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market charges and allowances and provision of suitable ware-houses. The definite advantages of high premium and the large profits involved in the grading of the produce for the *ryots* needs no special mention. The establishment of grading centres at important jaggery trade centres with definite standards would go a long way in increasing the returns of the jaggery manufacturer.

To make the jaggery manufacturer independent of the loan giving middlemen, a sound marketing policy indicated should be coupled with provision of cheap credit. Co-operation appears to have great potentialities in this direction. The middlemen advance loans before the crop is sown and unless the co-operative societies can furnish to cultivators all the facilities that the middlemen offer them the progress of co-operative effort cannot be rapid or certain. In Baroda, it is learnt, the state has recently commenced the issuing of crop loans for sowing improved types of cotton at 4½ per cent interest. It is obligatory for the farmer who receives the loan to market his produce through co-operative agency. Such a scheme modified to suit the conditions of this Presidency may be tried till co-operative endeavour is able to take up the whole work. A scheme that provides for regulated markets and systematic grading of the produce coupled with the provision of cheap credit through co-operative societies would make jaggery making more paying and would secure for the cane cultivator his due share of the consumer's price which at present is denied to him by innumerable middlemen and unscrupulous traders.

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Cropping Behaviour In Mangoes.*

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The fairly frequent occurrence of lean years in mango production and the shy bearing tendencies of many reputed varieties are well-known to form the limiting factors in the successful mango culture all over the world. It is commonly assumed that there is alternate bearing or a definite periodicity of bearing in mangoes. Hartless (1914), Burns and Prayag (1921), Sen (1939) and Singh and Khan (1939) have maintained that lean and good years alternate with each other without exception, while Popenoe (1917 and 1927) states that heavy production in *mulgoa* occurs once in

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rour years in Florida. One of us (Naik 1940) has recently shown that good or bad cropping years occur at indeterminate intervals and do not conform to any alleged conception of rhythmic or cyclic production. The causes of scanty fruiting in many varieties according to the senior author is due partly to the genetic make up of the individual and partly to the varietal characteristics, while those for lean years in mangoes may be mainly environmental influences including pest and disease incidence. On the other hand, Burns and Prayag (1921) and Popenoe (1927) postulate that the problem is a physiological one connected with the nutritional conditions of the tree.

In fruits subject to such erratic production, a knowledge of some of the pre-fruiting characters which influence or govern productivity is essential, in that it furnishes to the grower a means of predicting the size of the crop and of undertaking in advance suitable measures for regulating the future crop-bulk in the desired channel through modification of the concerned pre-fruiting growth features. In the present paper are outlined the results of investigations carried out at the Fruit Research Station, Kodur, from August 1936 to May 1941 on certain commercial varieties of mangoes on the problem of productivity as affected by growth conditions and by certain blossom biological considerations. In mango where perplexing crop uncertainties upset the growers' expectations occasionally, any effective step towards reducing the swing from heavy to light crops is bound to be of considerable value, and the investigations were all designed with this main objective.

Season of growth, and growth as affected by flowering or fruiting performance. Under Kodur conditions, growth in mangoes is characterised by two active phases, one commencing in February and lasting till June and another occurring in October-November. Minor growth phases may, however, occur mainly in December. The production of a heavy crop of blossom in one season is found to considerably retard the tree-activity in the succeeding season of growth. Shoots which flower but shed the flowers early or in which the fruit drops off at an early stage of development produce a very much larger number of lateral shoots in the subsequent growing season than the non-flowered ones. Shoots that carry fruits to maturity on the other hand either do not produce any laterals at all for the year, or if they give out any, such laterals tend to make poor growth and are mostly produced very late in the year.

Flower Production. With regard to flower production it is observed that panicles are largely borne on the preceding year's growth which may have emerged from the leaders that had either flowered or not flowered that year. Shoots of several years of age have also been noted to produce flowers in some cases, but rarely the fruits are set and carried to maturity on these. During 1940, the percentage of flowering shoots among leaders was 43 in *neelum* and 27 in *bangalora*, whereas among laterals the percentage of cropping shoots was 17 and 18 respectively.

Between the flowered and non-flowered leader or lateral shoots, no statistical difference is observed with regard to flower production in the

succeeding year. Thus the importance of flowered shoots in any given year for the production of flowers in the following season is found to be as great as that of the non-flowered shoots of the same year. The general belief that the shoots that flower in one year are incapable of producing a crop of flowers in the subsequent year is, therefore, erroneous under normal conditions of growth and culture.

It must, however, be admitted that a shoot that flowers need not necessarily carry fruits to maturity. As has already been pointed out, shoots which shed flowers early in the season possess different growth features from those that carried fruits to maturity. Such differential growth features as the poor extension growth and the late production of new growth in shoots that carried fruits to maturity are found to form adverse factors for the production of blossoms in the succeeding season. No profitable crop can therefore be expected from trees which have produced a bumper crop in the previous year and at the same time have failed to record adequate amount of extension growth early in the season on shoots of the previous season. This leads to the conclusion that the effect of flowering on the succeeding year's performance of the shoots is not the same as that of fruiting. Obviously the development of the fruit exerts a more profound influence on the shoot performance in the following year than the production of flowers alone.

