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Studies on flowering behaviour of mango Cv. Alphonso under changing climatic conditions of Konkan region

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Abstract
Field experiment was conducted at College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, (MS) during 2019-2020 at different location to study the flowering behaviour of mango Cv. Alphonso. The field experiment was carried out at three different locations *viz.*, L_1: Centre of Excellence for Mango, College of Horticulture, Dapoli, L_2: Central Experiment Station, Wakawali and L_3: Goa Mankur plot, College of Horticulture, Dapoli. The experiential results showed that the early initiation of flowering was recorded at L_1- Centre of Excellence for Mango, Dapoli on 14th January 2020 followed by the location of L_3- Goa Mankur plot whereas L_2- Central Experiment Station, Wakawali recorded late initiation of flowering during the experimentation. The highest flowering density (63.07%) was found at L_1- Centre of Excellence for Mango while that of L_2- Central Experiment Station, Wakawali showed lowest flowering density (59.62%). L_1- Centre of excellence for mango recorded maximum total number of flowers (1503 nos.) and per cent male flower (90.25%), while L_2- Central Experiment Station, Wakawali recorded maximum percentage of hermaphrodite flower (12.00%). The maximum flower panicle length (30.2 cm) and panicle width (21.0 cm) was recorded at L_2-. Central Experiment Station, Wakawali. Based on the present study, it was observed that the average temperature, tree vigour, vegetative and reproductive growth, geographical location and many other factors play a vital role in flowering behaviour of mango Cv. Alphonso.

Keywords: Mango, flowering, flower density, hermaphrodite flowers, location

Introduction
Mango is a very popular and choicest fruit in tropical and subtropical region of world belonging to family Anacardiaceae and also known as "*king of fruits*" and is a cross pollinated allopolyploid crop having chromosome number 2n=40. Mango is popular for its rich taste, flavour, colour, huge variability and varied end usage. During 2020, bulk of mango production in India accounted for around 21.0 million metric tons. In Maharashtra, mango occupies an area of 16.76 thousand hectare with annual production of 791.36 thousand MT [2]. The Konkan region, the western coast of Maharashtra is one of the largest mango growing belts particular cultivars of Alphonso. In Konkan region, the district Ratnagiri has the maximum area (49.0%) and production (48.0%) of the total Alphonso production in the Konkan region, but the productivity of Alphonso in the Konkan region is quite low (ranging from 2.5-2.8 t/ha) as compared to the national average productivity (6.5 t/ha). The causes for the low productivity are shy bearing tendency of the variety, lesser percentage of hermaphrodite flowers, low fruit set, high fruit drop, large areas of old and unproductive orchards, rainfed cultivation and highly leached soils with low nutrient supplying capacity, widespread prevalence of insect pests, diseases and general negligence of the orchards [5]. The flowering is a significant factor in productivity of mango. Variations in the extent of flowering may be within trees from year to year, between trees in the same year, and between branches on the same tree. The single panicle bears 500-6000 flowers. The percentage of hermaphrodite flowers are an inherited character associated with the productivity of mango and most important factor influencing initial fruit set on panicle. These parameters are also greatly influenced by environment, because mango cultivars exhibit eco-geographical preference for flowering and fruiting [9]. In recent years weather vagaries is affecting the crop phenology especially the vegetative growth dynamics greatly affecting the reproductive phenophases through occurrence of recurrent flowering affecting crop outputs, quality and profitability of Alphonso production [5]. In nature more than 50% of mango flowers remain unpollinated. The low fruit set in mango is also ascribed to self-incompatibility and numerous problems encountered in pollination, fertilization and low temperature during flowering.

A study pertaining to flowering behaviour of Alphonso has significant implications on the mango production scenario in Konkan region. The limited reports on floral biology of Alphonso in our region prompted us to analyze the behaviour of this critical biological event among three different locations in Dapoli.

