to produce a large number of lateral shoots during the remaining part of the year. In *Bangalora* and *Mulgoa* such new growths have been totally absent, while in *Baneshan* their number is fairly high. But none of these has produced any crop in 1940. It may, therefore, be concluded that the laterals emerging in any given year from the shoots produced in the same year are valueless for producing a crop of flowers for the succeeding year.

Period of emergence of laterals in relation to flowering. Owing to the practical difficulty in obtaining an adequate number of laterals emerging every month from April 1939 to January 1940 in each of the six classes of shoots in these varieties, it has become impossible to ascertain the relationship between the period of emergence of lateral shoots from each of the six classes of shoots and their flowering potentialities. However, the flowering performance of the varying number of new laterals emerging in 1939 during the different months in these three varieties has been studied. The data are presented in Table III. It is seen that April and May are the most important months for the production of new laterals from the point of view of flower production.

Relation between length of shoots and blossom bud formation. Examination of the data relating to the flowering frequencies of shoots of various lengths in two varieties, viz. *Neelum* and *Bangalora*, has shown that the flowering shoots in both leaders and laterals show medium variation with high frequency of growth in the middle ranges of growth and the non-flowered groups exhibit either very high or very poor extension growth. In other words, the modal class is situated at the ends of the range in non-flowered leaders and laterals. It may, therefore, be concluded that shoots of medium length are most fruitful.

Duration and extent of growth and growth cessation in relation to flowering. Observations extending over four flowering seasons have shown that increased vegetative growth is immediately followed by low flower production or vice versa, and that trees which ceased growth early, say by the end of May, are most prolific in bearing, while those in which the growing period was prolonged up to July or August, or which showed growth activity in the season immediately preceding the flowering period failed to produce good crop. An early cessation of growth during the first lush as well as a definite dormant period immediately preceding the

flowering season are therefore vital for the formation of a good crop of flower buds.

It will be recognized that all the above mentioned favourable conditions for flower-bud formation are subject to be considerably influenced by the prevailing seasonal conditions and to a certain extent by the orchard cultural practices.

Discussion On the basis of independent studies, Singh and Naik (1933), Galang and Lazo (1935), Sen (1939) and Singh and Khan (1939) in mangoes, and Roberts (1929) and Swarbrick and Naik (1932) in apples, have shown that a number of factors associated with tree growth are intimately connected with the subsequent performance of those trees. From such definitely established relationship it has been found possible to predict in some instances the future tree performance with some exactitude and also to shape the growth of the trees in a manner most conducive to optimum production. A number of workers like Hodgson and Cameron (1935) and Marseille (1937) have studied the relationship between certain climatic factors and tree performance, while Brown (1936) and Bane (1939) have pointed out the various cultural practices by which the tree-growth can be regulated in the desired channel. These various investigations serve to lift the fruit growing industry from the empirical to the scientific sphere. It is on these lines that the Indian mango industry can hope to tide over the present uncertainty and ensure reasonable returns to the grower by guaranteeing regular cropping in desired bulk. The underlying objectives of the present investigations revolve upon this principle of imparting the exactness to the erstwhile 'hit and miss' method by furnishing a correct understanding of the relationship between various growth features and productivity.

One of the outstanding points emerging from this study, is that in any investigation of the problem of blosom-bud formation in relation to growth features, grouping of all classes of shoots into a single category will be valueless. It has been clearly shown that each of the six classes of shoots in mango included under this study possesses different growth features and flowering potentialities. It is, therefore, amply borne out that the conclusions drawn on the basis of a single class of shoots will not be valid except in affording broad indications, particularly in regard to the growing season, and growth as influenced by performance in the previous season. Some of the interesting results such as the relation between flowering and the different classes of shoots, and that between the extension growth of shoots and blossom-bud formation and again between regularity of bearing and the characteristic growth features of the variety can only be obtained by a study of the growth features of each class of shoots separately.

