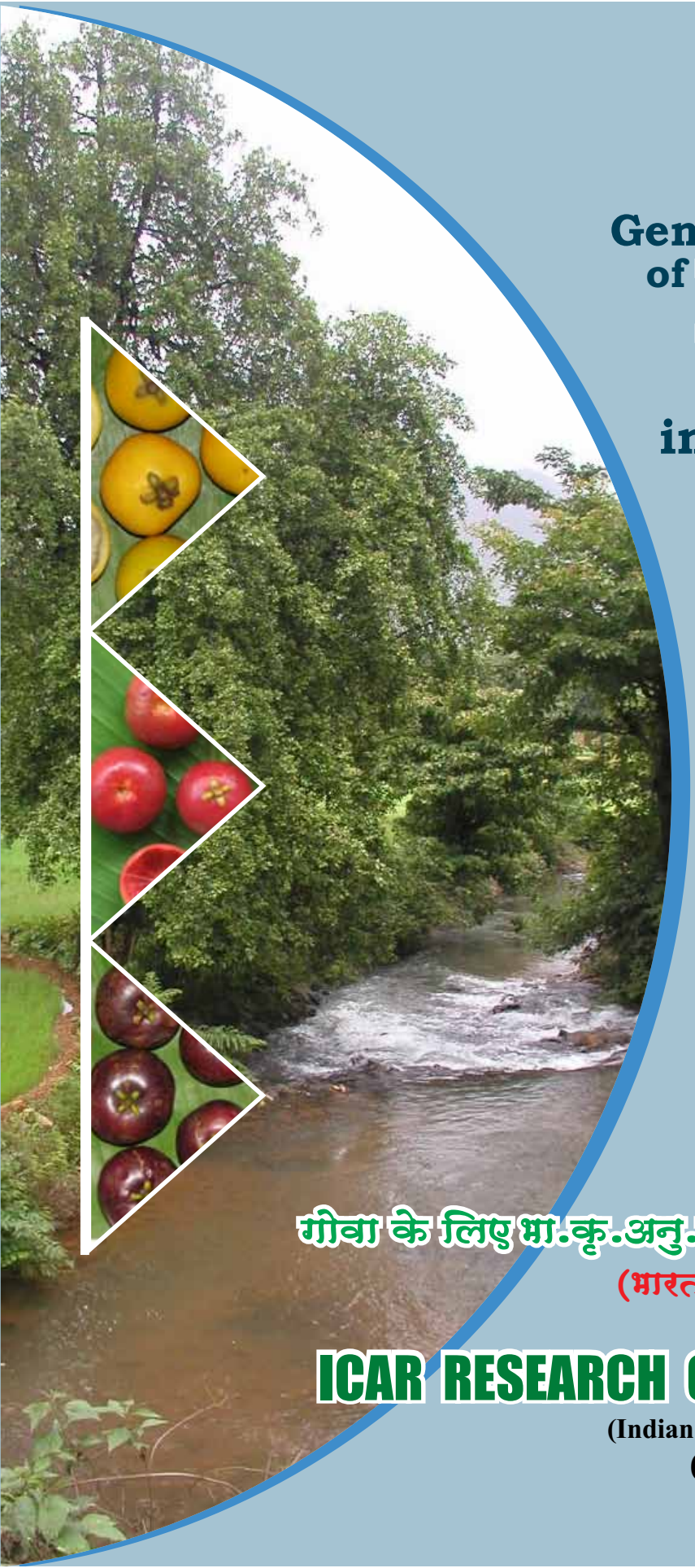
Technical Bulletin No.: 33



Genetic diversity of Kokum (*Garcinia* indica) in Goa-Tree and fruit characters

CELEBRATING 25 Years Silver Jubilee Publication

S. Priya Devi
M.Thangam
K. Ramachadrudu
J. Ashok Kumar
N. P. Singh

भाकृअनुप ICAR

गोवा के लिए भा.कृ.अनु.प. का अनुसंधान परिसर
(भारतीय कृषि अनुसंधान परिषद)
ओल्ड गोवा ४०३ ४०२, गोवा, भारत

ICAR RESEARCH COMPLEX FOR GOA
(Indian Council of Agricultural Research)
Old Goa - 403 402, Goa, India

Technical Bulletin No.: 33

Genetic diversity of Kokum (*Garcinia* indica) in Goa-Tree and fruit characters

S. Priya Devi
M.Thangam
K. Ramachadrudu
J. Ashok Kumar
N. P. Singh

ICAR RESEARCH COMPLEX FOR GOA
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
Old Goa - 403 402, Goa (India).

Published by
Dr. N.P. Singh
Director
ICAR Research Complex for Goa
Ela, Old Goa- 403 402, Goa, India

Phone : +91 832 2284678/679
Fax : +91 832 2285649
E-mail : director@icargoa.res.in
Website: www.icargoa.res.in

*

Authors
Dr. S. Priya Devi, Dr. M. Thangam, Dr. K. Ramchandrudu, Dr. Ashok Kumar and Dr. N.P. Singh.

*

Correct citation:

S. Priya Devi, M. Thangam, K. Ramchandrudu, Ashok Kumar J. and N.P. Singh. (2013): Genetic diversity of Kokum (*Garcinia* indica) in Goa-Tree and fruit characters. Technical Bulletin No. 33, ICAR (RC), Goa.

*

Printed at:
M/s. Impressions, Belgaum

FOREWORD

Kokum (Garcinia indica Choisy), an under utilized fruit tree is gaining importance due to its nutraceutical and pharmaceutical values. Presence of sugars and acids especially, HCA in fruits and edible fat in seeds are the key features of kokum. Survey of the existing diversity and identification of ideal accessions for yield and quality as well as suitability for processing is a long felt need. In this challenge of identification of potential areas and regions for collection of Garcinia indica germplasm for better utilization of the available diversity, the recently updated technology DIVA-GIS which elucidates genetic, ecological and geographic patterns in the distribution of crops and wild species has been used. ICAR Research Complex scientists have made an attempt and successfully collected 268 germplasm. The grid maps generated with GIS data clearly depicts the diversity, richness and distribution of the species studied. This technical bulletin throws light on the tremendous variability existing in kokum with respect to fruit characters. Use of modern software to study the biodiversity and distribution is appreciable. I compliment and congratulate the authors of this very useful technical bulletin, which could be useful for all those who are working on this crop and to plan future strategies for utilising these accessions for identifying suitable varieties which will go a long way in building up of nutritional security.

Dr. P. Rethinam

PREFACE

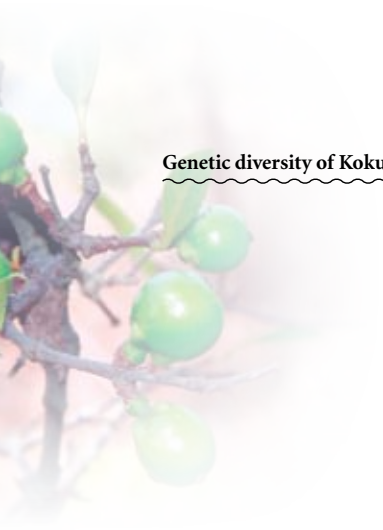
Kokum *(Garcinia indica Choisy)* belongs to the genus *Garcinia*, which is a very large genus of polygamous evergreen trees and shrubs, native to Asia, South Africa and Polynesia. Konkan region of Western Ghats in general is known for its biodiversity. Kokum is one such native species, which is dioecious in nature. Cross pollination coupled with seedling population of kokum has lead to large genetic diversity and wide adaptability. Presence of Hydroxy Citric Acid (HCA) in kokum rind has enhanced the value of this species in international market, owing to the anti-obesity factor of HCA. Other than these virtues, kokum also serves as a source of natural food colours, resins, tannins, *etc.*

In Goa, kokum trees are naturally distributed in the hill slopes, forest regions, rocky plateaus, roadsides, farm bunds and stream banks. The favoured habitats for the kokum trees are the secondary forests that are close to human habitation. Unfortunately, these are under serious threat due to rapid urbanization. Kokum therefore requires greater attention from conservationists. Till now, the tremendous genetic diversity of kokum existing in Goa state has not been scientifically documented. Systematic identification, documentation and conservation of genetic diversity of kokum either ***ex situ*** or ***in situ*** are the need of the hour. Therefore, survey of the existing diversity and identification of ideal accessions for yield traits was attempted. The challenge lies in identification of potential areas and regions for collection of *Garcinia indica* germplasm for better utilization of the available diversity. DIVA-GIS, a Geographic Information System (GIS) is designed to assist the plant genetic resources and biodiversity communities to map the range of distribution of species of interest. DIVA GIS supports the analysis of exploration, gene bank and herbarium databases to elucidate genetic, ecological and geographic patterns in the distribution of crops and wild species. Considering the importance of *Garcinia* indica, we have mapped the distribution and diversity for exploration and conservation in the state of Goa and the same is presented in this bulletin.

I take this opportunity to sincerely thank ICAR, New Delhi for extending the facility required to carry out this study. I express my deep and sincere sense of gratitude to former Director V.S. Korikanthimath for his motivation and support since the initiation of this study. I also duly acknowledge the technical assistance rendered by Mr M.M. Zalmi, Department of Agriculture, Govt. of Goa and farmers of Goa throughout the survey period.

Authors

CONTENTS



Genetic diversity of Kokum *(Garcinia indica)* in Goa-Tree and fruit characters

INTRODUCTION

Kokum, botanically *Garcinia indica* Choisy (Thouars), is a commercially under-utilized perennial tree species, found wide spread as a native species in Goa. It belongs to family Clusiaceae of order Theales and sub class Dilleniidae. Few important genera under this family are *Garcinia, Hypericum, Vismia, Cratoxylon, Triandenum, Pentadesma, Mammea, Allenblackia, Calophyllum, Mesua etc.* (Robson and Adams, 1968). The genus *Garcinia* includes 200 species, out of which 30 different species are reported to be found / grown in India (Korikanthimath and Desai, 2005). However, Karnik (1978) mentioned that over 400 species of *Garcinia* have been identified and 40 edible species listed. Few economically important species distributed in tropical Asia are *G. mangostana, G. indica, G. gummigutta, G. xanthochymus, G. hombroniana, G. cowa, G. morella etc.* Around 30 species of *Garcinia* are available in India (Nadkarni *et al*., 2001). A feature of the genus is the presence of yellow or white latex plant parts. Out of thirty species, G.indica is confined to India and Sri Lanka only (Patil *et al*, 2005)

G. indica is commonly known as Brindonia Tallow tree or Kokum Butter tree in English. The other vernacular names are kokum, birand, amsol (Konkani and Marathi), brindon (Portuguese in Goa), murugalu (Kannada) and punarpuli (Malayalam). The chromosome number of kokum is reported as 2n = 54 by Krishnaswamy and Raman (1949) and as 2n = 48 by Thombre (1964).

Kokum is an evergreen, perennial, monopodial and tall growing tree found in the West coast of India, in Northern Kerala, Coastal Karnataka, Goa and Konkan belt of Maharashtra. Besides, kokum is also found in Andaman and Nicobar Islands, Orissa and North Eastern regions to a lesser extent (Rema and Krishnamurthy, 2000).