The lateral shoots appear to be proportionately of lesser importance than leaders with regard to production of flower buds. Every leader shoot however, is capable of functioning not merely as a single leader but also may produce a number of laterals. Similarly, every lateral shoot is capable of producing in its turn numerous secondary shoots from its axillary buds. Inasmuch as there are a larger number of laterals than leaders on a tree, and that laterals are also found capable of bearing flowers to some extent, it is to be expected that on a tree, panicles borne by the laterals may be far more numerous than those borne by leaders. From this, it may be concluded that because of their larger preponderance in number, the laterals may influence the gross crop-yield to a considerable extent.

The emergence of a high proportion of lateral shoots during the flowering period and the fact that a large proportion of such shoots produce blossoms in the next season are points of great interest and importance, in that the production of flowers and of shoots that flower in the succeeding year go hand in hand, thus ensuring regularity of bearing. 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 great abundance, in influencing the gross crop yield and in ensuring regularity of bearing cannot be underestimated. The well-known regular bearing habit of *neelum* is possibly due to its ability to produce a large number of laterals, many of which are potential croppers in the following season.

The time of emergence of lateral shoots is also of considerable importance in regard to blossoming of trees in succeeding years. Observations extending over four flowering seasons have shown that shoots produced in the months of March, April and May produce the largest number of panicles in the succeeding year in all the varieties, excepting in *neelum*, in which those produced in October also bear crop to some extent. This feature of *neelum* is undoubtedly an additional contributory factor for its greater regular bearing habit.

In regard to the period of growth of shoots, observations have shown that trees which ceased growth early, say by the end of May are most prolific in bearing, while those in which the growing 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 flush of the previous year as well as a definite dormant period for about a month immediately before the emergence of blossoms are therefore vital for the formation of a good crop of flower buds. It will be recognised that all these favourable conditions for flower-bud initiation such as an abundant production of leader shoots during the first flush, a good extension growth of these, an early growth cessation, a good crop of laterals in varieties like *neelum* and a definite period of dormancy towards the close of the year are subject to be influenced considerably by the prevailing seasonal conditions and to a certain extent by the orchard cultural practices.

Blossoming in relation to varieties and seasonal conditions. The main flowering season under normal climatic conditions for most of the commercial varieties of mangoes grown at Kodur appears to be from December to February. Certain varieties like *neelum*, *rumani*, *allipasand* and *nazukpasand* were observed to produce more than one crop of blossoms and in such cases the period of blossoming and fruit-set are not restricted to any particular periods of the year, depending mainly on the seasonal conditions. The heavy and late rains during 1940 has for example resulted in prolonging the extension growth of shoots during the close of the past year, thus preventing a favourable crop of flowers on one hand, and encouraging on the other the production of an off-season crop of flowers in many varieties in 1941. The dry and relatively rainless summer of 1941 evidently helped the shoots to get the desired dormancy prior to initiation of flower buds. The ability of certain varieties to produce more than one crop of flowers in a year when the first one is destroyed and thereby prolong the fruiting season is a feature of considerable economic interest and importance.

Sex distribution and bearing tendency. The mango panicle is polygamous and bears male and hermaphrodite flowers. Investigations in the 1939 flowering season on 16 varieties have shown that the percentage of perfect flowers varies from 3·47 in *alampur baneshan* to 16·41 in *neelum*. The terminal portions of the panicle were found to have the highest proportion of such flowers, containing more than double the perfect flowers

in *mulgoa*, *baneshan* and *peter*, of that found in the lower parts. This fact is in conformity with the known behaviour of mangoes to bear fruits mostly at the terminal ends.

Observations collected in 1940 flowering season in a young plantation revealed the complete absence of perfect flowers in a panicle of *jahanger*, and a small percentage (0·12) of such flowers in *imampasand*, as compared to 11·7 recorded previously on a 20-year old tree of the same variety. It is possible that the huge variation in the percentage of perfect flowers between trees of the same variety are due to the differing nutritional conditions of the trees or to the differing ages of the trees. At any rate, an extension of the work to elucidate these points seems necessary.

It will be clear that the proportion of perfect flowers in the panicles will be an important determining factor in mango productivity. This has been proved from observations collected in 1940 when a definite positive correlation between the percentage of perfect flowers in the panicle and the number of fruits borne per panicle was established. Thus, *neelum* which has so far shown to possess the highest proportion of perfect flowers produced the maximum number of fruits, while *baneshan* with a relatively poor proportion of such flowers bore a much lesser bulk of fruits. There is reason to believe that, apart from the influence of prefruiting growth characters, the cluster bearing habit of certain varieties and the ability of varieties to withstand damage from high winds are two of the most important contributory causes for regularity of bearing. Of these, the former is undoubtedly associated with a high proportion of perfect flowers while the latter is purely an inherent varietal character.

