PART - I

Effects of photoperiod with and without ringing on growth and flowering in mango.
INTRODUCTION

The most intensive and critical research in the physiology of flowering has been initiated due to the discovery by Garner and Allard in 1920 of photoperiodism. Photoperiodic control of flowering in many herbaceous plants has been clearly demonstrated and accordingly they have been classified as short-day, long-day and day-neutral plants. Artificial control of light period has been used quite successfully to regulate time of bloom and increase flowering of many greenhouse flower plants (White, 1960; Weise et al. 1964). Photoperiodic control of flowering in crop plants has received a good deal of attention by scientific workers. Many of the important varieties of Indian rice are season bound short-day plants while there are also varieties which are day-neutral and can be grown any time of the year (Hector et al. 1934; Roy and Subramaniyan, 1955). Flowering in season bound short-day varieties of rice could be enhanced and induced in off-season by artificial short-day treatment (Ali and Saran, 1938; Sircar and Parija, 1945; Ghose and Shasstry, 1954; Sen and Mitra, 1957).

The flowering of woody plants is affected by two basic environmental factors, photoperiod and temperature, as well
as by internal factors of maturity (Salisbury, 1961; Hillman, 1962). Investigation relating to the influence of photoperiod to flowering in fruit trees has yet been relatively few. In recent years, some studies on photoperiodism of certain temperate fruit trees such as apples, peaches, cherries and olives which are also known to show irregularity of bearing have been reported (Gorter, 1955; Hoyle, 1955; Lammerts, 1943; Chouard, 1947; Smeets, 1956; Piringer and Downs, 1959; Visser, 1956; Stahly and Piringer, 1962; Hackett and Hartmann, 1964). However, no positive relation of photoperiod to flowering has been found in these trees, although interesting effects of varying day length on vegetative growth have been noted (Wareing, 1956; Mitsch, 1957; Piringer and Downs, 1959; Stahly and Piringer, 1962). In Coffea arabica (coffee) flowering is photoperiodically controlled (Piringer and Borthwick, 1956). Gowing (1958) observed that smooth cayenne pineapple plants were induced to flower by exposure to 8-hr. day. Interruption of the dark period by illumination suppressed the inductive effect. Bailey and Rossi (1965) observed that in catskill strawberry plants, under both long and short days, high and low temperatures, petiole length, leaf size, leaf number and number of blossoms were positively correlated with the number of hours of chilling. Furr al. (1947) concluded that the flowering of citrus was intermediate with respect to photoperiod, whereas Samygin and Lisander (1951) stated that the flowering of lemon was controlled by day length but gave no details of the response. Piringer et al. (1961) reported that
plants of all citrus species studied responded to the different photoperiods relatively early in their growth and developed the shortest stems on 8 hrs. and the longest ones on 16 hrs. generally because of more and longer internodes. Experiment by Nakata and Watanabe (1966) also presents evidence that flowering of Litchi chinensis - a sub-tropical woody fruit tree is promoted by low night temperature and is not influenced by photoperiod.

The effect of day length upon extension growth has been investigated in over 60 species distributed among 35 genera and, in all except a few of these, well marked responses have been demonstrated. Citrus species (Samygin and Lexandr, 1951), Pyrus sps. (Meshkov, 1932), sweet cherry (Smeets, 1956), Jonathan apple and Elberta peach (Piringer and Downs, 1959) and Prunus persica (Lammerts, 1943) among fruits and many forest species have shown photoperiodic sensitivity with respect to extension growth. In all such cases, exposure to short day conditions results in reduced extension growth, attributable to (a) earlier cessation of apical growth which results in a reduced number of internodes, and (b) reduced internode extension.

Several plant physiologists have studied the influence of the environment on flower formation and sex expression in hermaphrodite or monoecious species (Nitsch et al. 1952; Resende, 1950; Resende and Viana, 1952). Nitsch et al. (1959) observed that shortening the day from 16 to 8 hrs. results in
an advanced appearance of the first female flower on the vine of Acorn Squash (*Cucurbita pepo* L.) also in a faster increase of the percentage of female flowers as the development of the vine proceeds. A light period of intermediate length (12 hrs.) gives results which are intermediate also. They further reported that high temperature and long days favour the development of the male flowers whereas low temperature and short days cause the development of female flowers. Tiedjens (1928), Edmond (1930), Whitaker (1931), Currence (1932), Hall (1948b), Fuji (1954), Shifriss and Galun (1956) report similar facts.