In Goa, kokum is reported to be found in an area of 1,200 ha with 10,200 t production. This translates to 8.5t/ha of yield in which rind accounts to 3.6t/ha, fresh seed 1.9t/ha, pulp 3.0t/ha (Korikanthimath and Desai, 2005). The trees are found naturally in the hill slopes, secondary forest region, rocky plateaus, stream bunds *etc.* They are either found single or in clusters of 2-3 on elevations of Western Ghats forests. The kokum trees naturally co-exist in the ecosystem along with other forest and fruit trees especially like karonda, jamun *etc.* Besides, the trees found in farmers' fields are reported to exist for ages, retained without cutting along with arecanut, coconut or cashew trees (Adsule *et al*., 2001)

Kokum has got multifarious uses and therefore, finds an inevitable place in the lifestyle of local population. The fruit juice is used for production of syrup, squash, RTS, *agal* (salted juice) *etc.* The dried rind is used as a souring agent in Goan cuisine. The seeds are a rich source of kokum butter, which is nutritive, demulcent, smoothening, softening *etc.* and used for cosmetic, confectionary and culinary purposes. Raw fruits, young leaves and bark are also used as medications against several disorders. The fruit rind is a rich source of α Hydroxy Citric Acid (HCA) that prevents fat accumulation in body cells, and thereby functions as the main natural source for production of anti-obesity drugs. (Patil *et al*., 2005). Being also a natural source of anthocyanin pigment, it is a fit nutraceutical species.

The species is dioecious with around eleven types of flowers being reported, that can broadly be classified into staminate, hermaphrodite and pistillate. This feature owes to the cross pollination and subsequent natural heterogeneous population of kokum. Besides this, the sexual mode of propagation (population is of seedling origin) has resulted in heterozygosity in the genetic makeup of trees. This renders each and every individual tree to be different from each other. (Rawat and Bhatnagar, 2005)

Till now, the tremendous genetic diversity of kokum existing in Goa state has not been scientifically documented. Such rich diversity is posed to dangerous threats of genetic erosion due to urbanization and other developments. Systematic identification, documentation and conservation of genetic diversity of kokum either *ex situ* or *in situ* are the need of the hour. Therefore, a study was planned and focused to assess the genetic diversity of kokum in Goa.

Diversity Studies for kokum in Goa

The study was conducted in the state of Goa located between 14^{0}16" North latitude and 73^{0}75" East longitude with the states of Maharashtra on the North and Karnataka on the East and South and Arabian Sea on the West. Extensive surveys were conducted in all the erstwhile eleven taluks /zones of Goa namely, Pernem, Bardez, Tiswadi, Bicholim, Ponda, Sanguem, Sattari, Salcete, Mormugoa, Quepem and Canacona running from north to south. Several villages in all the taluks of Goa were surveyed for the naturally occurring kokum trees, which are of seedling origin. The details of the villages surveyed are as follows:

Table 1. Taluk wise locations and accessions under study

Sr. No	Taluk	Place of collection	Number of trees/ accessions
1.	Pernem	Amerem	2
2.		Bagayat	3
3.		Bandarwada	3
4.		Malpe	3
5.		Naibag	1
6.		Parashte	3
7.		Pednem	2
8.		Keri	1
9		Puaskadem	3
10		Satarda	7
11		Toxem	4
12		Ugvem	4
13.	Tiswadi	Curca	1
14.		Divar	1
15.		Karmali	2
16.		St. Inez	1

17.	Bicholim	Arvalem	3
18.		Dimonem	5
19		Gola	9
20		Kasarpal	12
21		Kharekazan	5
22		Lakerem	1
23		Mattan	1
24		Maulinguem	9
25		Mayem	6
26		Mulgaon	3
27		Ona Maulinguem	4
28		Parye	3
29		Tulsimad	1
30		Curchorem	7
31	Bardez	Carrem	4
32		Donwado	1
33		Madian	2
34		Maina	1
35		Mapusa	1
36		Mansher	1
37		Pomburpa	1
38		Siolim Oxel	1
39		Soccoro	2
40		Sodiem	1

41	Ponda	Borim	1
42		Conepriol	3
43		Dabbal	5
44		Farmagudi	2
45		Khandola	7
46		Khazorda	1
47		Nirangal Gola	1
48		Ponda Keri	2
49		Savoi	1
50		Savoi Kamini	3
51		Savoi Verem	6
52		TSP	3
53		Veling	1
54	Sattari	Dhave	9
55		Dabose	4
56		Thane	2
57		Hedode	1
58		Volpoi	1
59	Salcete	Chandor	3
60		Curtorlim	4
61		Dramapur	1
62		Manora	1
63		Nuvem	1
64		Verna	1
65	Quepem	Balli	3
66		Gokuldem	1
67		Kargegal	1
68		Padi	3
69		Quittol	4
70		Soliem	4
71		Xeldem	2

72	Canacona	Agaskhola	1
73		Canacona	1
74		Cotigaon	2
75		Mashem	4
76		Pedem	7
77		Poinguinim	7
78		Polem	1
79		Satorli	1
80		Shali	2
81		Shirate Khola	7
82		Shristal	1
83	Sanguem	Darbandora	3
84		Gurke	1
85		Khaluli	5
86		Madlawada	1
87		Margwadi	4
88		Netravali	7
89		Tambdi Surla	3
90	Mormugoa	Sancoale	5
Total			268

A total of 268 trees were identified during the extensive surveys conducted in Goa for kokum diversity. The kokum accessions studied were spread all over Goa covering all eleven taluks /zones representing different eco regions (Fig1 and 2).

Various morphometric and quality characters were observed in all the accessions studied. The latitude, longitude and altitude of the spot, where the accession is located were recorded using GPS (Garmin GIS12, Made in USA, supported by twelve satellites). The values recorded in degree/minutes/seconds were decimalized by dividing minutes by 60 and seconds by 3600. These decimal values were used to plot the accessions on Goa map using software "DIVA-GIS" Version 5.2.To know the spatial distribution and assessment of variability DIVA-GIS version 5.2 was used. Maps on the distribution pattern and diversity were generated with the help of point -to - grid analysis using circular neighbourhood method. Analysis was done based on the location (latitude and longitude) and additional attributes of point data.

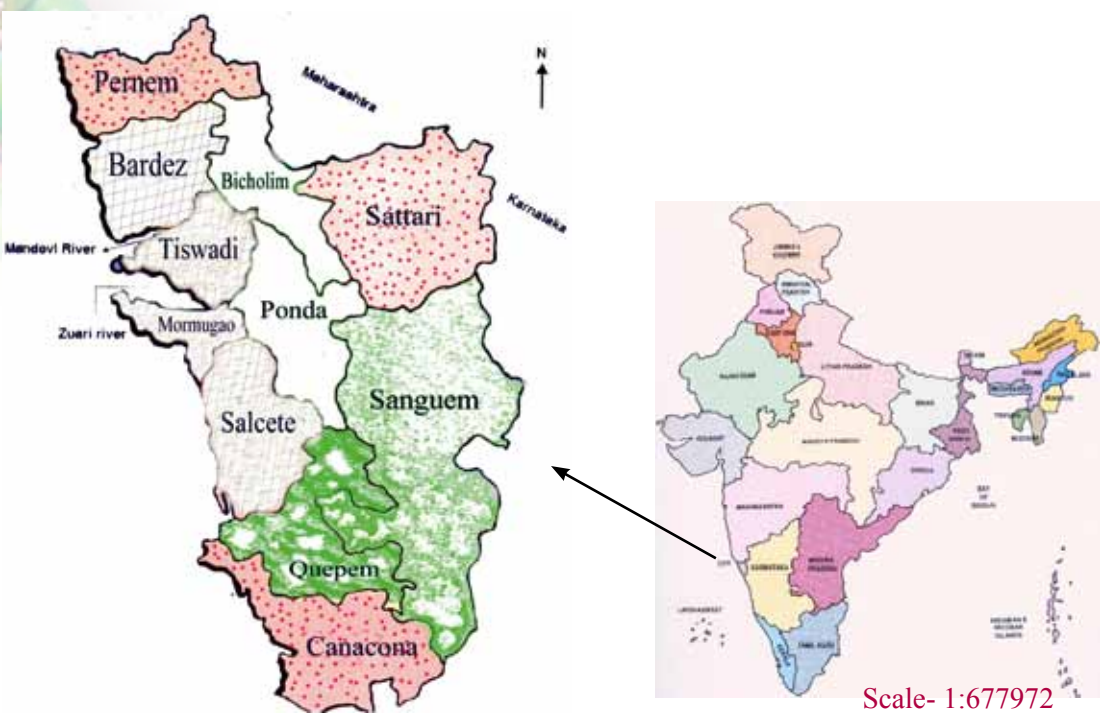


Fig 1.Goa map with eleven zones

Fig.2. Map of Goa showing distribution of kokum accessions (268) under study

Diversity in tree characters

3.1. Geographical location of kokum accessions

Kokum trees were spread throughout the geographical area of Goa, right from northernmost taluk Pernem that adjoins neighbouring state Maharashtra to the southernmost taluk Canacona adjoining Karnataka. All taluks towards coast as well as uplands were covered in the study. The longitude ranged from N 15^0 45' 33.8" to N 14^0 54' 36.5" (North to South) and the latitude ranged from E 73^0 42' 21.6" to E 74^0 13' 19.3" (West coast towards inland border). Parthasarathy *et al*. (2006) conducted a similar biodiversity study on pepper in Kerala. Geographical Information System (GIS) has been successfully used to study geogr aphical distribution of cultivated species as well as pests of agricultural crops (Hijimans and Spooner, 2001 and Ganeshaiah *et al*., 2003).

Distribution of kokum trees throughout Goa depicted in Goa map (Fig.2) shows rich distribution in taluks like Pernem, Bicholim, Ponda and Canacona.

3.2 Altitude

Altitude (in meters from mean sea level) ranged from 6 m to a maximum of 178 m, followed by 153 m and 128 m. Trees located at 6 to 10 m altitude are found towards coast or on river banks of backwaters especially in taluks adjoining coast like Pernem, Bardez, Quepem, Canacona *etc*. Even trees like Kharekazan-2, 3, 4 and 5 (Acc. Nos. 72, 73, 74 and 75) in Bicholim taluk recorded 6-8m altitude, as they were found along bank of a freshwater stream in Western Ghat region.

Trees at higher altitudes like Gokuldem-1 (Acc. No.198 at 178 m MSL) in Quepem taluk and Cotigaon-1 (Acc. No. 209) and 2 (Acc. No. 210) in Canacona were found on slopes of wild life sanctuaries of Western Ghats. Other trees found on higher altitudes were Savoi Kamini-3 (Acc. No. 151 at 110m MSL) and Savoi Verem-3 (Acc. No. 153 at 128 m MSL) both found in Ponda taluk.

Accessions located in altitude range of 145 to 178 m (red) followed by 112-145 m (orange), 79-112 m (yellow), 46 to 79 m (light green) and 6-46 m (dark green) are depicted in Fig.3.