Material and Methods

Field studies were carried out at College of Horticulture, Dr. B.S.K.K.V., Dapoli, Dist. Ratnagiri in the year of 2020 flowering season to evaluate Alphonso at different locations for flowering traits. The field experiment was carried out at three different locations *viz.*, L_1: Centre of excellence for mango, College of Horticulture, Dapoli, L_2: Central Experiment Station, Wakawali and L_3: Goa Mankur plot, College of Horticulture, Dapoli. The location L_1: Centre of Excellence for mango, College of Horticulture, Dapoli is situated at an altitude of 240 m above MSL with 17°75' latitude and 73°18', L_3: Goa Mankur plot, College of Horticulture, Dapoli is situated at an altitude of 240 m above MSL with 17°748' latitude and 73°190' longitude while the location L_2: Central Experiment Station, Wakawali is situated at an altitude of 242 m above MSL with 17°48' latitude and 73°78' longitude. The experiment was conducted during the flowering season of mango beginning from January 2020. Three trees at random were selected from different locations with 20 tags from all directions per tree. The observations were made in a daily basis to determine the time of initiation, 50% flowering and complete flowering from January to March. Panicle length was measured from the point of emergence to the apex of panicle at full bloom stage with the help of meter scale. Panicle width was measured at the broadest part of the full bloom panicle; average of 20 panicles were taken and expressed in centimeters. Date when 10 out of 20 panicles were bloomed was considered as 50% flowering. Date when all the 20 panicles were bloomed was considered as completion of flowering. Reproductive shoots per square meter canopy were counted in four directions. [3] The flowering density was worked out with the following formula:

$$\text{Flowering density} = \left(\frac{\text{No. of flowering shoots}}{\text{Total no. of shoots}}\right) \quad 100$$

Male and hermaphrodite flowers were counted on selected panicles with the help of forceps and magnifying glass. [1] Male flower percentage and hermaphrodite flower percentage was calculated as:

$$\text{Male flower per cent} = \left(\frac{\text{No. of male flowers}}{\text{Total flowers}}\right) \quad 100$$

$$\text{Hermaphrodite flower per cent} = \left(\frac{\text{No. of hermaphroditeflowers}}{\text{Total flowers}}\right) \quad 100$$

[8] Sex ratio was calculated by following formula:

$$\text{Sex ratio} = \left(\frac{\text{No. of male flowers}}{\text{No. of hermaphrodite flowers}}\right)$$

Results and Discussions

The observations tabulated in Table 1 ascertained the time of flower initiation as shown in figure 1, 50% flowering and complete of flowering as shown in figure 2 varied as per the locations. The date of initiation ranged between January and February 2020, according to data collected from three separate places. The early initiation of flowering was observed on 14th January 2020 at Centre of Excellence for Mango, followed by L_3- Goa Mankur plot on 15th February 2020 and L_2- CES, Wakawali reported late flower initiation i.e., on 20th February 2020. The difference in flower initiation is due to variations in geological locations and difference in weather conditions during the flowering season. L_1- Centre of Excellence for Mango plot lying at an altitude of 240m above MSL coincided with less minimum temperature in earlier week *i.e.*, 12.8 °C and residual effect of paclobutrazol application in previous year and age of tree along with stress condition might be resulted in early flower initiation followed by L_3- Goa Mankur plot reported less minimum temperature of 12.4 °C in earlier week whereas, L_2- CES, Wakawali plot being located at an altitude of 242m above MSL reported consecutive high minimum temperature in earlier weeks *i.e.*, 17.14 °C which resulted in delayed flower initiation. Hence it can be quoted that increase in temperature leads to delayed initiation of flowering [8]. The maturity of shoot also determines the rate of panicle initiation [6]. Flowering and fruit set of different cultivars and seasons were associated with reduced vegetative growth. The date of 50 per cent blooming ranged from January to March 2020. L_1- Centre of Excellence for Mango plot displayed the earliest 50 per cent blooming amongst the three locations on 25th January 2020, followed by L_3- Goa Mankur plot on 25th February 2020 whereas L_2- CES, Wakawali plot showed late 50 per cent flowering on 4th March 2020. The variation in 50 per cent flowering is due the temperature differences. L_1- Centre of Excellence for Mango plot reported less minimum temperature of 13.1 °C in earlier weeks which was favourable for early 50% flowering whereas L_2- CES, Wakawali plot reported high minimum temperature of 16.91 °C in the earlier weeks which delayed 50 per cent flowering. Therefore, it can be stated that delayed initiation of flowering at warmer areas results in delayed 50 per cent flowering. The timing of full bloom ranged from January to March 2020. L_1- Centre of Excellence for Mango plot displayed early date of completion of flowering on 4th February 2020 which was followed by L_3- Goa Mankur plot on 6th March 2020 whereas L_2- CES, Wakawali reported delayed full bloom i.e., on 17th March 2020 as compared to remaining locations. The variation in complete flowering duration is due to the differences in temperatures and precocity of trees to induce flowering. L_1- Centre of Excellence for Mango plot reported lowering temperature from 13.1 °C to 12.4 °C which favoured flowering which resulted in early complete flowering whereas L_2- CES, Wakawali plot registered subsequent increase in minimum temperature which resulted in late complete flowering. Therefore, it can quoted that the location with high minimum temperature delays initiation of flowering and subsequently complete flowering.