The data emphasise that, despite wide variation in the nature, extent, and period of growth among the individuals, there is some easily definable relationship between flower-bud formation and growth features in the preceding season. Since growth in its turn is influenced by a variety of factors such as seasonal conditions, tree-metabolism and cultural practices, it is

necessary to understand the correlations of all these factors for comprehending the contributory causes of productivity.

It has been commonly assumed that there is a definite periodicity in mango production. Hartless (1914) and Burns and Prayag (1921) have adduced data to show that lean and good years alternate with each other almost without exception. Popenoe (1927), while admitting that biennial bearing possibly exists in some varieties, has found that heavy production in *Mulgoba* occurs on an average once in four years in Florida. In a general discussion on bearing in mangoes, Sen (1939) and Singh and Khan (1939) have maintained that biennial bearing is an established feature, although no definite evidence has been furnished by them in support of this assertion. Data collected in a mixed plantation at Kodur (Naik, 1940) have shown that good or bad cropping years occur at indeterminate and irregular intervals and do not conform to any alleged conception of rhythmic or cyclic production. The position at present, therefore, is one of dispute, and this is perhaps attributable mainly to the fact that the different workers have adopted dissimilar approaches to the study of the problem and have based their inferences on dissimilar varieties grown under widely varying conditions.

Taking the extent of flowering as the proper basis, the first direction to which attention is to be properly diverted is towards the growth features during the seasons preceding the flowering period. It has been shown in the present paper that flowers are borne on leaders as well as lateral shoots. The number of shoots of each of these classes varies in a tree to some extent as does also the proportion of each of these classes of shoots to bear flowers. If the leader shoots by themselves are more important as a class for flower production, the lateral shoots, because of their large number are of equal importance. The former class of shoots occur as extension growths, while the latter are formed mainly from around the tips of shoots which have ceased growth previously. A large number of such lateral shoots also occur around the tips of shoots that have borne flowers. It, therefore, follows that in the case of a tree which has borne a very heavy crop of flowers, a large number of lateral shoots develop either during the time of flowering itself or a little later. Even among that class of shoots which fail to produce flowers, a number of laterals originate from the terminal rosette of such shoots. Data have been adduced to show that some proportions of all these classes of laterals produce flowers in the next season although the extent may vary according to varieties, age and genetic make-up of the trees. Since the production of a very large number of laterals has been proved to occur in every year all the four varieties under study, and since a proportion of such laterals has been shown to be capable of producing flowers in *Neelum, Bangalora* and *Mulgoa*, it seems to be clear that these three varieties at least, are not prone to biennial or periodic bearing. It must be stated that these three varieties bore a fair to good crop in this tract during 1939, and the former two varieties again produced almost the

same size of crop during 1940. *Bangalora* registered a crop of slightly lesser size in 1940 than in 1939. Failure of shoots of *Baneshan* to flower in 1940 has already been shown to be due to the longer period of growth of the shoots in the first flush and its vegetative activity in the season immediately preceding the flowering period, and cannot therefore be due to the fact that this variety was in the 'off' year. If the latter be the case, a similar feature should have been evident in the other three varieties also either during 1939 or during 1940, both of which years cannot be definitely termed as lean years for these varieties.