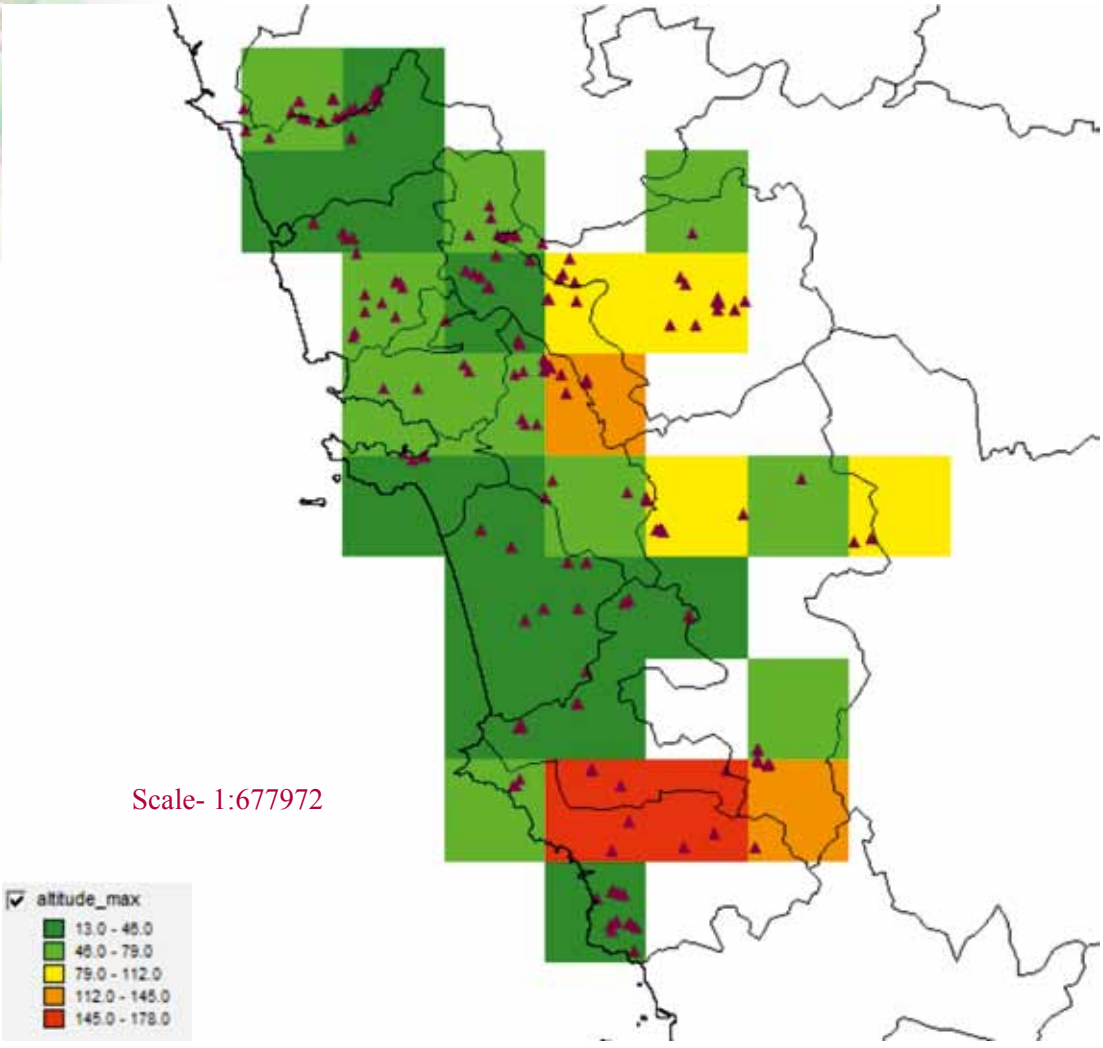


Fig.3. Map of Goa showing altitude levels at different locations under study

3.3 Tree characters

3.3.1. Tree shape

Canopy shape of each accession studied was recorded. The canopies were basically either pyramidal or conical or of spreading. In total, out of 268 trees studied, 59 (22.01%) were conical, 111 (41.42%) were pyramidal, 71 (26.49%) were pyramidal and spreading, 15 (5.60%) were spreading, 9 (3.36%) were pyramidal and drooping and 3 (1.12 %) were conical and medium spreading (Plate 2a to 2e). All types were found in all the taluks. Subash Chandran (1996) reported different canopy shapes *viz*., drooping and pyramidal shape in kokum trees with 10-15m height. Similar findings were also reported by Korikanthimath *et al*. (2008), Shinde *et al*. (2001) and Gawankar *et al*. (2001) in kokum.

(a) Conical shape

(b) Pyramidal shape

(c) Pyramidal and drooping

(d) Pyramidal and spreading

(e) Spreading canopy

VARIOUS CANOPY SHAPES IN KOKUM

3.3.2. Number of branches

Number of primary branches that arose from main trunk varied from a minimum of one (in several accessions) to a maximum of 42 branches in the accession 119. The number of primary branches was found to have no correlation with the shape of the tree. Number of secondary branches that arose from primary branches ranged from 0 to 156 number and did not play a significant role in deciding the shape of the canopy. Number of tertiary branches that branch out of secondary branches varied from 0 to a maximum of 210 in accessions 20, 260 and 267 followed by 205 branches in accession 36 and 202 branches in accession 51. Presence or absence of tertiary branches was observed to be crucial in deciding the shape of the canopy. Accessions with more number of tertiary branches were either spreading or pyramidal and spreading in shape.

3.4. Leaf characters of kokum accessions

3.4.1. Leaf description

The kokum leaves were largely lanceolate, few broadly lanceolate/narrowly lanceolate, some with obovate and ovate shapes. Majority of the leaves were lanceolate with acute tip and a mild wavy margin near the tip of the leaf. Few leaves had sub acute tips and very less number of accessions had obtuse tips. Out of the 268 accessions studied, 164 (61.19%) accessions had lanceolate leaves with or without wavy margin and acute or sub acute tips; 56 accessions (20.90%) were broadly lanceolate with or without mildly wavy margin and acute or obtuse tips; 44 (16.42%) accessions either ovate or obovate with acute to obtuse tips with or without wavy margins; 4 (1.49%) accessions were narrowly lanceolate with acute to sub acute tips with wavy margin. Similar variation was reported in kokum by several others like Anon. (1956), Cooke (1954) Sawant *et al*., (1999) and Godbole and Das (2000).

3.4.2. Leaf length (cm)

The leaf length showed a good variation ranging from a minimum of 6.24 cm in accession 222, to a maximum of 11.95 cm (Acc. No. 265) and 11.76cm (Acc. Nos. 30, 169, 174 and 191). The leaf length ranging from 10.95 to 11.95 were not ovate / obovate in shape.

3.4.3. Leaf width (cm)

Observations on width of all accessions studied varied from a minimum of 2.42 cm in Acc. No. 228, followed by 2.48 cm in Acc. No. 267 to a maximum of 5.25 cm (Acc. No. 30) followed by 5.10 cm (Acc. No.241). The accessions having mean leaf width ranging from 4.19 cm to 5.25 cm were ovate or broadly lanceolate / broadly ovate (Acc. Nos. 2, 71, 258 and 238) and those with leaf widths range

of 3.12 cm to 4.00 cm were lanceolate and those in a range of 2.7 to 2.88 cm were narrowly lanceolate.

3.4.4. Leaf length: width ratio

Ratio between length and width of the leaf ranged from a minimum of 1.87 (Acc. No.153; broadly lanceolate) to a maximum of 4.12 (Acc. No. 232; narrowly lanceolate). The lower ratios ranging from 1.86 to 2.06 had broadly lanceolate and ovate leaves (Acc. Nos. 153, 157 and 52), where as the group with ratio varying from 2.32 to 3.19 had lanceolate leaves (Acc. Nos. 18, 27, 31, 49, 57 and 69); the leaves that were narrowly lanceolate had larger ratios like 3.46 (Acc. No. 267), 3.48 (Acc. No. 259), 3.95 (Acc. No. 95) and 4.12 (Acc. No. 232).

3.4.5. Petiole Length (cm)

Petiole length varied from 0.60 cm in Acc. No. 231, to a maximum of 1.37 cm in Acc. No. 264. The petiole length had no correlation with the leaf shape or leaf length.

3.4.6. Petiole colour

Colour of petiole was either green or pink or greenish pink. Out of the 269 accessions studied, a total of 131 accessions had green petioles (48.88 %); 48 accessions had pink coloured petioles (17.91 %) and 89 accessions had greenish pink petioles (33.21 %). All the three types were found to occur in all the taluks / zones.

3.5. Variation in flower types

3.5.1. Male flower-Type-1 (Plate 3)

In general, pure male trees were seen with out fruits. Flowers were dissected to study the parts of flowers. Male trees had typical flowers with long pedicels, stamens ranging from 40 to 60, all fertile, centrally crowded, hemispherical rudimentary, receptacle and pistils were absent in this types.

3.5.2. Male flower-Type-2 (Plate 3)

Numerous stamens, all fertile, long pedicellate having rudimentary structure, conical in shape present in place of pistil, measured 5mm in length, carpels were absent.

3.5.3. Bisexual flower (Plate 4)

Bisexual flowers were seen on bisexual tree having 20-30 stamens arranged in radial fashion, all fertile, loosely arranged, not as compact as in male flowers. Pistils were fully developed and cross section showed four locules but irregular

Male flower type 1

Parts of male flower type 1

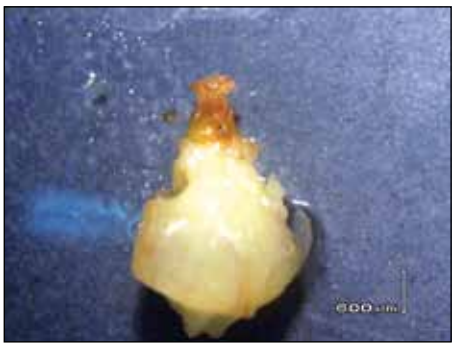
Androecium of male flower type 1

Rudimentary pistil and Anthers

Male flower type 2

Stamen and Pistil of male flower type 2

Anthers of male flower type 2



Rudimentary pistil of male flower type 2

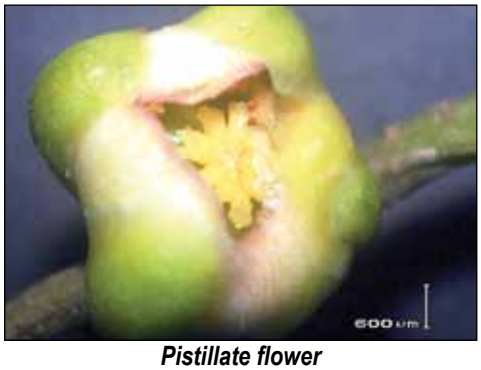
TYPES OF MALE FLOWERS IN KOKUM ACCESSIONS

Bisexual flower

Anther and pistil of bisexual flower

Stigma of bisexual flower

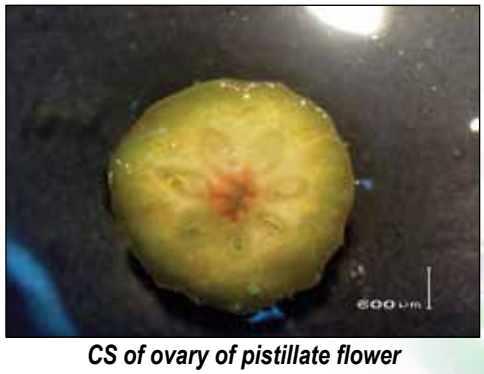
CS of ovary of bisexual flower



Pistillate flower

Stamen and Pistil of Pistillate flower

Stamen of Pistillate flower



CS of ovary of pistillate flower

BISEXUAL FEMALE FLOWERS IN KOKUM ACCESSIONS

in shape, there were four stigmatic lobes attached on the ovary. A decrease in masculinity and a strong tendency towards femininity was observed.

3.5.4. Female flower (Plate 4)

Flowers were seen only on female trees. The flowers had globose, well developed ovary measuring around 3-4 mm long, stigmatic surface with eight distinct lobes, each lobe with two lines of tubercles with sessile staminodes, 8-20 in number arranged in four tufts in decussate fashion.

3.6. Span of flowering and fruiting in kokum accessions

Accessions showed a great variation for flowering and fruiting. In general, there was little variation into initiation of flowering. The accessions attained 50 per cent flowering after 30-45 days from initiation of flowering. Generally, span of flowering spread for 8-9 weeks and fruiting season lasted for two months (Plate 5).