In a series of experiments on cucumber Ito and Kato (1953), Ito and Saito (1957b), Saito (1961), Saito and Ito (1961) made comprehensive studies and observed that sex in cucumber varies with variety, age, light, temperature and fertilizer treatment, short days and low night temperature favouring pistillate flowers. These environmental factors affected sex expression by changing the physiological condition of the plant before flower differentiation. Lengthening the daily duration of darkness up to a maximum of 18 hrs. promoted the formation of female flowers. The optimum diurnal temperature range for female flower production was found to be 24°-17°C. In monoecious plants other than cucurbits comparable observations have been made which are reviewed by Loehwing (1938). In corn, Schaffner (1930) showed that short winter days completely inhibit the formation of male flowers and were able to induce the formation of female flowers on the terminal tassel by growing corn plants at low temperature under 8-hrs. of sunlight.

Even hermaphrodite plants like tomato can be shifted towards
maleness or femaleness by appropriate environmental conditions
since summer days stimulate the formation of large stamens
whereas winter days favour the development of pistil (Howard, 1939). Some other instances in which either photo or thermo-period bring about the same effects are reported by Murneek and Went (1948). Singh et al. (1966) suggested that temperature plays an important role in controlling the process of perfect flowers in the various types of panicles of mango, although other factors as day length may be important. According to Heslop-Harrison (1957) day length, temperature and also other factors are considered to act on sex expression through their effects on auxin level. Both Mitsch et al. (1955) and Resende (1952) also point to the possible relationship between auxins and sex-expression and Resende (1952) emphasizes especially the auxin-antiauxin balance.

The general hypothesis that maturity and hence flowering in mango trees depends on a high level of carbohydrates commands a good support from the observations involving manipulation and their effect on flowering. Of these methods, one of the most widely favoured is girdling - the removal of a ring of bark, including phloem, on an entire tree or on a branch. The demonstrated effects are (1) inhibition of vegetative growth and (2) accumulation of assimilates above the girdle. Girdling is often effective in causing flowering of plants too young to flower otherwise in species as unrelated as citrus (Murr et al., 1947); Pinus (Hoekstra and Morgen, 1957) and apples (Sax, 1957). The possible relationship of floral initiation
to starch accumulation was reported by Harley, Masure and Magness (1941). Murneek (1941) indicated that girdling of apple stems resulted in more flowering with concomitant greater accumulation of starch in the stem without influencing the sugar level. Shamel and Pomeroy (1934, 1944) reported that girdling the branches of both Valencia and Washington Navel orange trees gave increased yield. L. Singh and others (1940), in order to avoid the adverse effects of root pruning on the santara orange (Citrus reticulata) tried ringing, which invariably increased the yield of sky-bearing trees about 10-years old. S. Singh (1940) reported that in the case of 16-year old santara trees which had never borne an economic crop, root pruning failed, and ringing increased the crop markedly. Wagle (1920) found that by ringing and notching he could increase the number of inflorescences and fruits on bearing trees, but that he could not secure flowers on trees in a vegetative stage. In a later paper (1931) he reported some success with ringing, manuring and pruning off the October-November flush. Sen (1945) reported that ringing in August resulted in satisfactory flowering the following spring. Mallik (1951) also reported a significant increase in the flowering of 20-year old Bombay, Langra and Fazli mango trees in both "off" and "on" years following the removal in August of rings of bark one half inch wide from large branches. Nakata (1956) and Young (1957) concluded that girdling round the branch or trunk greatly increased flowering and fruiting in some varieties of Litchi and they opined that flowering and fruiting, in general, was heavier after
September or October girdling than on non-girdled or November girdled trees. Gaskin et al. (1963) noted that October girdling of 4-year old mango seedlings increased flowering and fruiting. Jacob (1934), Coombe (1959), Lider and Sanderson (1959) reported that girdling at or near full bloom markedly increased the set of berries on the clusters and increased fruit yield over ungirdled vines in several grape varieties.

Researches on photoperiodism of fruit trees reviewed above mainly deal with the temperate and sub-tropical fruits. Reports on photoperiodic response of tropical fruits are very few. An experiment has been carried out with a view to investigate the effects of photoperiod with and without ringing on growth, flowering, panicle size, sex expression and yield of an intensively biennial mango, variety Langra during 1967-68 and 1968-69.
MATERIALS AND METHODS

The experiments were conducted in an orchard of the Seva-Bharati Farm School and Agrarian Research Centre at Kappargi, Midnapore, West Bengal, in two successive years, 1967-68 and 1968-69. Five 14-year old grafted Langra (intensively biennial) mango trees having uniform growth and in full bearing age were employed. The trees were in "off" year phase in the first year of experimentation.