It has to be remembered, however, that growth is influenced by a number of factors, each of which may vitally influence its course and extent, and through these, ultimately the productivity. It has been stated by some workers that a heavy cropping year is followed up by no crop in the same tree or a variety. But this is only a half-truth ; for apart from the fact that the individual trees constituting a variety differ markedly in their productive capacity as well as in their ability to bear regularly from year to year, the effects of a heavy crop of flowers are quite different from those of a heavy crop of fruits. The former, if it does not carry a large number of fruits to maturity may result in a good crop of laterals which may, in turn, be responsible for the production of a good crop in the succeeding year. On the other hand, in the latter case, imagining an extreme instance, it is possible to conceive delay in lateral shoots formation and poor extension growth or complete non-appearance of laterals and consequently of poor or no crop in the succeeding season. Not only such extreme instances do not occur in the case of every tree of a variety, but there are also numerous other modifying influences which seem to make it impossible for the regular occurrence of this so-called biennial or periodicity of bearing in mangoes. Favourable weather or cultural practices at the proper time may force vegetative growth during the blossoming period or it may extend the growth too late in the season. In the former case the crop is adversely affected for that season, while in the latter case trees are rendered partly or completely unfruitful during the succeeding year. Heavy rains during the blossoming period, insect and fungoid diseases, strong gales, prolonged dry spells, artificial cultural practices such as ringing, pruning, smudging, notching, deep ploughing, grassing, manurial and irrigational practices and also varietal peculiarities such as off-season or second flowering capacities may all exert their individual and cumulative influences which will ordinarily render the regularity of biennial or periodic tendency in mangoes a practical impossibility. It is, however, admitted that the influences of certain environmental conditions may exert on such a wide scale as to destroy the crops of a whole tract in one year with a better crop prospect for the next year. But such adverse influences do not naturally occur according to the set plan of the alleged biennial or periodic bearing phenomenon.

More than all, the belief in biennial bearing does not take into account the extreme variability in the genetic make-up of mango trees. It has been

shown by the senior author (1940) from a study of a number of varieties over a four-year period that, there is a wide variation in tree-yield, and that the proportion of productive or regular bearing trees over a given period of years varies from year to year. That there are as many as 100, 92, 84 and 100 per cent consistently poor-cropping individuals in *Mulgoa*, *Bangalora*, *Neelum* and *Andrews* respectively during a four-year period is a definite testimony against the existence of the so-called biennial or periodic bearing in mangoes. It is possible to visualise fairly uniform performance in a plantation planted to standardized root-stock and scion varieties. But this is an achievement that can be but a fond hope at present. Realising the unstandardised production of mango trees in Indian nurseries, it is essential to make due allowance for the extremely varying performance in Indian mango plantations—a feature that ill-fits the belief in biennial bearing.

Summary and conclusions. In mangoes, a definite relationship is found to exist between various growth features and blossom-bud formation.

No significant difference is observed between flowered and non-flowered shoots with regard to flower production. The general belief that, shoots that flower in one year are incapable of producing a crop in the succeeding year, is therefore, erroneous.

Mango flowers have been found to be borne largely on the shoots that originate in the first flush of the previous year.

Although a higher percentage of leaders than laterals bear flowers, the latter shoots because of their great abundance on a tree exert a profound influence in increasing the gross flower crop.

None of the shoots that carry fruits to maturity seem to bear in the succeeding year, which means that this class of shoots is less efficient than that in which the flowers shed early or in which flowers were not produced in that year.

An early production of lateral shoots during the first flush, an early cessation of growth during the same flush and complete dormancy in the season immediately preceding the flowering period, seem to be conducive to regular bearing in mangoes.

Heavy flowering is followed by retarded tree activity in the following growing season.

The available data and the knowledge on the nature of bearing in mangoes indicate that biennial bearing is not an established feature and that the incidence of lean years at unregulated intervals is due to factors other than those associated with the natural growth tendencies of the mango.

Acknowledgements. During the period of about four years when this investigation was in progress the authors have had the valuable assistance of the late P. Parthasarathy, then Farm Manager, Fruit Research Station, Kodur, for a time. A portion of the data presented in this paper formed part of the thesis submitted by the junior author to the University of Madras for the M. Sc. degree. The authors wish to record these facts with gratitude.

Bibliography.

Bane, W. A. (1939)—Manurial experiments with apples and pears, 1919—1938. *Sci. Hort.* 7.

Brown, W. S. (1936)—Influence of irrigation upon yields, quality and profits of small fruits. *Proc. Mtg. Ors. St. Hort. Soc.* 1935.

Burns, W. and Prayag, S. H. (1921)—The Book of the mango. *Bombay Dept. Agri. Bul.* 103.

Galang, F. G. and Lazo, F. D. (1935)—The relation of fruiting to vegetative growth characters in Carabao mango. *Phil. J. Agri.* 6, No. 1.