3.6.1. Time of initiation of flowering

Flowering was initiated during first week of December for late and last week of November for mid season bearers. In the earliest bearer Acc.No. 149, flowering was initiated during 4th week of October. But, for other early bearers (Acc.No. 18, 12, 46, 47, 50, 51, 59, 81, 179) flowering initiated during 1st and 2nd week of November.

Mid season bearers recorded flower initiation during 3rd and 4th week of November. Late bearers recorded initiation of flowering during 1st or 2nd week of December.

3.6.2. Time of 50 per cent flowering

Irrespective of type of bearers, the accessions recorded 50 per cent flowering after one month of flower initiation. Early bearers recorded 50 per cent flowering during 1st and 2nd week of December.

Mid season bearers recorded 50 per cent flowering during 3rd to 4th week of December. All the late bearers recorded 50 per cent flowering during 1st and 2nd week of January.

3.6.3. Span of flowering

Total span of flowering ranged from 8-9 weeks after initiation of flowering. For early bearers, flowering was noticed in November-December. In the earliest accession no.149, the span of flowering was from 4th week of October to 1st week of January. For other early bearers (Acc.No. 18, 12, 46, 47, 50, 51, 59, 81, 179), the flowering was recorded from 2nd week of November to 3rd week of January. In

STAGES OF FRUIT DEVELOPMENT IN KOKUM

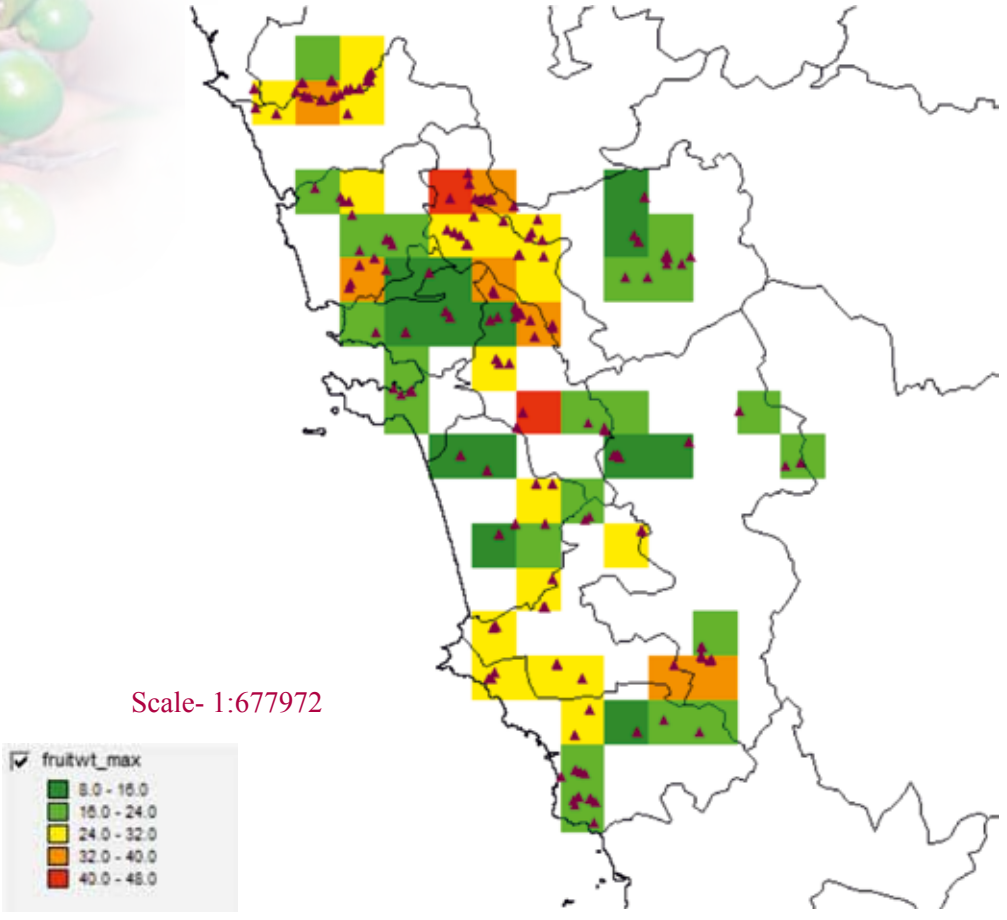


Fig.4. Map of Goa showing distribution of accessions for fruit weight

mid season bearers, the span of flowering was noticed from 3rd week of November to 4th week of January. In late bearers flowering span was noticed throughout December and January. Few accessions namely 4, 77, 78, 79 had flowering even up to 1st week of February.

3.6.4. Span of fruiting

Harvesting was completed in last week of April to 2nd week of May in early bearers. Those accessions in which, more than 2/3rd of fruits were harvested during 4th week of May were named as mid season bearers. But 60.82 per cent of accessions studied were late bearers, where more than 2/3rd of produce could be harvested only after the onset of monsoons i.e. after 1st week of June. This rendered a huge wastage of fresh fruits owing to the fact that the rind could not be sun dried after harvest. With the onset of monsoons, the fallen fruits pick up secondary infection and get wasted.

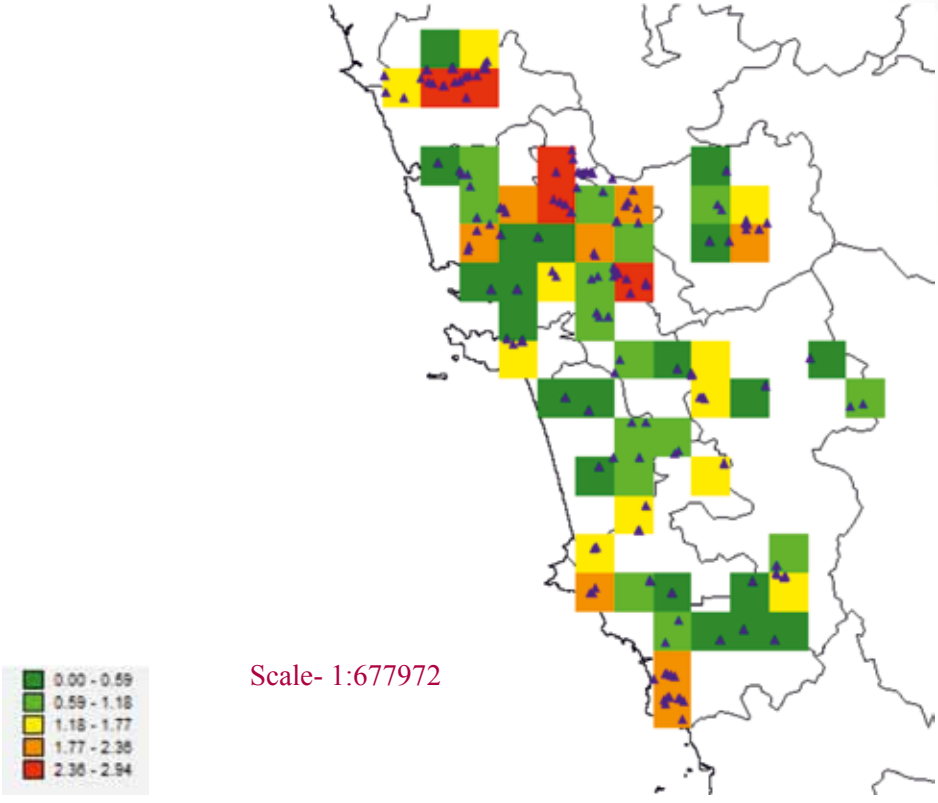


Fig.5. Map of Goa showing kokum diversity for fruit weight

3.7. Classification based on bearing

Out of 268 accessions studied for flowering and fruiting, there were early, mid and late bearers. Among them, 38 accessions (14.18 per cent) were early bearers, 67 accessions (25.00 per cent) were mid season bearers and 163 accessions (60.82 per cent) were late bearers.

Out of 268 accessions studied, Acc.No. 149 (Savoi Kamini-1) which was located in Ponda taluk was the earliest among all for flowering and fruiting, followed by Acc.No.18 (Pernem Keri-1) located in Pernem taluk and Acc.No.179 (Hedode-1) from Sattari taluk.

3.8. Fruit characters of kokum accessions

3.8.1. Fruit weight (g)

Mean values of individual fruit weight varied widely from 6.80g in Acc. No. 249 to 47.60g in Acc. No.126. Twelve accessions recorded fruit weight of 10g and below.

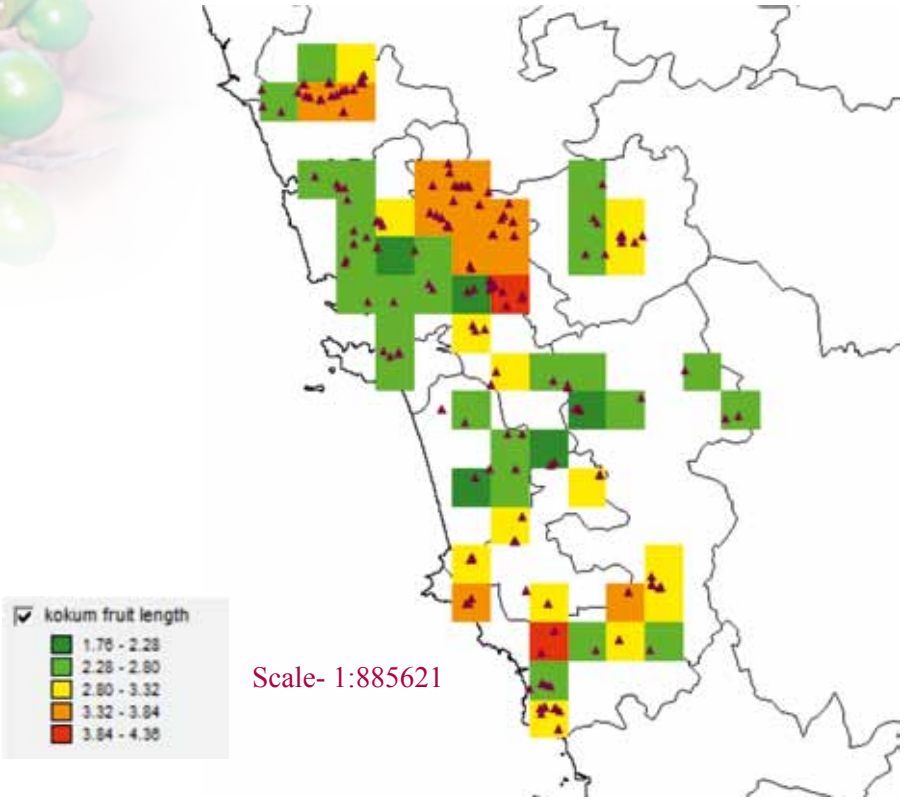


Fig.6. Map of Goa showing distribution of accessions for fruit length (cm)

Studies on genetic variation in fruit characters were carried out by several workers in konkan tract of Maharashtra. Rodrigues (2003) recorded a fruit weight range of 22.10 to 33.80g in some promising naturally occurring seedling kokum accessions in Goa. This range corroborates with the present study. Gawankar *et al*. (2004a) recorded a range of 19.15g to 40.80g in nine seedling progenies of kokum evaluated under field conditions in Maharashtra. All these trees were projected as promising accessions of the study. Gawankar *et al*. (2001) reported a variation of 25.40g to 58.38g in fruit weight of kokum types. In an evaluation study in clonal orchards on performance of grafts of promising types of kokum, the average fruit weight ranged from 25.40 to 58.38 g (Shingre *et al*., 2001) under well managed conditions. In the present study also promising accessions recorded 47.60 g and 41.25 g under natural conditions. Higher fruit weight can be obtained from these promising genotypes under well managed conditions.

