



ISSN (E): 2277-7695  
ISSN (P): 2349-8242  
NAAS Rating: 5.23  
TPI 2023; 12(4): 1550-1554  
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[www.thepharmajournal.com](http://www.thepharmajournal.com)

Received: 02-02-2023

Accepted: 04-03-2023

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## Flowering behavior and flower morphology of kokum (*Garcinia indica* Choisy) under Konkan agroclimatic conditions

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### Abstract

The study on "Flowering behavior and flower morphology of kokum (*Garcinia indica* Choisy) under Konkan agro-climatic conditions" was carried out at college of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri (Maharashtra) during the year 2020-21 and 2021-2022. For the present study, thirty-two kokum trees of full bearing stage (ten trees from each district and two released varieties viz., Konkan Amruta and Konkan Hatis) were selected randomly from three districts viz; Sindhudurg, Ratnagiri and Raigad of the Konkan region of Maharashtra. The experiment was laid out in randomized Block Design with thirty two treatments viz. T<sub>1</sub> (Accession 1) to T<sub>32</sub> (Accession 32) with single tree with three replications. The result indicated that the flower bud initiation was started from first week of October to third week of November and flowering started from first week of November to third week of December. The kokum accessions namely T<sub>6</sub>, T<sub>7</sub>, T<sub>16</sub> and T<sub>21</sub> were started earlier flowering in both the years as compared to other accessions. With regards to flower morphology, all the parameters were significantly varied i.e., flower length, flower breadth, pedicel length, number of staminodes, number of pistil lobes, pistil length and pistil breadth among the thirty two kokum accessions under study. The accessions T<sub>22</sub> showed significantly the highest flower length (0.79 cm), flower breadth (0.81 cm), pistil length (0.40 cm), and pistil breadth (0.35 cm), while pedicel length in T<sub>25</sub> (0.25 cm), number of pistil lobes in T<sub>1</sub> (8.64) and number of staminodes in T<sub>27</sub> (14.38) except pedicel length and number of staminodes.

**Keywords:** Flowering behavior, flower morphology, *Garcinia indica* Choisy, Konkan agroclimatic

### Introduction

Older than the Himalaya mountains, the mountain chain of the Western Ghats represents geomorphic features of immense importance with unique biophysical and ecological processes. A chain of mountains running parallel to India's western coast, approximately 30-50 km inland, the Ghats traverse the states of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra and Gujarat. The site's high montane forest ecosystems influence the Indian monsoon weather pattern. Moderating the tropical climate of the region, the site presents one of the best examples of the monsoon system on the planet. It also has an exceptionally high level of biological diversity and endemism and is recognized as one of the world's eight 'hottest hotspots' of biological diversity. Among these florae, the genus *Garcinia* is an important genus of the Western Ghats and well known for their edible fruits and nutraceutical properties.

The polygamo-dioecious genus *Garcinia* is the largest genus within the family Clusiaceae (formerly Guttiferae) and comprises nearly 250 species worldwide. The genus name *Garcinia* derived from *Garcias*, who described it in 1974 (Subhash Chandran, 1996) [16]. Over 20 species out of 250 world tropical species which make up the genus *Garcinia*, are found in India. The prominent among these are *Garcinia indica*, *Garcinia purpurea*, *Garcinia cambogia*, *Garcinia morella*, *Garcinia livingstonei*, *Garcinia mangostena*, *Garcinia lanceifolia*, *Garcinia microstigma*, *Garcinia dulcis*, *Garcinia echinocarpa* and *Garcinia xanthochymus* (Robert, 1984) [13].

Among *Garcinia* species, *Garcinia indica* Choisy belongs to family Clusiaceae, is one of the industrially important species grown in the tropical region. It is commonly called as 'Kokum'. Kokum is a moderate to large size evergreen tree occurring up to an elevation of about 800 meters from the mean sea level. It is abundant in western India and is distributed throughout Konkan (Maharashtra), Goa, North Kanara, South Kanara and in areas west of Bombay

(Muhammed *et al.* 1994) [8]. According to Krishnamurthy *et al.* (1981), it is found in the tropical rain forest of Western Ghats, North Malbar, Coorg, Wynad, West Bengal and Assam. In Maharashtra, it occurs widely in the low-lying belt of the Konkan region. It is also known as “*Ratamba*” or *Bhirand*” in Konkan.