Marked variations have been observed between varieties in the length of style, length of stamen and distance between stigma and anther tip. The ratio of style length to stamen length has revealed that shorter style length and lower ratios of style length to stamen length observed in certain varieties are helpful in securing a better set of fruits by means of open pollination. This is also a fact that has to be reckoned with in elucidating the causes responsible for heavy yielding nature of some varieties.

Pollination. Several workers (Popenoe, 1917 and Burns and Prayag 1921) have previously shown that mango is eminently suited for cross-pollination. The wide variation between varieties in regard to quality of fruit, yield, time of bearing, regularity of bearing and off-season cropping is also well-established. In order to see how far some of the desirable fruit qualities that are now dispersed in different varieties can be combined, some controlled pollination studies were undertaken in 1939 and were continued during the 1940 and 1941 flowering seasons. Of the 3,561 flowers pollinated, 1,093 set fruits, 43 matured and only 26 were finally available for harvest. These results are obviously unsatisfactory, in view of the fact that observations here and elsewhere have indicated the necessity for pollination in mangoes. But if it is remembered that a mango tree in normal years is capable of producing five to ten thousand panicles, each

with 1,000 to 1,500 flowers. The above figures need not be a matter of surprise and dissatisfaction, as even with about 2% perfect flowers per panicle and with only 1% of these carrying fruits to maturity, the yield from the tree cannot but be high. The data however indicate that a high proportion of perfect flowers when pollinated with the pollen of compatible varieties will be of far reaching importance in ensuring regularity of bearing. Although the available data do not warrant any valid inference in regard to the suitable pollenizers for our cultivated mangoes, strong evidence points out to the suitability of *panchadarakalasa* as a pollenizer for *baneshan, bangalora, neelum* and *chinnasuvarnarekha*, and baneshan as pollenizer for neelum, jehangir, and bangalora.

Application of Results. Erratic crop production is a special feature of most of our cultivated mango varieties. It has recently been found out at Kodur (Naik 1940) from a study of a number of varieties over a four-year period that there are a very large number of inherently unfruitful or excessively irregular bearing trees in commercial plantations in the Ceded Districts. It would therefore seem that, apart from the proper and regulated supplies of fruits in our internal markets, the main line of activities for the stabilisation and development of mango industry would lie primarily in (1) the planting of choice fruiting, regular bearing, productive and standardized varieties (2) the increase of orchard efficiency so as to obtain the maximum crop every year and (3) the regulation of mango crop by suitable cultural practices with a view to guarantee normal crop and avoid partial or total crop failure in any season.

The data collected at Kodur clearly indicate that, despite wide variation between varieties in regard to growth, there appears to be some easily distinguishable relationship between flower-bud formation and growth characters in the preceding seasons. Since growth in its turn is influenced by a variety of factors such as seasonal conditions, nutritional problems and cultural practices, it is necessary to gain an insight into the effect of all these individually and collectively with the various interplays between themselves for obtaining a full understanding of the contributory causes of the productivity.

While the importance of cultural practices can never be minimised in profitable fruit production, it is essential to recognise certain limitations of such practices also. That selection of parents has a determining influence has already been emphasised. Another factor that has been shown to govern productivity is the proportion of perfect flowers in the panicles. It has also been shown that heavy bearing is associated with the ratio of style length to stamen length. Obviously these features are at present incapable of being altered by cultural practices alone. Hybridisation may offer a possibility, and therefore the importance of a comprehensive scheme of breeding in mangoes is obvious. Rich collection of mango varieties representing the choicest germ plasm has been made or is still being

made in many centres, and an excellent opportunity is available for utilization of this material. The study into the possible methods of improvement of controlled pollination and of the varietal peculiarities should necessarily precede any hybridisation programme.

The effective control of mango production cannot be sought through a limited sphere of research alone. Selection of off season or double or triple cropping varieties, and of those that are capable of producing one or more crops of flowers when the first one is destroyed, appears to be the problem that demands special attention from workers on mango. Selection of more regular bearing varieties of those that bear fruits in clusters and can withstand heavy winds, as well as of prolific individual parents are yet other profitable lines of work which should rightly engage the serious attention of the fruit grower, nurseryman and the horticultural worker alike.

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ABSTRACTS

A brief account of the studies on the harmful after-effects of *cholam* crop on cotton. V. Ramanatha Iyer and S. Sundaram. *Indian Journal of Agricultural Science 11*, (1941).

On the rain-fed black soils of the 'Tinnies" tract, farmers generally follow a four-course rotation of *cholam*—cotton—*cumbu*—cotton. It is commonly observed there that cotton grown after *cholam* is paler in appearance, shorter in growth and poorer in yield than that coming after *cumbu*. According to the data collected at Koilpatti Agricultural Research Station during the past 31 years, the average yield of kapas in the former is 405 lb. as against 471 lb. in the latter. This phenomenon has not been peculiar to the "Tinnies" tract alone but has been observed to exist under conditions obtaining in Coimbatore, Salem and South Arcot of the Madras Presidency, in parts of Bombay and the United Provinces; and is said by American agronomists as a much dreaded feature of *cholam* growing in their arid and semi-arid tracts. Different hypotheses have been put forward by different American workers concerning the nature and