When the accessions were mapped based on point to grid analysis (Fig.4), it was found that the fruits of higher fruit weight i.e above 40g were located in Ponda (Acc. No.126) and Bicholim (Acc. No.69) taluks (Red grids). The accessions that

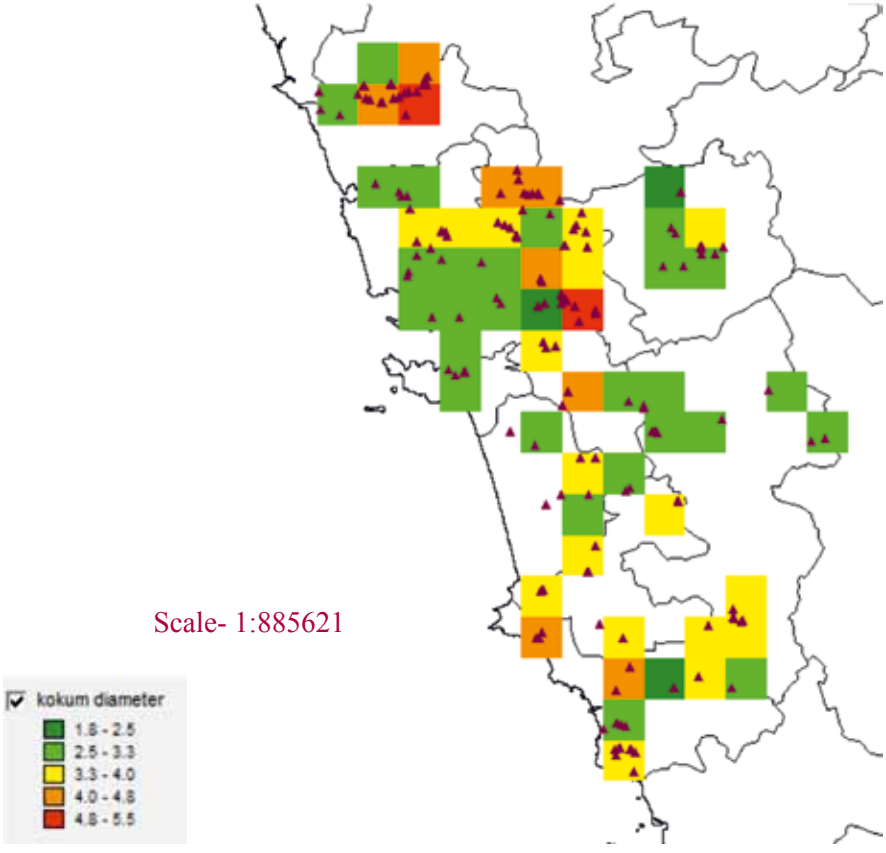


Fig.7. Map of Goa showing distribution of accessions for fruit diameter

bore fruits of weights ranging from 32 to 40g were scattered in Pernem (Acc. Nos. 24, 6 and 7), Bardez (Acc. No.118), Bicholim (Acc. Nos. 97, 98 and 110), Ponda (Acc. Nos. 138,153 and 157) and Sanguem (Acc. Nos. 257 and 259) which were depicted by orange grids.

Accessions of medium sized fruits of rate ranging from 24 to 32g (Yellow grids) were distributed in almost all taluks except Mormugoa, Sanguem and Sattari. The mean of this group was 26.68g. Accessions represented in light green grids of figure 4 having average fruit weight ranging from 16 to 24g are scattered all over the taluks except Bicholim and Quepem. In these taluks, the accessions were categorized into any one among the 1st, 2nd or 3rd cluster.

Very small fruits weighing 10.00g and below were noticed in taluks like Sattari (Acc.No. 173 and 168), Salcette (Acc.No. 188), Sanguem (Acc.Nos. 249 and 262), Canacona (Acc.Nos. 224 and 228), Ponda (Acc.No. 139), Tiswadi (Acc.No. 37) and Bicholim (Acc.Nos. 53, 60, 67 and 87).

When the data on fruit weight were subjected to diversity analysis (Shannon model), it was observed that the maximum diversity of 2.36 to 2.94 (red grid) (Fig.5) was in Ponda, Bicholim and Pernem taluk, followed by an index range of 1.77 to 2.36 (orange grid) in Sattari, Bardez, Bicholim, Canacona taluks. A medium diversity index of 1.18-1.77 (yellow grid) was noticed in Pernem, Sattari, Bardez, Mormugoa, Sanguem and Quepem. Less diversity (index range of 0.59 to 1.18 in light green) and very low diversity (index range of 0.00 to 0.59 in dark green grids) were found scattered throughout the state of Goa.

3.8.2. Fruit length (cm)

Average of observations on fruit length ranged from 1.19 (Acc.No. 224) to 4.36cm (Acc.No. 194) with a mean value of 2.63cm. Fruit length ranged from 1.19 to 1.97 in 12 accessions (Acc.Nos. 9, 53, 168, 188, 224, 228, 248, 249, 251, 258, 262 and 263), distributed in Canacona, Sanguem, Quepem, Pernem and Bicholim taluks. The next range of fruit length varying from 2.03 cm to 3.00 cm was found in around 201 accessions spread throughout Goa. Higher fruit lengths ranged from 3.00 to 4.00 cm in 46 accessions and length of above 4 cm was observed in three accessions (Acc.Nos. 150, 153 and 194).

When all the 268 accessions were mapped using point to grid analysis in DIVA-GIS (Fig.6), it was observed that there were five clusters as follows:- The highest fruit length range of 3.84 to 4.36 cm was depicted by red colour. Such red grids were noticed in Canacona, Ponda and Bicholim taluks. The next highest range of 3.32 to 3.84 cm shown as orange grids were seen in Pernem, Bicholim, Ponda and Canacona taluks. The medium fruit length range of 2.80 to 3.32cm represented by yellow grids were scattered in Pernem, Bardez, Sattari, Ponda, Quepem, Canacona and Sanguem taluks. Accessions having fruit lengths between 2.28 and 2.80 cm shown as light green grids were seen throughout Goa, except two taluks *viz*., Bicholim and Quepem. The lowest fruit length range of 1.76 to 2.28 cm depicted by dark green grids was noticed in Tiswadi, Ponda, Sanguem and Salcete taluks.

3.8.3. Fruit diameter (cm)

The average fruit diameter varied widely from 1.80 (Acc.No. 188) to 5.51cm (Acc.No. 194) with a mean fruit diameter of 2.97 cm. Similar diversity studies for fruit traits were attempted earlier by Nair (1986) who reported a range of 1.17 to 4.02 cm and 0.76 to 4.17 for fruit length and diameter respectively. Like wise, Gawankar *et al*. (2001a) also observed similar variation in fruit length (3.20 to 4.28cm) and fruit diameter (3.30 to 4.75cm) in kokum genotypes.

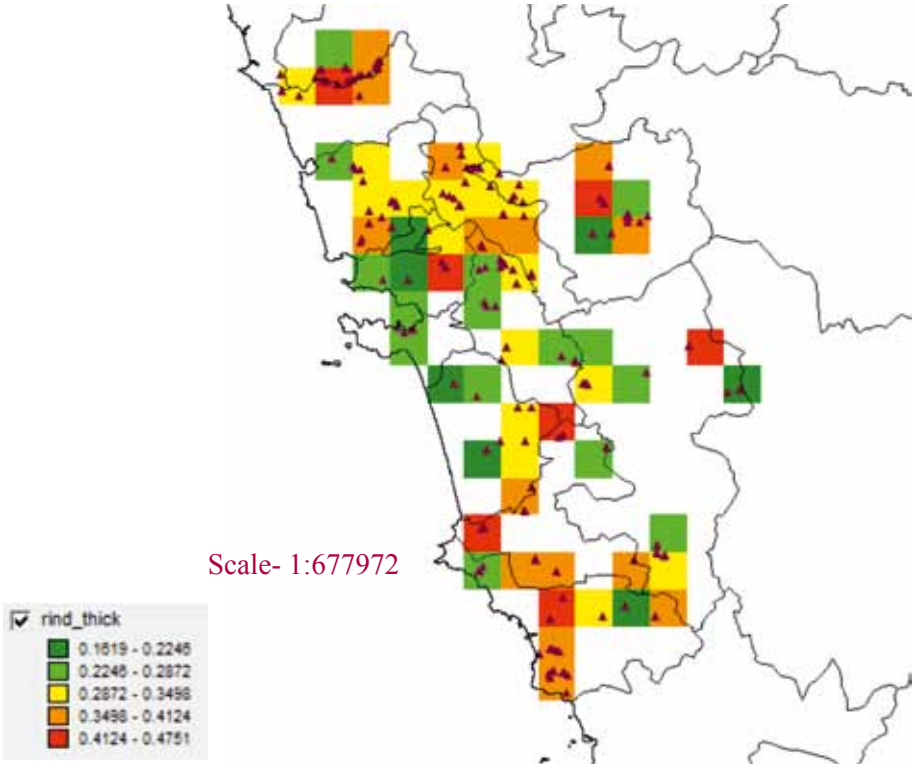
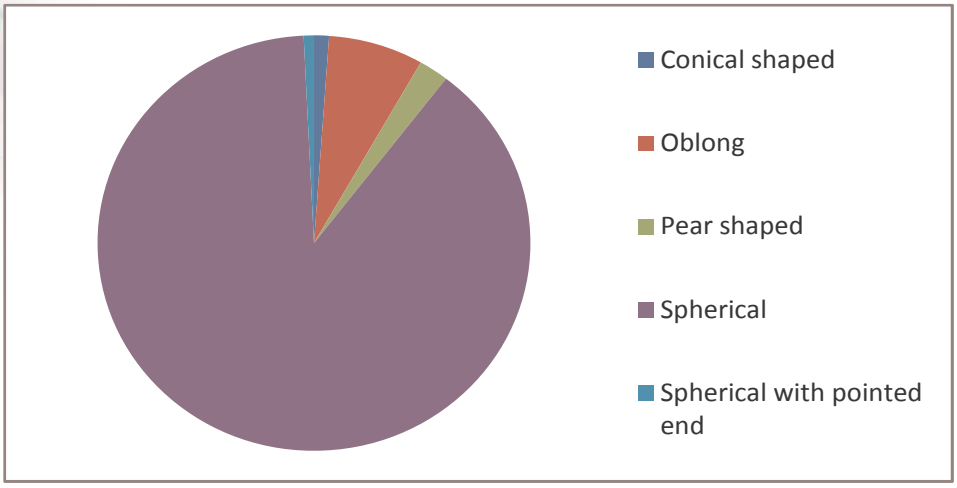


Fig.8. Map of Goa showing distribution of accessions for rind thickness (cm)

When fruit diameter data was plotted as grids on Goa map during diversity analysis, it was observed that the highest range of fruit diameter 4.80 to 5.50 cm (red grids) was found in Bicholim and Pernem taluks, followed by orange grids (of range 4.00 to 4.80 cm) spotted over Pernem, Bicholim, Ponda and Canacona taluks. The accessions having medium diameter range of 3.30 to 4.00 cm (yellow grids) were also distributed in Bardez, Sattari, Bicholim, Salcete, Quepem and Canacona taluks. The accessions having lower range (light green grids) of fruit diameter (2.50 to 3.30 cm) were widely distributed all over Goa, except Quepem taluk and the accessions having lowest range of 1.80 to 2.50 cm of fruit diameter were only seen in few trees found in Sattari, Bicholim and Canacona taluks. (Fig. 7)