In spite of its incredible medicinal and nutritive properties, kokum is generally not cultivated systematically on orchard scale like that of mango, cashew nut, etc. It is mostly found as a kitchen garden plant or mixed crop in plantations of coconut, areca nut, as roadside plants or in forest. The kokum tree reaches a height of about 10 to 15 meters. It has dark green and drooping foliage smaller than most of the other species of the genus *Garcinia*. It is distinguished by oblong, lanceolate glabrous leaves. The tree flower in November to February and the fruits ripen in April to May (Bhat *et al.* 2005) [17]. The fruits are spherical, unfurrow and dark purple in colour, 1 to 1.25 inches in diameter, encasing 5 to 8 seeds (Shameer *et al.* 2016) [15]. The fruits of *Garcinia indica* are anthelmintic and cardiotoxic and useful for piles, dysentery, tumours, pains and heart complaints. Syrup from the fruit juice is given in bilious affections. The root is astringent (Kirtikar and Basu 1999) [5].

In the Konkan region of Maharashtra, there is rich diversity in the seedling progenies of kokum and it is the best opportunity for identifying and selecting a promising genotype for commercialization as far as industrial point of view. Considering the rising industrial as well as nutraceutical importance great demand for exploitation of the area under of kokum cultivation in near future.

### Material and Methods

The experiment on “Flowering behavior and flower morphology of kokum (*Garcinia indica* Choisy) under Konkan agro-climatic conditions” was conducted at College of Horticulture, Dapoli, Dist. Ratnagiri under Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (Maharashtra) during the year 2020-21 and 2021-22. For the present study, thirty-two kokum trees of full bearing stage were selected randomly from three districts viz; Sindhudurg, Ratnagiri and Raigad of the Konkan region of Maharashtra. The observations regarding flowering behavior and flower morphology were recorded. The Randomized Block Design was used for statistical analysis with single plant with three replications (Panse and Sukhatme, 1995). The thirty two treatment viz., T<sub>1</sub> (Accession -1) to T<sub>32</sub> (Accession -32). T<sub>1</sub> to T<sub>10</sub> -, T<sub>11</sub> to T<sub>22</sub>. Ratnagiri and T<sub>23</sub> to T<sub>32</sub>. Raigad were studied as kokum accessions. The observation on the flowering behavior and flower morphology was recorded as below.

### Flowering behavior

To study the flowering pattern, fifty flower buds were tagged per tree randomly when they just appeared in the leaf axil. The observations recorded are as follows.

### Flower bud appearance

The flower bud appearance since initiation was observed and recorded in the respective week of the month.

### Appearance of flower on shoots

The time required for appearance of flowers on shoots was observed and recorded in days.

### Type of morphology

Randomly 10 flowers from each tree were selected during the flowering period. Observations on morphological characters of flowers i.e. flower length, flower breadth, pedicel length, number of staminodes, number of pistil lobes, pistil length and pistil breadth were recorded and average was worked out.

### Results and Discussion

The data recorded on flowering pattern and flower morphological parameters were interpreted and pooled data of both the year discussed as below.

### Flowering behavior

First important step for any tree improvement programme is to determine all the available variations within or between species. Evaluation and screening of different genotypes of tree species for morphological and biochemical characteristics is an important aspect of tree improvement programme. The large variation for commercially important traits of fruits indicates wide opportunities for phenotypic selection to improve productivity. Before domestication of any plant genetic resource, it is important to determine the extent, cause and nature of variations present in natural population in order to use it efficiently in selection and breeding. This is because forest trees are generally genetically variable in order to survive, grow and reproduce under numerous environments (Antonovicks, 1971) [1]. Although *Garcinia indica* has a numerous use, there are scanty reports on exploration, identification and documentation of trees of intra-specific variation.

### Flower bud appearance

The data regarding period of flower bud appearance in different kokum accessions are presented in the Table 1. It has been observed that the flower buds were singly or as fascicular cymes only in leaf axils and tetramerous. Further it was noticed that the period of initiation of flower bud appearance from the first week of October (Accession 6, 7, 16 and 21) to third week of November (Accession 18, 31 and 32). In general, maximum kokum accessions were noticed initiation of flowering from the second week of November onwards. While observing flower bud initiation; kokum accessions selected from Ratnagiri and Sindhudurg; the period was more or less same but comparatively earlier than the Raigad districts in both the year of study.

Earlier researcher Sawant *et al.* (1997) [14] evaluated 36 high yielding accessions of *Garcinia indica* for fruiting and quality traits. They observed flower bud appearance period from 29<sup>th</sup> September to 8<sup>th</sup> October in the different kokum accessions. Similar results were also reported by Raorane *et al.* (2012) [11]. They noticed that the female flowers of kokum were borne axillary or terminal. The flowers were tetramerous and hypogynous. The period of initiation of flower bud appearance was from September to third week of November. The present results was accordance with Kore *et al.* (2005) [6], they reported that the maximum kokum tree showed initiation of flower bud from fourth week of October to second week of November and kokum flower buds initiation were axillary or terminal.