Table 1: Flowering season of Alphonso at different locations

Locations	Date of initiation of flowering	Date of 50% flowering	Date of Complete flowering
L_1	14th Jan'20	25th Jan'20	4th Feb'20
L_2	20th Feb'20	4th March'20	17th March'20
L_3	15th Feb'20	25th Feb'20	6th March'20

(L_1- Centre of Excellence for Mango, Dapoli L_2- CES, Wakawali L_3- Goa Mankur plot, Dapoli)

The perusal of data collected from three distinct locations regarding the flowering density, total numbers of flowers, male flower percentage, hermaphrodite flower percentage, sex ratio are presented in Table 2 and publicised in figure 3.

Fig 1: Flower initiation at different locations

Fig 2: Complete flowering in Alphonso

a **b**

Fig 3: (a) Male flower (b) Hermaphrodite flower

Flowering density ranges between 59.62% to 62.52%. L_1- Centre of Excellence for Mango plot showed highest flowering density of 63.07%, followed by L_3- Goa Mankur plot with 62.52% whereas L_2- CES, Wakawali plot showed least flowering density with 59.62%. This is due to the temperature variation at different locations. Flowering and fruit set is associated with reduced vegetative growth. L_1- Centre of Excellence for Mango plot with subsequent less

minimum temperature as compared to other plots gave less vegetative growth and more reproductive growth whereas L_2- CES, Wakawali plot recording increasing minimum temperature leads to heavy vegetative growth with lesser flowering. [6] Reduction of vegetative growth requires physiological changes which resulted in higher in terms of flowering. L_1- Centre of Excellence for Mango plot had the maximum flowers (1503), followed by L_3- Goa Mankur plot (1426) and L_2- CES, Wakawali (1357) had the least number of flowers (1357). This is due the temperature difference at each location. L_1- Centre of Excellence for Mango plot with less minimum temperature throughout the flowering period (Jan-Feb) gave maximum flowers per panicle whereas L_2- CES, Wakawali plot recorded high minimum temperature during the flowering period (Feb-March) resulted in least number of flowers per panicle [7]. Therefore it is clear that increase in temperature increased inflorescence size while there was an inverse effect on mean number of flowers per inflorescence.