There were in all four treatment combinations between photoperiod (short day and normal day) and ringing (ringing and no ringing) - short day with ringing, short day with no ringing, normal day with ringing and normal day with no ringing i.e. control. The short day treatments were given at three different times in both the years. At each time of experimentation short day treatment was administered for consecutive 30 days and each short day treatment consisted of a daily 8-hrs. exposure to natural day light from 8 A.M. in the morning to 4 P.M. in the afternoon. In the first year, short day treatment was given from (i) mid-April to mid-May, (ii) mid-June to mid-July, and (iii) mid-August to mid-September, corresponding to vigorously active phase of vegetative growth, less vigorously active phase of vegetative
growth and cessation of vegetative growth. Ringing was done at each time one month ahead of administering the short day treatment while in the second year, ringing was done only at one time in mid-March and short day treatment was given from (i) mid-September to mid-October, (ii) mid-October to mid-November, and (iii) mid-November to mid-December, corresponding to the stages of ripeness to flower condition, beginning of fruit-bud initiation, initiation of fruit-buds and their differentiation respectively. The normal day length varied from 13.5 to 12.5 hours in 1967-68 and 11.6 to 10.3 hours in 1968-69 during the period of experimentation.

For each set of experiment, four comparable limbs, approximately 8.5 cm to 10.5 cm in diameter were selected on each of the five trees of which two were ringed and the other two non-ringed. One each of the two ringed and two non-ringed limbs received short day treatment and the others were under normal day condition. The limbs which were non-ringed and under normal day represented the control.

Ringing was done by removing a ring of bark 1.5 cm wide and it was maintained up to December by occasional removal of the callus tissue. Short day (8-hrs. day) treatment was given to the whole limbs carrying current year’s growth by enclosing them in an improvised dark cloth cover from 4 P.M. in the afternoon to 8 A.M. next morning.

On each treated limb, a sample of 20 current year's shoots of single flush growth was selected at random and
tagged. Growth records on length (linear growth) and girth (diameter growth) of the tagged shoots under each treatment were taken at monthly intervals starting from the date of treatment application to December when growth had ceased completely. The increase of linear and diameter growth of shoots under different treatments were calculated on the basis of the increase in growth over the initial in control of March application taken as 100 percent. Flowering record was taken at full bloom in the following spring. The percentage of shoots flowering per treatment was then calculated.

For studying the effect of treatments on sex expression, ten panicles were tagged for each treatment, taking two from each tree. In order to ascertain the total number of male and hermaphrodite flower, a daily count was made by carefully removing the opened flowers with the help of a forcep, from the time the flowers actually started opening on each panicle till opening was over. Finally, the percentage of hermaphrodite flowers per panicle was calculated.

Besides, yield record for each treatment was maintained by harvesting the fruits at maturity.

Statistical analyses of the data on growth, flowering, panicle size, sex expression and yield were worked out according to Randomized Block design. Critical difference was then calculated to determine the significance of difference among the means of treatments, times of application and their interactions.
RESULTS

Results of the experiments conducted in two successive years 1967-68 and 1968-69 respectively on the intensively biennial mango variety Langra to study the effects of photoperiod with and without ringing on growth both linear and diameter, flowering, panicle size, sex expression and yield are reported hereunder. The mean values and analyses of variance are presented in Tables 1-22, given in appendix. The significant effects are also graphically represented in Plates 2, 3 and 4.

I. Effect of Linear growth of shoots (Tables 1,2; Plate-2,Fig.2).

Irrespective of time of application, ringing significantly retarded and caused earlier cessation of linear growth of shoots in both the years. Short day exhibited a significant reduction in 1967 only but the magnitude of reduction in 1968 did not reach the significant level. Between ringing and short day the former was more effective in reducing linear growth than the latter.

Retardation of linear growth caused by ringing and short day treatment given at different times showed, in general, variation due to different times of application in both the
years but the variation was significant only in 1967. Among the three times of treatment application, mid-April application brought about maximum reduction of linear growth followed in order by mid-June and mid-August application. Further the difference of magnitude of reduction between mid-April and mid-June application was not statistically significant whereas those between mid-April and mid-August, mid-June and mid-August were found to be significant.