### Initiation of flowering

The data pertaining to the period of flower initiation are presented in Table 1. It was indicated that initiation of

flowering was from the first week of November (Accession 6, 7, 16 and 21) to third week of December (Accession 18, 31 and 32). The kokum accessions namely T<sub>6</sub>, T<sub>7</sub>, T<sub>16</sub> and T<sub>21</sub> were started earlier flowering in both the years as compared to other accessions under study. In general, the maximum flowering initiation was during the month of November to December. Also it was observed that late flowering started in Raigad district than the Sindhudurg and Ratnagiri district. Godbole and Das (2000) [18] reported that November to February as the flowering period in the kokum; whereas Sawant *et al.* (1997) [14] observed that the flowering initiation from 30<sup>th</sup> October to 10<sup>th</sup> November in different kokum trees under study. Similar finding was also reported by Raorane *et al.* (2012) [11]. Haldankar *et al.* (2014) [3] revealed that kokum plants flowered during December to January. Priya Devi *et al.* (2012) [10] conducted field survey to know the distribution and assessment of natural variability using DIVA-GIS version and reported that under Goa condition flowering span of kokum was from November to January. Thus it was revealed that kokum shows flower bud initiation and flowering during the month of October to December and sometime may extend to month of January.

### Flower morphology

The data pertaining to flower length(cm), flower breadth (cm), pedicel length(cm), number of staminodes, number of pistil lobes, pistil length(cm) and pistil breadth(cm) of different accessions were presented in Table 2. It was varied significantly among the different accessions of kokum under study.

With regards to flower length was varied significantly from 0.52 to 0.79 cm with an average of 0.64 cm among the different accessions of kokum. Significantly the highest flower length (0.79 cm) was recorded in T<sub>22</sub> (Accession 22) and it was at par with the T<sub>24</sub> (0.77 cm). Further, the significantly lowest flower length (0.52 cm) was recorded in T<sub>18</sub>, T<sub>19</sub> and T<sub>32</sub> accessions and it was at par with T<sub>5</sub> (0.54 cm) and T<sub>8</sub> (0.53 cm).

The data of flower breadth was also varied significantly from 0.51 cm to 0.81 cm with an average of 0.61 cm among the different accessions of kokum. Significantly the highest flower breadth (0.81 cm) was recorded in T<sub>22</sub> (Accession 22) and it was significantly superior over all other accessions of kokum. However significantly lowest flower breadth (0.51 cm) was recorded in T<sub>18</sub> and T<sub>32</sub> accessions and it was at par with the T<sub>8</sub> and T<sub>19</sub> (0.52 cm) accessions.

The data pertaining to pedicel length in different accessions of kokum was varied from the 0.05 to 0.25 cm. Significantly the highest pedicel length (0.25 cm) was recorded in the same accession i.e., T<sub>25</sub> and was significantly superior over all.

Significantly the lowest pedicel length (0.05 cm) was recorded in T<sub>1</sub> and at par with T<sub>2</sub> (0.06 cm). The number of staminodes was significantly varied from 6.21 to 14.38 with an average of 11.13. Significantly the highest number of staminodes (14.38) was observed in T<sub>27</sub> and it was at par with T<sub>4</sub> (14.22) accession. However, significantly the lowest number of staminodes (6.21) was recorded in T<sub>31</sub>.

It could be seen from the data, the number of pistil lobes per flower was varied significantly from 6.14 to 8.64 with an average of 6.85. Significantly the highest number of pistil lobes (8.64) was recorded in T<sub>1</sub>, which was significantly superior over all. Similarly, significantly the lowest number of pistil lobes (6.14) per flower was noted in T<sub>18</sub> and it was at par with T<sub>26</sub> (6.22) and T<sub>32</sub> (6.23) accessions. With regards to pooled data, pistil length was varied from 0.24 to 0.40 cm with an average of 0.32 cm. The highest pistil length (0.40 cm) was observed in T<sub>22</sub> and was significantly superior over all.

The data relevant to the pistil breadth was found varied from 0.21 to 0.35 cm with an average of 0.27 cm among the different accessions of kokum. The highest pistil breadth (0.35 cm) was observed in T<sub>22</sub> (Accession 22) and it was significantly superior over all other accession of kokum. However, the significantly lowest pistil lobes (0.21 cm) were recorded in T<sub>4</sub> and T<sub>5</sub> accessions and it was at par with it was at par with T<sub>8</sub>, T<sub>31</sub> and T<sub>32</sub> (0.22 cm) accessions.