Table 2: Flowering density, percent flowering and sex ratio of Alphonso at different locations

Locations	Flowering density	Total number of flowers	Male flower (%)	Hermaphrodite flower (%)	Sex ratio
L_1	63.07	1503	90.25	9.75	9.25
L_2	59.62	1357	88.00	12	7.33
L_3	62.52	1426	90.07	9.93	9.07

(L_1- Centre of Excellence for Mango, Dapoli L_2- CES, Wakawali L_3- Goa Mankur plot, Dapoli)

L_1- Centre of Excellence for Mango plot recorded highest male percentage of 90.25%, followed by the L_3- Goa Mankur plot (90.07%), whereas it was recorded lowest at L_2- CES, Wakawali (88.00%). The reason for variation in male flowers (%) is due the temperature difference at each location. L_1- Centre of Excellence for Mango plot reporting less minimum temperature during the course of study in comparison to other plots resulted in maximum per cent of male flowers per panicle whereas the location L_2- CES, Wakawali with increasing minimum temperature throughout the study resulted in minimum per cent of male flowers [4, 7]. Hence it can be stated that low temperature during flowering results in predominant staminate flowers. L_2- CES, Wakawali plot reported the highest hermaphrodite flowers (%) of 12%, followed by L_3- Goa Mankur plot (9.93%) and L_1- Centre of Excellence for Mango plot had the lowest hermaphrodite flower percentage (9.75%) [4, 7]. Higher temperature is associated with an increased number of hermaphrodite flowers. The location L_2- CES, Wakawali reported higher minimum temperature during the flowering period resulted in maximum per cent of hermaphrodite flowers whereas the location (L_1- Centre of Excellence for Mango) with less minimum temperature as compared to other locations exhibited less hermaphrodite flower per cent [3, 8]. The per cent hermaphrodite flowers were less in early emerged panicles compared to late emerged panicles. L_1- Centre of Excellence for Mango showed early initiation of panicles which also resulted in less per cent of hermaphrodite flowers similarly L_2- CES, Wakawali showed late initiation of panicles giving out more hermaphrodite flower per cent. When male and hermaphrodite flowers were analyzed, the maximum sex ratio (♂:♀) was reported at location L_1- Centre of Excellence for Mango plot (9.25) which was followed by L_3- Goa Mankur plot the (9.07) whereas minimum sex ratio (♂:♀) was observed at L_2- CES, Wakawali plot (7.33). The differences in sex ratios are due the variation in male and hermaphrodite flowers percentage [6]. The environmental conditions play an important role to determine the sex ratio during the panicle development in mango. As per the study the location L_2- CES, Wakawali with high temperature throughout the flowering period displays minimum sex ratio as compared to the location L_1- Centre of Excellence for Mango with less temperature and maximum sex ratio. The observations tabulated in Table 3 ascertained the length and width of inflorescence. L_2- CES, Wakawali plot recorded maximum length (30.2 cm) and width (21 cm) which was followed by L_3- Goa Mankur plot i.e., 26.6 cm and 15.78 cm respectively, while the L_1- Centre of Excellence for Mango plot reported minimum length and width of panicle i.e., 23.5 cm and 12.23 cm. The length and width of panicle is closely related to the variation in temperature at various locations. The size of inflorescence is more at warmer temperature areas as compared to cooler areas. L_2- CES, Wakawali plot resulted in maximum inflorescence length due to the high and increasing minimum temperature during the flowering period whereas L_1- Centre of Excellence for Mango plot resulted in minimum length and width of inflorescence due to low minimum temperature as compared to other locations during the flowering period. Variation in size and shape of panicles in mango genotypes might be due to genetic composition and more specifically the physiological condition of the shoot on which panicle is raised.

Table 3: Length and width of panicle

Locations	Length of panicle	Width of panicle
L_1	23.5	12.23
L_2	30.2	21
L_3	26.6	15.78

(L_1- Centre of Excellence for Mango, Dapoli L_2- CES, Wakawali L_3- Goa Mankur plot, Dapoli)

Conclusion

Based on the results it can be concluded that various factors like temperature, tree vigour, intercultural activities, geological location etc plays an important role in flowering behaviour of mango. Increasing minimum temperature is responsible for delayed flowering but increases the hermaphrodite flower percentage which is one of the yield contributing factor. Similarly, low minimum temperature initiates early flowering giving out more male flower percentage.

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