The interaction between ringing and time (RxT) was significant only in 1967. Among the three times of ringing, the earlier the ringing was done in the season, the more was its retarding effect on linear growth of shoots.

The interaction between ringing and photoperiod (RxP) was also significant in 1967 only. Ringing with short day and ringing with normal day though caused significantly very high degree of reduction than the control, the difference between them was non-significant. Reduction of growth under short day with ringing was much more than that under short day without ringing.

The interaction between photoperiod and time (PxT) did not show any significant variation in any of the year under study. Short day application made at different times though always reduced growth than the control, the magnitude/reduction noted under different times of application was not significant.
II. Effect on Diameter growth of shoots (Tables 3, 4; Plate 2; Figs. 3, 4)

Irrespective of time of application, both ringing and short day significantly reduced the diameter growth of shoots in both the years. The combined effect of ringing and short day was appreciably greater than their individual effects in this respect.

Inhibition of diameter growth brought about by ringing and short day treatment given at different times showed, in general, variation due to different times of application in both the years but the variation was significant only in 1967. Among the three times of application the retardation in diameter growth was maximum under mid-June, minimum under mid-April and intermediate under mid-August application. Further the magnitude of reduction noted under the different times of application varied significantly from one another.

III. Effect on Flower induction (Tables 5, 4; Plate 2; Figs. 5, 6)

Ringing, in general, exhibited significantly very high percentage of flower induction in both the years. But short day (8 hrs.) did not show any beneficial effect on flowering. It showed slight inhibiting effect in 1968 but slight promoting effect in 1969 compared to control, though the magnitude of inhibition and promotion did not reach the significant level.

Ringing with short day though showed slight reduction of flowering than that under ringing with normal day in 1968, the
magnitude of reduction was not statistically significant, whereas in 1969 both ringing with short day and ringing with normal day were equally effective with respect to induction of flowering (100%).

As regards the effect of ringing done at different times of the year, it was noted that earlier the ringing done, higher was the percentage of flowering. With regard to effect of short day on flowering, it was observed that irrespective of time of application short day decreased flowering than normal day in 1968, whereas in 1969 short day treatment administered during mid-September to mid-October promoted flowering while mid-October to mid-November and mid-November to mid-December treatments showed flower inhibiting effect.

IV. Effect on size of the panicle.

(a) Length of panicle (Table 7,8; Plate 3 : Figs. 1,2).

It was noted in both the years that irrespective of times of application, short day significantly reduced the length of the panicle than normal day, whereas ringing did not cause significant reduction in length of panicle.

Again, ringing and short day treatment showed significant variation with respect to reduction of panicle length due to different times of application. In 1967-68, among the three times of application, the magnitude of reduction of panicle length was maximum under mid-June, minimum under mid-August and intermediate under mid-April application. However,
no significant difference between panicle length under mid-April and mid-June application was noted, though the length under mid-August application was significantly higher than that under either mid-April or mid-June application respectively. In 1968-69, among the different times of application, the degree of reduction of panicle length was maximum under mid-October, minimum under mid-September and intermediate under mid-November application respectively. However, no significant difference between the length of panicle under mid-September and mid-November as well as mid-October and mid-November were noted, while the length under mid-September was significantly higher than that under mid-October application.

The interaction between ringing and photoperiod (RxF) was significant in both the years. Under both ringing with short day and ringing with normal day, the length of panicle was significantly smaller than the control i.e., normal day with no ringing, though the difference between them was not significant. Under short day without ringing the length of the panicle reduced to a minimum and the reduction was even significantly higher than those under both ringing with short day and ringing with normal day.

(b) Breadth of panicle (Table 9,10; Plate 3:Figs.3,4).

It was observed in both the years that short day, irrespective of times of application, significantly decreased the breadth than normal day, while ringing significantly increased the breadth than no ringing.
As regards their effect on breadth of panicle, ringing and short day treatments showed, in general, variation due to their different times of application in both the years; but the variation was significant only in 1967-68. Among different times of application the magnitude of reduction of breadth of panicle was maximum under mid-June, minimum under mid-August and intermediate under mid-April application. However, no significant differences between the breadth of the panicle under mid-April and mid-June as well as mid-April and mid-August were noted, although the breadth under mid-August application was significantly higher than that under mid-June application.