3.8.7. Fruit shape

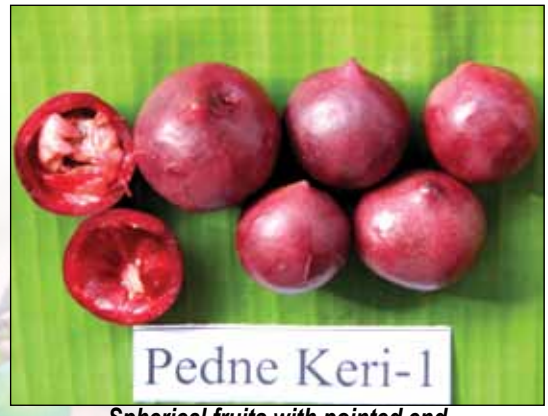
Fruits were of conical or oblong or pear shaped or spherical shape. The ratio of fruit length and diameter ranging from 0.9 and above were oblong or oval, where polar diameter was higher than equatorial diameter for this group of fruits. Rest of the accessions were spherical in shape. Fruits of three accessions namely Acc.No. 43, 79 and 146 were conical, with tapering end towards stalk end. These accessions were found in Bicholim and Ponda taluks. Nineteen accessions had oblong fruits,



Pie chart showing percentage of different shapes of fruits in Kokum

Oblong shaped fruits

Pear shaped fruits



Spherical fruits with pointed end

Spherical fruits

VARIOUS SHAPES KOKUM FRUITS

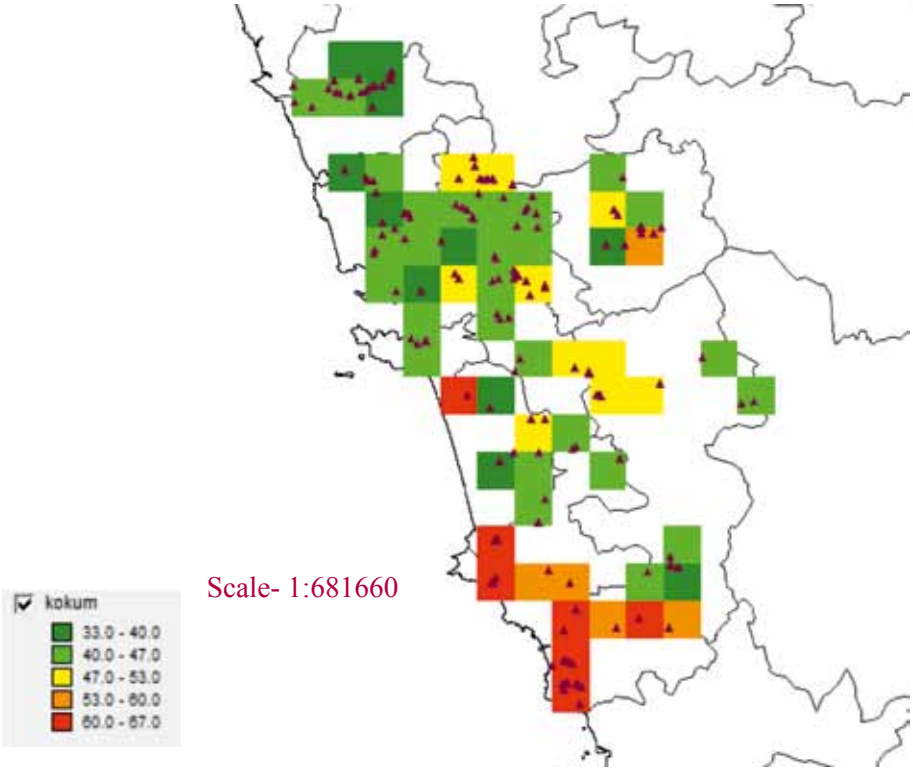


Fig.9. Map of Goa showing richness index for rind thickness (cm) of accessions.

among which Acc.No. 42, 80, 86, 87 and 106 were from Bicholim taluk, Acc.No. 11, 24 and 25 were found in Pernem taluk, Acc.No. 197 in Quepem taluk, Acc. No. 207 and 213 from Canacona taluk, Acc.No. 127 and 141 from Ponda taluk and Acc.No. 180 and 181 from Salcete taluk, Acc.No. 244 from Sanguem taluk, Acc. No. 117 from Bardez taluk and Acc.No. 165 from Sattari taluk.

Among these accessions, Acc.No. 86 had oblong fruits with a pointed tip at the stylar end. Six accessions *viz*., 45, 47 and 89 (Bicholim taluk), 139 (Ponda taluk), 177 (Sattari taluk) and 188 (Salcete taluk) were uniquely pear shaped.

Besides these, the remaining 240 accessions recorded spherical or round shaped fruits. Such accessions were widely spread throughout the state of Goa. Among these accessions having spherical fruits, two were spherical in shape with a pointed beak or tip towards stylar end (Acc.No. 18 and 150 from Pernem and Ponda taluks respectively). Therefore, among 268 accessions studied, 1.12 per cent of accessions had conical shaped fruits, 7.09 per cent had oblong fruits, 2.24 per cent had pear shaped fruits, 88.81 per cent of accessions had spherical shaped fruits and only 0.75 per cent had spherical shaped fruits with pointed ends (Plate3).

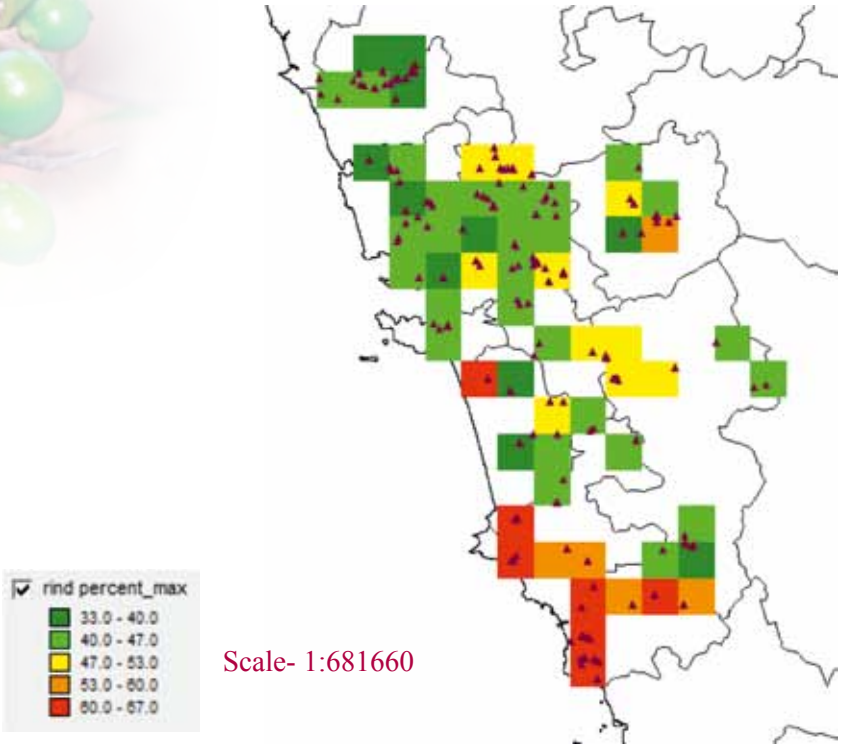


Fig.10. Map of Goa showing distribution of accessions for rind %.

3.9. Rind characters of Kokum accessions

3.9.1. Rind thickness (cm)

The thickness of rind of fruit showed a wide variation among the accessions studied. It varied from a minimum of 0.14cm in Acc. No. 16 (Pernem taluk) to a maximum of 0.48 cm in Acc. No.263 (Sanguem taluk). The rind thickness of 0.4 cm and above (up to a maximum of 0.48 cm) was noticed in fourteen accessions from various taluks *viz*., 0.40 cm and 0.43 cm in Acc. No.175 and 177 (Sattari taluk); 0.40 cm, 0.41 cm, 0.42 cm and 0.43 cm in Acc. Nos. 197, 192, 206 and 200 respectively (Quepem taluk); 0.40 cm, 0.43 cm, 0.45 cm and 0.47 cm in Acc. Nos. 19, 4,28 and 27 respectively (Pernem taluk); 0.41 cm, 0.42 cm and 0.48 cm in Acc. Nos.257, 243 and 263 respectively (Sanguem taluk) and 0.43 cm in Acc. No.240 of Canacona taluk. The mean rind thickness was 0.26 cm and 104 accessions had rind thickness above the mean value

Researchers have earlier reported on rind thickness and percentage but not on inner rind colour. Gawankar *et al*. (2001a) found that rind thickness and rind percentage of six promising accessions of kokum varied from 0.30 to 0.48 cm and 34.08 to 79.13 percentage. Similarly in another evaluation of 108 genotypes of kokum, Kshirsagar *et al*. (2003) reported that ten promising kokum accessions had

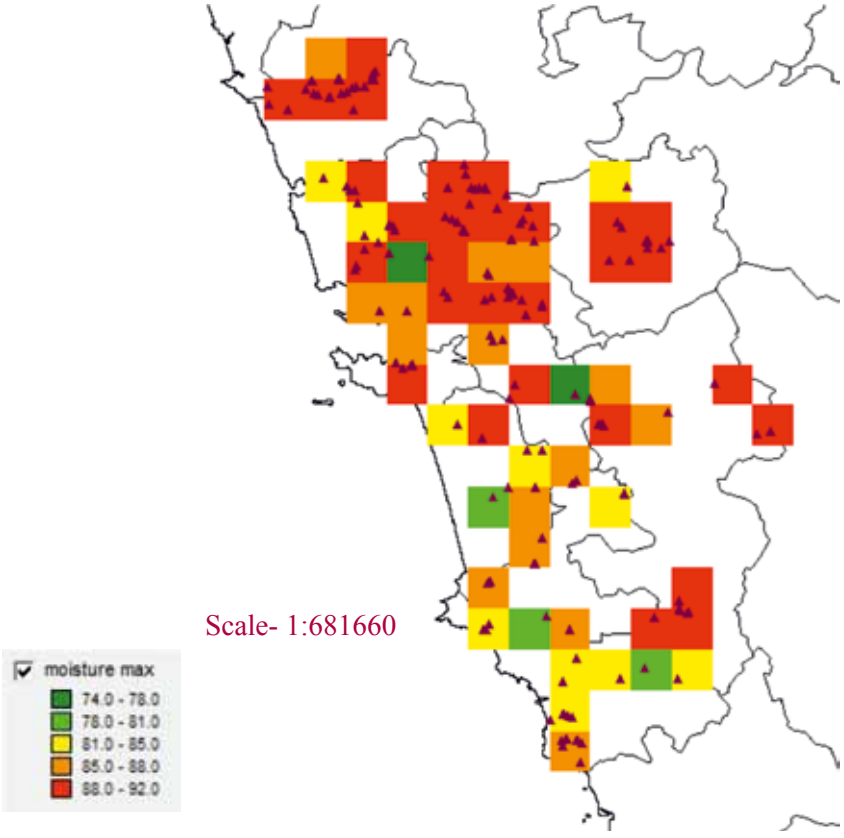


Fig.11. Map of Goa showing distribution of accessions for moisture (%)

rind percentage ranging from 38.53 to 72.73. Gawankar *et al*. (2003) reported that high variability existed among the different kokum seedling types under study in respect of rind thickness and percentage.