The above findings are in accordance with observation made by Raorane *et al.* (2012) [11], who observed that the flower length of kokum ranged from 0.45 to 0.80 cm with an average 0.69 cm, flower breadth ranged from 0.55 to 0.83 cm with an average 0.64 cm, pedicel length ranged from 0.00 to 0.74 cm with an average 0.17 cm, the number of staminodes per flower was 6.16 to 15 with an average of 10.34, the pistil length ranged from 0.26 to 0.41 cm with an average of 0.35 cm, the number of pistil lobes per flower ranged from 6.00 to 8.00 with an average of 6.99, the pistil breadth was ranged from 0.21 to 0.36 cm with an average of 0.30 cm.

While Kapatia., (2019) [4] conducted the experiments on the trees maintained as a germplasm collection, she studied 16 accessions for morphological characters of flower of kokum orchard at NBPGR, regional station, Vellanikkara and observed that that the length of flower ranged from 5.31mm to 8.44mm with an average of 6.67mm and the pedicel length varied from 0.52 cm to 2.24 cm with an average pedicel length (0.90 cm). Also Raysad (2016) [12] revealed that pedicel length of flower was in the range of 0.38 cm to 0.91 cm. The average pedicel length was 0.50 cm. The flower morphological character varied among the different genotype it may be due to genetic factor as well as environmental factor.

**Table 1:** Variation in flower bud appearance and flower initiation period among kokum genotypes under Konkan agro-climatic conditions

Kokum genotypes	Flower bud appearance (Month)		Initiation of flowering (Month)	
	Year 2020-2021	Year 2021-2022	Year 2020-2021	Year 2021-2022
T <sub>1</sub>	October (III)	October (II)	November (III)	November (II)
T <sub>2</sub>	October (III)	October (II)	November (III)	November (II)
T <sub>3</sub>	November (I)	October (IV)	November (III)	November (IV)
T <sub>4</sub>	October (III)	October (III)	November (III)	November (III)
T <sub>5</sub>	October (III)	October (II)	November (III)	November (II)
T <sub>6</sub>	October (I)	October (I)	November (II)	November (II)
T <sub>7</sub>	October (I)	October (I)	November (II)	November (II)
T <sub>8</sub>	October (III)	October (IV)	November (III)	November (III)
T <sub>9</sub>	October (III)	November (III)	November (III)	November (III)

T <sub>10</sub>	October (IV)	October (III)	November (IV)	November (III)
T <sub>11</sub>	November (I)	November(I)	November (III)	November (III)
T <sub>12</sub>	November (III)	November (II)	December (II)	December (II)
T <sub>13</sub>	November (II)	November (II)	December (II)	December (I)
T <sub>14</sub>	November (III)	November (II)	December (II)	December (II)
T <sub>15</sub>	October (II)	October (III)	November (II)	November (II)
T <sub>16</sub>	October (I)	October (I)	November(I)	November(I)
T <sub>17</sub>	November (I)	November(I)	December(I)	December(I)
T <sub>18</sub>	November (III)	November (III)	December (III)	December (III)
T <sub>19</sub>	November (I)	November(I)	December(I)	December(I)
T <sub>20</sub>	November (II)	November (II)	December (II)	December (II)
T <sub>21</sub>	October (I)	October (I)	November(I)	November(I)
T <sub>22</sub>	November (I)	November(I)	December(I)	December(I)
T <sub>23</sub>	November (II)	November (II)	December (II)	December (II)
T <sub>24</sub>	November (II)	November (II)	December (II)	December (II)
T <sub>25</sub>	November (I)	November (II)	December(I)	December (II)
T <sub>26</sub>	November (II)	November (II)	December (II)	December (II)
T <sub>27</sub>	November (I)	November (II)	December (II)	December (II)
T <sub>28</sub>	November (II)	November(I)	December (II)	December (II)
T <sub>29</sub>	November (II)	November (II)	December (II)	December (II)
T <sub>30</sub>	November (II)	November (II)	December (II)	December (II)
T <sub>31</sub>	November (III)	November (III)	December (III)	December (III)
T <sub>32</sub>	November (III)	November (III)	December (III)	December (III)

**Table 2:** Variation in flower length (cm), flower bradth(cm), pedicel length(cm), number of staminoides, number of pistil lobes, pistil length(cm) and pistil breadth(cm) among kokum (*Garcinia indica* Choisy) genotypes under Konkan agro-climatic conditions