The interaction between ringing and photoperiod (RxP) was significant in both the years. As regards their effect on breadth of panicle, it was observed that though ringing with short day and ringing with normal day caused significant reduction in breadth of panicle than the control, they, however, did not differ significantly from each other in this respect. Under short day without ringing, the breadth reduced to a minimum and the magnitude of reduction was even significantly higher than those under both ringing with short day and ringing with normal day.

The interaction between ringing and time was significant in 1969 only.
Irrespective of times of application, ringing significantly increased the total number of flowers per panicle than no ringing in 1968-69, while in 1967-68 no such promoting effect was noted. But short day, irrespective of times of application, significantly decreased the total number of flowers per panicle in both the years.

As regards their effect on total number of flowers, both ringing and short day treatments showed significant variation due to different times of treatment application in both the years. In 1967-68, the reduction was maximum under mid-June, minimum under mid-August and intermediate under mid-April application. However, no significant differences between the total number of flowers observed under treatments applied in mid-April and mid-June as well as mid-April and mid-August were noted, while the number of flowers under mid-August application was significantly higher than that under mid-June. In 1968-69, it was also noted that the reduction was maximum under mid-October, minimum under mid-September and intermediate under mid-November application. As regards the effect of times of treatment on the production of total number of flowers per panicle, no significant difference was noted between the treatments applied in mid-September and mid-November, mid-October and mid-November. However, the number of flowers per panicle under mid-September treatment was significantly higher than that under mid-October application.
The interaction between ringing and photoperiod (RnP) was significant in both the years. Both ringing with short day and ringing with normal day significantly reduced the total number of flowers per panicle than the control, though no appreciable difference was noted between them. Under short day without ringing, the reduction of total number of flower was maximum and the magnitude of reduction was significantly higher even than those under both ringing with short day and ringing with normal day.

V. Effect on Sex-expression (Tables 13,14; Plate 4:Figs.1,2).

Irrespective of time of application, both ringing and short day significantly increased the percentage of hermaphrodite flowers in both the years. Between ringing and short day, the former was more effective than the latter in this respect.

Promotion in the production of hermaphrodite flowers under both ringing and short day treatments showed significant variation due to their different times of application in 1968 only. Among three times of application, the production of mid-April and minimum under hermaphrodite flowers was maximum under mid-August treatment. Though the percentage of hermaphrodite flowers under mid-April was higher than that under mid-June, the difference between them was not statistically significant. However, the percentage of hermaphrodite flowers under both mid-April and mid-June treatments were significantly higher than that under mid-August treatment.
The interaction between ringing and photoperiod (RxP) was significant in both the years. The combined effect of both ringing and short day was significantly more than their individual effects. Short day without ringing significantly increased the percentage of hermaphrodite flowers than the control, although the magnitude of the percentage of hermaphrodite flowers produced was significantly less than those produced either under ringing with short day or ringing with normal day.

The interaction between ringing and times of application was significant only in 1969.

VI. Effect on yield (Tables 15,16; Plate 4; Figs. 3,4).

Irrespective of times of application, ringing significantly increased yield in both the years. Ringing with short day and ringing with normal day did not show any appreciable difference between them as regards yield. In comparison to control, under short day treatment the yield decreased considerably in both the years. Further, it was noted that the treatments did not exhibit any appreciable variation in yield due to different times of application.
FIGS. 1-6. EFFECT OF PHOTOPERIOD WITH AND WITHOUT RINGING ON GROWTH AND FLOWERING IN MANGO (VAR. LANGRA).

R- RINGING
NR- NO RINGING
SO-SHORT DAY
ND-NORMAL DAY

1967-68
T1- RINGING MARCH AND SHORT DAY (SEPTEMBER TO OCTOBER)
T2- MAY TO JUNE TO JULY
T3- JULY TO AUGUST TO SEPTEMBER

1968-69
T1- RINGING MARCH AND SHORT DAY (SEPTEMBER TO OCTOBER)
T2- OCTOBER TO NOVEMBER
T3- NOVEMBER TO DECEMBER

LINEAR GROWTH (INCREASE OVER INITIAL EXPRESSED AS PERCENTAGE OF CONTROL).
DIAMETER GROWTH (INCREASE OVER INITIAL EXPRESSED AS PERCENTAGE OF CONTROL).
FLOWERING (EXPRESSED AS PERCENTAGE OF SHOOTS FLOWERING).
FIGS. 1-4. EFFECT OF PHOTOPERIOD WITH AND WITHOUT RINGING ON SEX AND YIELD OF LANGRA MANGO