"Konkan Amruta" a released variety was reported to have an average rind thickness of 0.45 cm and rind percentage of 50.94 (Patil *et al*., 2005a). Therefore, it is evident that the accessions identified are really promising for rind characters.

When the data set on rind thickness of 268 accessions under study was mapped as grids on Goa map, (Fig.8) it was observed that, fruits having higher range of rind thickness (0.41 cm to 0.48 cm), represented by red coloured grids were seen in taluks like Pernem, Bardez, Sattari, Sanguem, Quepem and Canacona. The next range of 0.35cm to 0.41 cm, represented by orange coloured grids was shown over Pernem, Bardez, Bicholim, Sattari, Ponda, Quepem and Canacona taluks. The fruits having medium rind thickness of 0.29 cm to 0.35 cm (yellow grids) were spread over taluks like Pernem, Bardez, Bicholim, Ponda, Salcete, Sanguem and Canacona. The accessions having less rind thickness ranging from 0.23 cm

to 0.29 cm were shown as light green grids, found in Pernem, Bardez, Sattari, Tiswadi, Mormugoa, Ponda, Salcete, Sanguem, Quepem and Canacona taluks. The minimum range under classification i.e. 0.16 cm to 0.23 cm projected as dark green grids were spread over Bardez, Tiswadi, Sattari, Sanguem, Salcete and Canacona taluks of Goa

When diversity or richness index for rind thickness was mapped (Fig.9), it was found that, maximum diversity of 60.00 to 67.00 (represented by red grids) was found in Southern taluks *viz*., Quepem, Canacona and Salcete. Medium diversity index ranging from 53.00 to 60.00 was shown as orange grids in Quepem, Canacona and Sattari taluks. Regions having medium diversity index of 47.00 to 53.00 was dispersed over Bicholim, Ponda, Sattari, Bardez, Sanguem and Salcete taluks. Areas of lower orders of diversity for rind thickness (40.00 to 47.00) were represented as light green and green grids (33.00 to 40.00) and were recorded all over Goa, with the exception of Bicholim, Ponda, Sanguem, Quepem and Mormugoa taluks for the lowest diversity range.

3.9.2. Rind percentage

Among all 268 accessions studied, the rind percentage ranged from 30.19 in Acc. No. 259 (Sanguem taluk), followed by 31.28, 31.26, 32.10, 32.54 in accessions 24, 10, 31 and 34, all from Pernem taluk. The maximum rind percentage of 66.67 was noticed in Acc.No. 210 of Canacona taluk, followed by 65, 63.63 and 62.85 per cent in Acc.Nos. 200 (Quepem), and 238 and 240 (both from Canacona taluk). The grand mean of rind percentage was 42.87 for all 268 accessions.

Rind percentage in fruit is also an essential trait, because the dried rind is mainly used as souring agent in Konkan cuisine. In a similar study, Rodrigues (2003) reported that rind percentage varied from 21.24 to 51.78 in nine promising accessions studied and rind thickness ranged from 0.20 to 0.80 mm.

Point to grid analysis for rind percentage resulted in grids of five colours on Goa map (Fig.10). The red coloured grids that illustrated the locations with accessions having maximum rind percentage (60.0-67.0) were spotted in only three taluks *viz*., Canacona, Quepem and Salcete. Orange grids representing rind percentage range of 53.0-60.0 were found in three taluks *viz*., Canacona, Quepem and Sattari. Besides this, taluks like Bicholim, Ponda, Tiswadi, Sanguem and Salcete had accessions with medium range of rind percentage (yellow grids depicting 47.0-53.0). Lower range (40.0-47.0) denoted by light green grids were dispersed throughout Goa in all eleven taluks, whereas the least rind percentage (33.0-40.0) shown as dark green grids were found all taluks except Mormugoa, Bicholim, Quepem and Canacona.

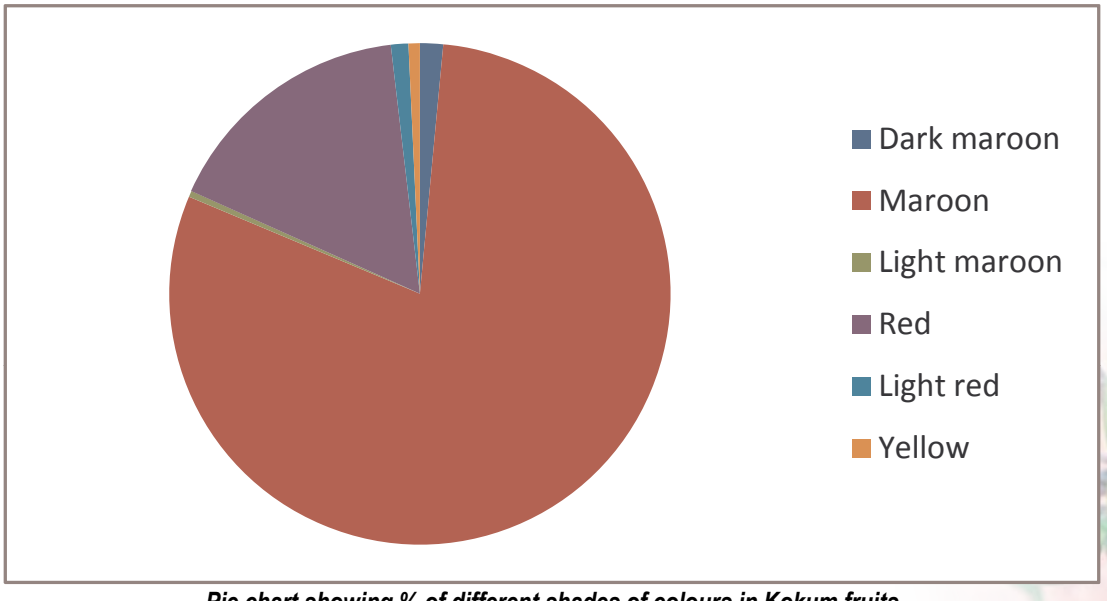
3.9.3. Rind moisture (%)

Moisture percentage in rind ranged from a minimum of 69.71 in Acc.No. 225, to a maximum of 91.93 in Acc.No. 91 (Bicholim taluk). The grand mean was observed to be 84.75.

When point to grid mapping was done using DIVA-GIS software (Fig.11), the accessions were classified into five groups as follows: moisture percentage ranging from 88.0 to 92.0 under red grids, 85.0-88.0 under orange grids, 81.0-85.0 under yellow grids, 78.0-81.0 under light green grids and 74.0-78.0 under dark green grids. Bicholim, Pernem, Tiswadi, Mormugoa and Sanguem taluks had accessions depicted by only red and orange grids. Accessions having medium moisture range illustrated by yellow grids were spotted in Bardez, Sattari, Salcete, Quepem and Canacona taluks. Light green grids were spotted in only southern taluks like Salcete, Quepem and Canacona. The least range of 74.0-78.0 was noticed in accessions of only two taluks *viz*., Tiswadi and Ponda.

3.9.4. Inner rind colour

Inner rind colour ranged from dark maroon to light maroon through maroon; from light red to red to reddish maroon. Two accessions (Acc.No. 90 from Bicholim and Acc.No. 221 from Canacona) exhibited yellow colour on inner side of rind, as they were yellow coloured fruits. Out of 268 accessions studied, four accessions *viz*., Acc.No. 226 (Canacona), Acc.No. 145 (Ponda), 197 (Quepem)



Pie chart showing % of different shades of colours in Kokum fruits

and 7 (Pernem) had dark maroon colour on the inner side of the rind. There was one accession 46 (Bicholim) that had light maroon colour on inner side of fruit rind and three accessions *viz*., Acc.Nos. 247, 256 (Sanguem) and 185 (Salcete) were showing light red on the inner side. Among all, 44 accessions had red colour and 2 (Acc.Nos. 221 and 99) had yellow colour on inner side of fruit rind. Besides these, the rest 214 accessions showed normal maroon colour. Hence, to conclude, out of 268 accessions, 0.38 per cent had light maroon colour, 0.74 per cent had yellow colour, 1.12 per cent showed light red, 1.49 per cent had dark maroon colour, 16.42 per cent had red colour and 79.85 per cent had maroon colour on the inner side of the rind.

The inner rind colour also varied through shades of maroon and red for all accessions studied except yellow coloured ones. Acc. No. 235 which had the darkest external colour recorded maroon colour inner rind. On the contrary, accessions that had normal maroon colour fruit recorded dark maroon as inner colour. Such interesting variability was noticed while correlating the outer and inner colours of rinds. As the rind colour adds to the value of end product (amsol), and also exhibits the richness in pigmentation, the study of diversity of the rind colour is a very significant part of the study.

Summary and Conclusions

Kokum, botanically *Garcinia indica* Choisy (Thouars) is a commercially under-utilized perennial tree species found wide spread as a native species in Goa. Assessment of genetic diversity in *Garcinia indica* (Choisy) was carried out in Goa. Geographical location was recorded for 268 accessions naturally existing throughout the Goa state. Morphological characters like canopy shape, number of branches, leaf characters and fruit characters were recorded for all the 268 accessions. Promising genotypes were identified for all the traits under study. Diversity analysis was carried out using DIVA-GIS and diversity hotspots were located. Salient findings of the study are as follows:

1) The trees studied were geographically located in all eleven taluks of Goa in elevations ranging from 6 to 178 m MSL.

2) Out of 268 accessions studied for tree shape, 59 were conical, 111 were pyramidal, 71 were pyramidal and spreading, 15 were spreading, 9 were pyramidal and drooping and 3 were conical and medium spreading.

3) Out of the 268 accessions studied, 164 (61.19%) accessions had lanceolate leaves with or without wavy margin and acute or sub acute tips; 56 accessions (20.90%) were broadly lanceolate with or without mildly wavy margin and acute or obtuse tips; 44 (16.42%) accessions either ovate or obovate with acute to obtuse tips with or without wavy margins; 4 (1.49%) accessions were narrowly lanceolate with acute to sub acute tips with wavy margin.

4) Colour of petiole was either green or pink or greenish pink. Out of the 269 accessions studied, a total of 131 accessions had green petioles (48.88 %); 48 accessions had pink coloured petioles (17.91 %) and 89 accessions had greenish pink petioles (33.21 %). All the three types were found to occur in all the taluks.

5) Kokum is a dioecious species. Two types of staminate flowers and one type each in hermaphrodite and pistillate flowers were studied in kokum. In staminate flowers, the gynoecium was either absent or in rudimentary form. Such flowers did not produce any fruit. Hermaphrodite flowers had 20-30 numbers of stamens and an ovary with 3-5 ill developed locules. Such trees produced smaller fruits. Pistillate trees had well developed ovary with 8 – 9 locules and produced big fruits above 30 g.

6) Accessions showed a great variation for flowering and fruiting. The accessions attained 50 per cent flowering after 30-45 days from initiation of flowering. Generally, span of flowering spread for 8-9 weeks and fruiting season lasted for two months.

7) The trees under study had flowering span from November to January, whereas fruiting period was from last week of April to first week of June.

8) Out of 268 accessions studied for flowering and fruiting, there were early, mid and later bearers. Among them, 38 accessions (14.18 per cent) were early bearers, 67 accessions (25.00 per cent) were mid season bearers and 163 accessions (60.82 per cent) were late bearers.

9) Out of 268 accessions studied, Acc.No. 149 (Savoi Kamini-1) which was located in Ponda taluk was the earliest among all for flowering and fruiting, followed by Acc. No.18 (Pernem Keri-1) located in Pernem taluk and Acc.No.179 (Hedode-1) from Sattari taluk.