Hartless, A. C. (1914)—Mango crops and some factors influencing them. *Agri. J. India*, 9, part 2.

Hodgson, R. W. and Cameron, (1938)—On the bearing behaviour of Fuerte Avocado variety in Southern California. *Proc. Amer. Soc. Hort. Sci.* 32.

Jennings, R. F. (1934)—Effects of weather variations in influencing navel yields. *Cal. Citrograph*, 20, 34, 45.

Marseille, O. (1937)—Climate and fruit production. *Forschungsdienst.* 3 34–42 *Hort. Abs.* 1 B. F. P. 8 No. 1, Abst. 15.

Naik, K. C. (1940)—Orchard efficiency analysis in mangoes and oranges. *Madras Agri. J.* 28, No. 3.

Popenoe, W. (1927)—*Manual of tropical and sub-tropical fruits.* Macmillan & Co.

Roberts, R. H. (1929)—Some stock and scion observations in apple trees. *Univ. Wis. Agri. Exp. Sta. Res. Bul.* 94.

Sen, P. K. (1939)—Alternate bearing in mangoes *Punjab Fruit J.* 3, 11.

Singh, L. and Naik, K. C. (1933)—Growth and fruiting characters of mango trees at Lyallpur. Paper read at the Research Societies' meeting. (unpublished)

Singh, L. and Khan, A. A. (1939)—Relation of growth to fruit-bearing in mangoes. *Ind. J. Agri. Sci.* 9, part 4.

Singh, L. and Khan, A. A. (1939) Relation of growth to bearing in mangoes. *Punjab Fruit J.* 3, 11.

Swarbrick, T. and Naik, K. C. (1932)—Some factors governing fruit-bud formation. *J. Pomology and Hort. Sci.* 10, No. 1.

TABLE I.

Mean flowering performance of the various classes of shoots in mangoes.

A. Non-flowered leaders. B. Non-flowered laterals.
C. Flowered leaders. D. Flowered laterals.

	A	B	C	D	G. M.	S. E.	Significant or not.	Critical difference. (P=0·05)
Mean number of flowering shoots per 100 selected shoots	40·33	20·67	43·67	17·67	30·58	6·31	Yes.	15·40
Mean number of flowering shoots as percentage of general mean	133·09	68·10	144·11	58·31	100·00	20·82	Yes	50·82

Conclusion—C, A, B, D.

'Current year's' shoots.

Varieties.	Current year's leaders.	Current year's laterals.	Mean.
Neelum	36	19	27·5
Bangalora	20	9	14·5
Baneshan	49	80	64·5
Mean	35·0	36·0	General Mean 23·7

Difference between leaders and laterals for P=·05—Not significant.

TABLE II

Mean performance of the lateral shoots produced by the different classes of shoots.

A. Non-flowered leaders. B. Non-flowered laterals.
C. Flowered leaders. D. Flowered laterals.

	A	B	C	D	General mean.	S. E.	Significant or not.	Critical difference. (P=0·05)
Mean performance of the lateral shoots produced by the different classes of shoots	39·0	37·0	31·5	9·0	29·1	16·07	Yes	39·2
Mean performance as percent of general mean	132·6	125·8	107·1	30·6	100·0	54·68	Yes	133·3

Conclusion $\overline{A, B, C, D}$

TABLE III

Flowering performance of the lateral shoots produced during the different months of 1939*

A—April, B—May, C—June, D—July, E—October.

	A	B	C	D	E	General mean.	S. E.	Significant or not.	Critical difference (P=0·05)
Mean performance of lateral shoots	60·0	47·0	13·5	10·5	7·5	27·7	6·97	Yes	19·4
Mean performance as percent of general mean	222·0	173·9	49·9	38·9	27·8	100·00	25·78	Yes	71·7

Conclusion $\overline{A, B,}$ $\underline{C, D, E}$

* No shoots were produced in September 1939 and January 1940, while those produced in August, November and December 1939 failed to flower in 1940.