SEX (PERCENTAGE OF HERMAPHRODITE FLOWERS)

| Year | No Ringing | Ringing
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1967-68</td>
<td>No SD</td>
<td>No SD</td>
</tr>
<tr>
<td>1968-69</td>
<td>No SD</td>
<td>No SD</td>
</tr>
</tbody>
</table>

YIELD OF FRUITS (Kg/BRANCH)

| Year | No Ringing | Ringing
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1967-68</td>
<td>1 R</td>
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<tr>
<td>1968-69</td>
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RINGING

- No ringing: March-June
- Ringing: March-September
- Short day: June-July
- Normal day: July-September
- Long day: September-October

FIG. 1

FIG. 2

FIG. 3

FIG. 4
FIGS. 1-6. EFFECT OF PHOTOPERIOD WITH AND WITHOUT RINGING ON SIZE OF PANICLE IN MANGO (VAR. LANGRA).

- **Fig. 1**: Length of panicle in cm.
- **Fig. 2**: Breadth of panicle.
- **Fig. 3**: Total number of flowers per panicle.
- **Fig. 4**: Number of flowers per panicle.

Legend:
- **A**: Photoperiod
- **B**: Photoperiod + Ringing
- **C**: Photoperiod - Ringing

Legend for Phases:
- **1967**: April to May
- **1968**: June to July
- **1969**: August to September

*Note: The text is partially obscured and may require additional context for full understanding.*
The results presented in the previous pages bring out some interesting effects of ringing and short day on growth, flowering, size of the panicle, sex expression and yield of an intensively biennial mango variety Lanera.

It has been noted that both ringing and short day significantly retarded linear as well as diameter growth of shoots. Their combined effect was found to be relatively greater than their individual effects. Further, the treatments showed variation due to times of application. Treatments given relatively earlier in the season proved to be most effective in this respect. Between short day and ringing, the latter exhibited better effect as regards retardation and earlier cessation of linear growth than the former, irrespective of times of treatment. But with respect to their effect on retardation of diameter growth of shoots, they were found to be almost equally effective. Growth retardation and earlier cessation of shoots in mango due to ringing was also reported by some workers (Gandhi, 1955; Daschowdhury, 1969). Growth inhibition by ringing is thought to be due to rise in the level of carbohydrates increasing C/N ratio in the tissues above the ring (Daschowdhury, 1969)
and probably consequent fall in the auxin content of terminal
buds (Kato and Ito, 1962) and thus bringing about condition
unfavourable for vegetative growth.

Exposure for short day (8 hrs.) conditions also caused
significant retardation of both linear and diameter growth of
mango shoots. The results are in complete agreement with those
of Piringer and Downs (1959), Smeets (1956), Lammerts (1943),
Samygin and Lezandr (1951), Moshkov (1932) who also noted
similar growth suppressing effects under short days in apple,
peach, cherry, Prunus, citrus and Pyrus species. Many forest
species have also shown photoperiodic sensitivity with respect
to extension growth and in all such cases exposure to short
day conditions results in reduced extension growth, attributa-
table to (a) earlier cessation of apical growth which results in
a reduced number of internodes, and (b) reduced internode
extension (Wareing, 1956). Nitsch (1957) suggests a hypothesis
that the natural cessation of growth under short days may be
caused by a deficiency in some GA-like substance. There are
also evidences that in plants grown under short days there
occur both a decrease in the level of growth promoting substanc-
es and an increase in the concentration of inhibitors which
may be responsible for retardation and earlier cessation of
However, Nitsch (1957) remarks that the internal change caused
by a modification in the photoperiodic regime appears to be
far more complex than an increase or decrease in the level
of one single substance.
No off-season flowering was noted in biennial Langra mango under short day (8 hrs.) treatment in any of the years of study. Flowering occurred as usual in the normal season in spring. Short day did not show any beneficial effect of increasing the floral induction over control. It showed slight inhibiting effect in 1967-68 and slight promoting effect in 1968-69 compared to control, though the magnitude of inhibition or promotion did not reach the significant level. Similar observations were made by Piringer and Downs (1959), Stahly and Piringer (1962) on temperate fruits like apples and peaches in which they mention that there exists no positive relation of photoperiod to flowering in these fruit trees.