Kokum genotypes	Flower length (cm)	Flower breadth (cm)	Pedicel length (cm)	No. of staminoides	No. of pistil lobes	Pistil length (cm)	Pistil breadth (cm)
T <sub>1</sub>	0.64	0.63	0.05	10.05	8.64	0.31	0.31
T <sub>2</sub>	0.68	0.62	0.06	12.29	6.65	0.36	0.31
T <sub>3</sub>	0.55	0.56	0.10	12.27	7.29	0.26	0.24
T <sub>4</sub>	0.60	0.56	0.12	14.22	7.11	0.24	0.21
T <sub>5</sub>	0.54	0.53	0.10	12.24	6.94	0.26	0.21
T <sub>6</sub>	0.70	0.67	0.15	12.08	6.67	0.35	0.31
T <sub>7</sub>	0.69	0.63	0.14	12.87	7.08	0.30	0.28
T <sub>8</sub>	0.53	0.52	0.12	10.13	6.47	0.25	0.22
T <sub>9</sub>	0.68	0.64	0.16	8.16	6.62	0.38	0.33
T <sub>10</sub>	0.67	0.69	0.14	8.88	6.08	0.35	0.30
T <sub>11</sub>	0.65	0.65	0.16	10.14	7.31	0.32	0.27
T <sub>12</sub>	0.67	0.62	0.17	13.36	6.31	0.33	0.28
T <sub>13</sub>	0.57	0.58	0.17	12.31	6.34	0.35	0.28
T <sub>14</sub>	0.56	0.54	0.16	10.59	6.84	0.30	0.26
T <sub>15</sub>	0.73	0.66	0.15	9.22	7.05	0.30	0.26
T <sub>16</sub>	0.56	0.64	0.16	12.26	7.78	0.31	0.27
T <sub>17</sub>	0.56	0.60	0.19	9.43	6.46	0.35	0.27
T <sub>18</sub>	0.52	0.51	0.20	11.51	6.14	0.29	0.25
T <sub>19</sub>	0.52	0.52	0.12	6.63	6.52	0.27	0.23
T <sub>20</sub>	0.65	0.61	0.14	10.16	6.45	0.30	0.26
T <sub>21</sub>	0.75	0.70	0.15	13.11	8.18	0.37	0.29
T <sub>22</sub>	0.79	0.81	0.22	11.26	6.42	0.40	0.35
T <sub>23</sub>	0.71	0.65	0.20	12.36	7.18	0.34	0.29
T <sub>24</sub>	0.77	0.72	0.22	13.17	7.27	0.38	0.31
T <sub>25</sub>	0.71	0.66	0.25	11.27	6.44	0.32	0.30
T <sub>26</sub>	0.72	0.65	0.22	10.64	6.22	0.33	0.28
T <sub>27</sub>	0.69	0.62	0.22	14.38	7.15	0.35	0.31
T <sub>28</sub>	0.67	0.57	0.19	12.18	6.72	0.31	0.27
T <sub>29</sub>	0.58	0.54	0.18	11.21	6.35	0.29	0.23
T <sub>30</sub>	0.69	0.62	0.20	11.23	6.69	0.31	0.26
T <sub>31</sub>	0.61	0.54	0.18	6.21	7.66	0.27	0.22
T <sub>32</sub>	0.52	0.51	0.11	10.24	6.23	0.27	0.22
Mean	0.64	0.61	0.16	11.13	6.85	0.32	0.27
Range	0.52-0.79	0.51-0.81	0.05-0.25	6.21-14.38	6.14-8.64	0.24-0.40	0.21-0.35
SEm±	0.007	0.004	0.004	0.06	0.03	0.005	0.004
CD @ 5%	0.021	0.011	0.012	0.18	0.09	0.013	0.011



## Conclusion

It was noticed that the period of initiation of flower bud appearance from the first week of October (Accession 6, 7, 16 and 21) to third week of November (Accession 18, 31 and 32) among the kokum accession under study. The kokum accessions namely T<sub>6</sub>, T<sub>7</sub>, T<sub>16</sub> and T<sub>21</sub> were started earlier flowering in both the years as compared to other accessions. The flower morphology parameters were significantly varied i.e., flower length, flower breadth, pedicel length, number of staminodes, number of pistil lobes, pistil length and pistil breadth among the thirty two kokum accessions under study. The accessions T<sub>22</sub> showed significantly the highest flower length (0.79 cm), flower breadth (0.81 cm), pistil length (0.40 cm), and pistil breadth (0.35 cm), while pedicel length in T<sub>25</sub> (0.25 cm), number of pistil lobes in T<sub>1</sub> (8.64) and number of staminodes in T<sub>27</sub> (14.38) except pedicel length and number of staminodes among the kokum accession under konkan agro-climatic conditions.

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