Ringing, in general, irrespective of times of treatment, has been found to bring about significantly very high increase of floral induction in both the years. In 1967-68 ringing and exposure to short day condition slightly decreased the flower increasing effect of ringing which was noted to be increasingly pronounced in the treatments given successively later in the season, while in 1968-69 short day could not decrease the overwhelmingly increasing flower inducing effect of ringing. Increase in flowering due to girdling of branches has also been reported earlier in mango (Sen, 1943; Mallik, 1961; Roy, 1963; Gandhi, 1955). There may some relation between the ability of ringing to cause early growth cessation and the flowering of the shoots. Cessation of growth is an important aspect in influencing flowering in mango. Earlier
workers as Singh and Khan (1939); Sen and Mallik (1941); Naik and Rao (1942); Sen (1943); Roy (1953); Singh (1957); Krishna-murthy et al. (1961) and Sen (1962) have all emphasized that mango shoots must cease growth early in the season in order to differentiate fruit buds laying thereby special stress on the physiological maturity of the tissues. Ringing, in general, effected considerable changes mainly in the carbohydrate and nitrogenous constituents of the shoots in mango. Due to this treatment, accumulation of carbohydrate during winter was further augmented (Daschowdhury, 1969). The increment in the content of carbohydrates as a result of ringing has also been noted in fruit plants like apple (Murneek, 1941), grapes (Weaver and McCune, 1959) etc. High accumulation of starch due to ringing was deservedly by Ogaki, Fugita and Ito (1963) in their studies on Ushiku orange trees. The large accumulation of nutritional reserves due to ringing is often associated with the tendency of the ringed shoots to promote flowering. Transition from the vegetative to reproductive state is controlled by a carbohydrate - nitrogen (C/N) ratio in plant. An increase in the ratio favoring reproduction in mango has been put forward by many workers (Sen, 1951; Sen and Daschowdhury, 1965; Singh, 1960; Sen and Guha, 1963). An increase in C/N ratio, as a result of ringing was noted in the shoots of Langra mango (Daschowdhury, 1969). These observations may may be significant in reference to the promotion of flowering in ringed branches. From these observations, it is considered that ringing retards the translocation of sap out of the branch
and thus restricts the movement of sugar and other organic substances in the portion of the branch above the ring bringing about a chemical environment in its leaves favourable for the production of a flowering stimulus.

It has been observed that both ringing and short day exert its influence on size of the panicle, though did not affect the length, significantly increased the breadth and total number of flowers per panicle which may be related to the higher nutritive status of the shoots under ringed branches. Short day adversely affected the size of the panicle of the shoots under ringed branches. The significant reduction of length, breadth as well as the total number of flowers per panicle under short day condition may be due to the devitalised condition of the shoots as a result of limited photosynthesis brought about by curtailment in the period of exposure to usual day length.

Both ringing and short day (8 hrs.) have been found to exhibit a profound effect on sex expression. They have increased the percentage of hermaphrodite flowers in both the years. Between ringing and short day, the former was more effective than the latter in this respect. It was further noted that earlier the time of treatment application, higher was the percentage of hermaphrodite flower produced. Sex regulation is considered to be a genetically controlled phenomenon, although complicated gene environmental interaction plays a masterly role. Various environmental components which influence the sex condition are such as, nutritional status of the plant, thermophase, photophase besides the role of auxins and anti-
auxins. A number of earlier workers provide positive evidence of the effect of temperature and day length in cururbita species (Nitsch et al., 1959; Tiedgens, 1928; Edmond, 1930; Whitaker, 1931; Currence, 1932; Hall, 1940; Fuji, 1954; Shifriss and Galun, 1966; Ito and Kato, 1953; Ito and Saito, 1957b; Saito, 1961; Saito and Ito, 1965). Short days and low night temperature favour the development of pistillate flowers whereas long days and high temperature cause the development of male flowers (Nitsch et al., 1959). These environmental factors affect sex expression by changing the physiological condition of the plant before flower differentiation (Ito and Saito, 1965). Singh et al. (1966) suggested that temperature plays an important role in controlling the percentage of perfect flowers in the various types of panicles of mango, although other factors as day length may be important. According to Heslop-Harrison (1957) day length, temperature and also other factors are considered to act on sex expression through their effects on auxin level. Dhillon (1966) suggests that the effect of temperature and photoperiod may be a concurrent factor along with nutrition through its influence on carbohydrate metabolism.

Ringing has been found to significantly increase the production of hermaphrodite flowers in mango in both the years. Hartmann (1949) also reports that girdling causes a shift to production of more flowers of the perfect type in olive where abundant production of staminate flowers and only a few perfect flowers is a problem. Development of sex organs is
profoundly influenced by the nutritive condition within the plant. Tiedjens (1928) and Minina (1938) offered a lucid explanation that a correlation between flower formation and the amount of available carbohydrate and nitrogen exists and that the ratio between female and male flowers is the result of this nutrient condition. The high C/N ratio in ringed branches may be possibly the guiding factor for the production of high percentage of hermaphrodite flowers.

It has been observed that irrespective of "off" and "on" years, ringing significantly increased yield in mango, while short day considerably decreased yield than the control. Under ringing with short day, the decreasing effect of short day was not only compensated but also the yield was very highly increased. A number of earlier workers reported similar promoting effect on yield by ringing in a variety of fruits such as apple, orange, litchi, grapes etc. (Murneek, 1939; Harley et al., 1942; Sax, 1957; Shamel and Pomeroy, 1934, 1944; Singh et al., 1940; Nakata, 1956; Young, 1957; Jacob, 1934; Coombe, 1936; Lider and Sanderson, 1959). Wagle (1928), Sen (1945), Mallik (1951), Gaskin et al. (1963) also reported the beneficial effect of ringing on fruiting of mango. Ringing not only promoted flower induction and production of hermaphrodite flowers but also increased set and ultimately produced a very high yield. Higher yield under ringing is possibly due to larger number and bigger size of fruits. Reduction in yield under short day is considered to be due to its adverse effect on flower induction, size of the panicle, setting and ultimate...
Failure of short day (8 hrs.) treatment to induce flowering in *Lanera* (biennial) mango trees may, however, be explained in different ways. It may be that mango trees are not photosensitive or their flowering is not controlled by a single factor like short day but affected by an interaction of more than one factors such as light and temperature. In litchi, it has been reported (Nakata and Watanabe, 1966) that between photoperiod and temperature, the latter has a direct requirement for floral initiation. None of the litchi plants exposed to short (8 hrs.) day and long (16 hrs.) day flowered under a night temperature regime of 75°F, and flowering occurred only when the night temperature was maintained at 60°F or lower for a period of about two months. Flowers were initiated in the plants kept in the green house (16 hr. day) and in outdoors (12.1 - 12.8 hrs. day) after the minimum temperature dropped to and below 65°F for about a 30 day period. With these in view, it may be of interest, to study the effect of photoperiod on flowering in mango under controlled temperature.
Experiments were conducted to study the effects of photoperiod with and without ringing applied at three different times, in two successive years 1967-68 and 1968-69 respectively, on an intensively biennial mango variety Langra. Observations were made on growth, both linear and diameter, flowering, size of panicle, sex expression and yield.

Irrespective of times of application, both ringing and short day (8 hrs.) significantly inhibited linear as well as diameter growth of shoots in both the years. The combined effect of ringing and short day was appreciably greater than their individual effects. Between ringing and short day, the former was more effective than the latter in this respect. A trend of increasing reduction of linear growth in earlier treatments was noted in both the years, while no such consistent trend was observed in case of reduction of diameter growth.

Ringing, irrespective of times of application, showed significantly very high percentage of flower induction in both the years. Further, earlier the ringing done, the higher was the percentage of flowering. Exposure to short day condition did not induce any off-season flowering, but in general, showed an inhibiting effect on flowering in the normal season.
Short day significantly reduced the length, breadth and total number of flowers per panicle in both the years, whereas under ringing the reduction of length was not significant but the breadth significantly increased in both the years and the total number of flowers per panicle increased significantly only in 1968-69. These effects of short day and ringing on size of the panicle showed significant variation due to different times of application in both the years.

Both ringing and short day, irrespective of times of application, significantly increased the percentage of hermaphrodite flowers in both the years. Between the two treatments, ringing was more effective in significantly increasing the percentage of hermaphrodite flowers than short day. The combined effect of both ringing and short day was significantly more than their individual effects in this respect. It was also noted that earlier the time of treatment application, the higher was the percentage of hermaphrodite flower production.

Ringing, in general, significantly increased the yield in both the years. Ringing with short day and ringing with normal day did not show any appreciable difference between them as regards yield. Exposure to short day condition considerably decreased yield than the control. Further, these treatments did not show any appreciable variation in yield due to different times of application.
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