10) Among the accessions studied, average fruit weight ranged from 6.80 g to 47.60 g. Fourteen accessions were found in the promising cluster for fruit weight above 30 g. The two most promising accessions are Borim-2 from Ponda taluk and Kasarpal - 5 from Bicholim taluk.

11) When the accessions were mapped based on point to grid analysis, it was found that the fruits of higher fruit weight i.e above 40g were located in Ponda (Acc. No.126) and Bicholim (Acc. No.69) taluks

12) Average of observations on fruit length ranged from 1.19 (Acc.No. 224) to 4.36cm (Acc.No. 194) with a mean value of 2.63cm.

13) The highest fruit length range of 3.84 to 4.36 cm, depicted by red colour grids were noticed in Canacona, Ponda and Bicholim taluks.

14) The average fruit diameter varied widely from 1.80 (Acc.No. 188) to 5.51cm (Acc.No. 194) with a mean fruit diameter of 2.97 cm.

15) When fruit diameter data was plotted as grids on Goa map during diversity analysis, it was observed that the highest range of fruit diameter 4.80 to 5.50 cm was found in Bicholim and Pernem taluks

16) Among 268 accessions studied for fruit shape, 0.75 per cent had spherical fruits with pointed ends, 1.12 per cent had conical, 2.24 per cent had pear, 7.09 per cent had oblong and 88.81 per cent had spherical fruit shape.

17) The thickness of rind of fruit showed a wide variation among the accessions studied. It varied from a minimum of 0.14cm in Acc. No. 16 (Pernem taluk) to a maximum of 0.48 cm in Acc. No.263 (Sanguem taluk).

18) Rind percentage ranged from 30.19 to 66.67. Point to grid analysis for rind illustrated the locations with accessions having maximum rind percentage (60.0-67.0), spotted in only three taluks *viz*., Canacona, Quepem and Salcete.

19) There was wide variation noticed for moisture per cent in rind from 69.71 to 91.93.

20) Inner rind colour of accessions was in shades of red and maroon.

Future strategies

Conservation of *Garcinia* germplasm resources

Underutilized crops (referred to also by other terms such as minor, orphan, neglected, under exploited, under developed, lost, new, novel, promising, alternative, local, traditional, niche crops) have been included in world wide plans of action after having successfully raised the interest of decision makers. Leading international research organization such as the Consultative Group on International Agricultural Research (CGIAR) is among those taking a keen interest in strengthening the work on these species (Swaminathan, 1999). Such crops are part of the (threatened) biological assets of the rural poor. The strategies for conservation and use can be applied combined to secure the resource base of such crops. New technologies (e.g. molecular genetics and GIS) will certainly play their part in the process of developing conservation and use strategies. Perhaps, there needs to be some deliberate determination of the way in which these powerful tools can be best used for such crops (Padulosi *et al*., 2000).

Well structured research and developmental programmes have to be laid out for crops like kodampuli and kokum, not only to conserve the biodiversity but also to broaden the genetic base by breeding programmes and make it a successful industry. In the race for modernization and urbanisation, the farmers as well as researchers have begun to rapidly lose the valuable and natural genetic resources (Chaudhuri, 2005). For instance few elite mother trees of kokum that were identified for quality characters and earliness were lost in Pernem, Sattari and Canacona taluks due to natural and man-made causes. The strategies that preserve the biodiversity are often embedded in community action, which channelizes and encourages individual households to act in such ways to foster biodiversity. This social locus of biodiversity management need to be encouraged and rewarded in order to achieve insitu conservation.

Intensive and systematic surveys taken up through out Goa have resulted in identification of certain promising mother trees for earliness, yield and quality characters. As an attempt towards ex-situ conservation, a core germplasm block

for such elite or outstanding accessions has been established at ICAR Research Complex for Goa. Further evaluation and selection will result in varieties of kokum. Future work on hybridization will broaden the genetic base of the crop, thereby enriching the genetic resources of Kokum in Goa. Besides kokum, few accessions of *G. cambogia, G. mangostana, G tinctoria* and *G hombroniana* also find place in institute germplasm bank

Future line of work

Priority research and management for conserving and positively exploiting the genetic resources of *Garcinia* spp in Goa include the following:

1. More efforts in collecting and conservation of public and private *Garcinia* genetic resources and natural mutants, with special emphasis on earliness, yield and quality.

2. Priority research on elite germplasm including studies on genetic analysis and heritability of characters. Use of molecular tools to analyze genetic diversity, mapping and tagging of genes with closely linked markers for maker aided selection. Since it may not be possible to characterize entire range of diversity at molecular level, suitable core set of kokum collection on the basis of agronomic evaluation can be developed and further characterized at molecular level.

3. Priority studies on rapid multiplication techniques, especially for the elite germplasm, such as grafting and in vitro propagation *etc.*, for their immediate utilization for rural and agricultural development.

4. Studies towards the analysis of nutrient composition of the fruit germplasm with the objective of improving consumers' health status

5. As this Konkan tract is blessed to be a reservoir of gene sources for *G. indica*, breeders working together with farmers have more chance of developing appropriate varieties, and maintaining and enhancing biodiversity on farm.

References

Anonymous. 1956. The Wealth of India-Raw materials. **Council of Scientific and Industrial Research, New Delhi**, Vol. 4: p.102.

Adsule, P. G., A. R. Desai, S. Priya Devi, M.Thangam, K. Ramachandrudu. 2001. Status and prospects of horticultural and plantation crops in Goa and their utilization. **In:** Proceedings of the Symposium on Post harvest technologies for Agricultural produce and prospects for the food processing industry in Konkan region held at Dona Paula, Goa during 23-24 November 2001. pp. 14-18.

Chaudhuri,S,K., 2005. Genetic Erosion of Agrobiodiversity in India and Intellectual Property Rights: Interplay and some key Issues. http://www.patentmatics.org/pub2005/pub6c.pdf

Cooke, T.C.I.E. 1954. The flora of presidency of Bombay. **Saraswati Press Ltd. Calcutta**. pp.80-85.

Gawankar, M.S., D.V. Shingre and B.M. Jamadagni. 2001. Graft induced modification in plant architecture of kokum (*Garcinia indica* Choisy). **In:** Proceedings of First National Seminar on Kokum. 12-13 May, RFRS, Vengurle, Maharashtra, India. pp.19-21.

Gawankar, M.S., D.V. Shingre, M.B. Dalvi and B.M. Jamadagni. 2001a. Variability for morphophysical properties of fruits in kokum. **In:** Proceedings of First National Seminar on Kokum. 12-13 May, RFRS, Vengurle, Maharashtra, India. pp.1-3.

Gawankar, M. S., D.V. Shingre, P. J. Kshirsagar, H. R. Nadkarni, B. P. Patil, G. D. Joshi and N. D. Jambhale. 2003. Improvement of Kokum (*Garcinia indica* Choisy) by selection. **In:** Proceedings of the National Seminar on New Perspectives in Spices, Medicinal and Aromatic plants. 27-29, November, ICAR Research Complex for Goa, Goa, India. pp.126-130.

Gawankar, M.S., D.V. Shingrae, B.P. Patil, V.V. Sagvekar and G.D. Joshi. 2004. Evaluation of seedling progenies of kokum (*Garcinia indica* Choisy). **Indian J. Arecanut, Spices and Medicinal plants, 6(3):** 83-86.

Godbole, A. and S.K. Das. 2000. Flora of Maharashtra state Dicotyledons. **Botanical Survey of India, Calcutta**. pp. 273-283

Karnik, A.R. 1978. Studies on flowering and fruiting in Kokum (*Garcinia indica* Choisy). **M.Sc. (Agri.) Thesis**, Dr.B.S.Konkan Krishi Vidyapeeth, Dapoli, India.

Korikanthimath, V.S. and A.R. Desai. 2005. Status of Kokum (*Garcinia indica* Choisy) in Goa. **In:** Preview of 2nd National seminar on kokum. 4-5th March. Goa University, Goa, India. pp. 7-16.

Korikanthimath, V.S., S. Priya Devi and A.R. Desai. 2008. Kokum (*Garcinia indica*)-a horticultural crop with great potential. **In:** Recent initiatives in Horticulture Eds. K.L.Chadha, A.K.Singh and V.B.Patel. pp.393-399.

Krishnaswamy, N. and V.S. Raman. 1949. A note on the chromosome numbers of some economic plants in India. **Curr. Sci., 18:** 376-378.

Kshirsagar, P.J., M.S. Gawankar, B.P. Patil and S.B. Deshpande. 2003. Kokum- a unique food spice and medicinal fruit tree of Konkan. In: Proceedings of National Seminar on Spices. ICAR Research Complex for Goa, Goa, India. pp.38-41.

Nadkarni, H.R, P.J. Kshirsagar, N.R. Bhagwat, M.B. Dalvi and B.P. Patil. 2001. *Garcinia*- A unique genus for coming decade. **In:** Proceedings of First National Seminar on Kokum, RFRS, Vengurle, Maharashtra, 12-13, May, India. p.15.

Padulosi S, T. H., J. T. Williams and N. Hag. 2000. Under utilized crops: trends, challenges and opportunities in the 21st century. **In:** Proceedings of International conference on Managing plant genetic diversity, Kuala Lumpur, Malaysia, 12-13, June. pp.22.

Patil, B.P., M.S.Gawankar, V.V. Sahvekar and N.D. Jambhale. 2005. Status of existing kokum plantation in Maharashtra. **In:** Preview of 2nd National seminar on kokum. 4-5th March. Goa University, Goa, India. pp. 17-19.

Patil, B. P., M.S. Gawankar, D.S. Sawant, K.H. Pujari and N.D. Jambhale. 2005a. Cultivation of Konkan Amruta and Search for elite varieties. **In:** Preview of 2nd National seminar on kokum. 4-5th March. Goa University, Goa, India. pp. 29-34.

Sawant, D.S., P.M. Haldankar, D.D. Nagwekar and J.C. Rajput. 1999. Screening of kokum (*Garcinia indica* Choisy) genotypes. **Indian J. Arecanut, Spices and Medicinal plants, 2:** 55-58.

Rawat, R., and A.K. Bhatnagar. 2005. Flowering and pollination in *Garcinia indica*. **Acta Biol. Cracoviensia Series Botanica., 47. Suppl.1.** p.45.

Rema, J. and B. Krishnamurthy. 2000. *Garcinia* species of economic importance, distribution and uses. **Indian Spices, 37(1):** 20-23.

Rodrigues. 2003. Kokum genotypes of Goa. **In:** Workshop on Kokum. ICAR Research complex for Goa, Goa, India.

Robson, N. K. B. and P. Adams. 1968. Chromosomes numbers in *Hypericum* and related genera. **Brittonia, 20:** 95-106.

Shinde A.K, S.K. Godse, G.M. Waghmare and B.P. Patil. 2001. Performance of kokum grafts and seedlings during initial years. **In:** Proceedings of First National Seminar on Kokum. 12-13 May, RFRS, Vengurle, Maharashtra, India. pp.37-38.

Subash Chandran, M.D. 1996. The Kokum tree. **Resonance (January):** 86-89.

Swaminathan, M.S. 1999. Enlarging basis of food security: the role of under utilized species. International workshop held at the MSSRF, 17-19, February, Chennai, India.

Thombre, M.V. 1964. Studies in *Garcinia indica* Choisy. **Sci. Cult., 30:**453-454.

APPENDIX

Accession numbers relating to the trees studied

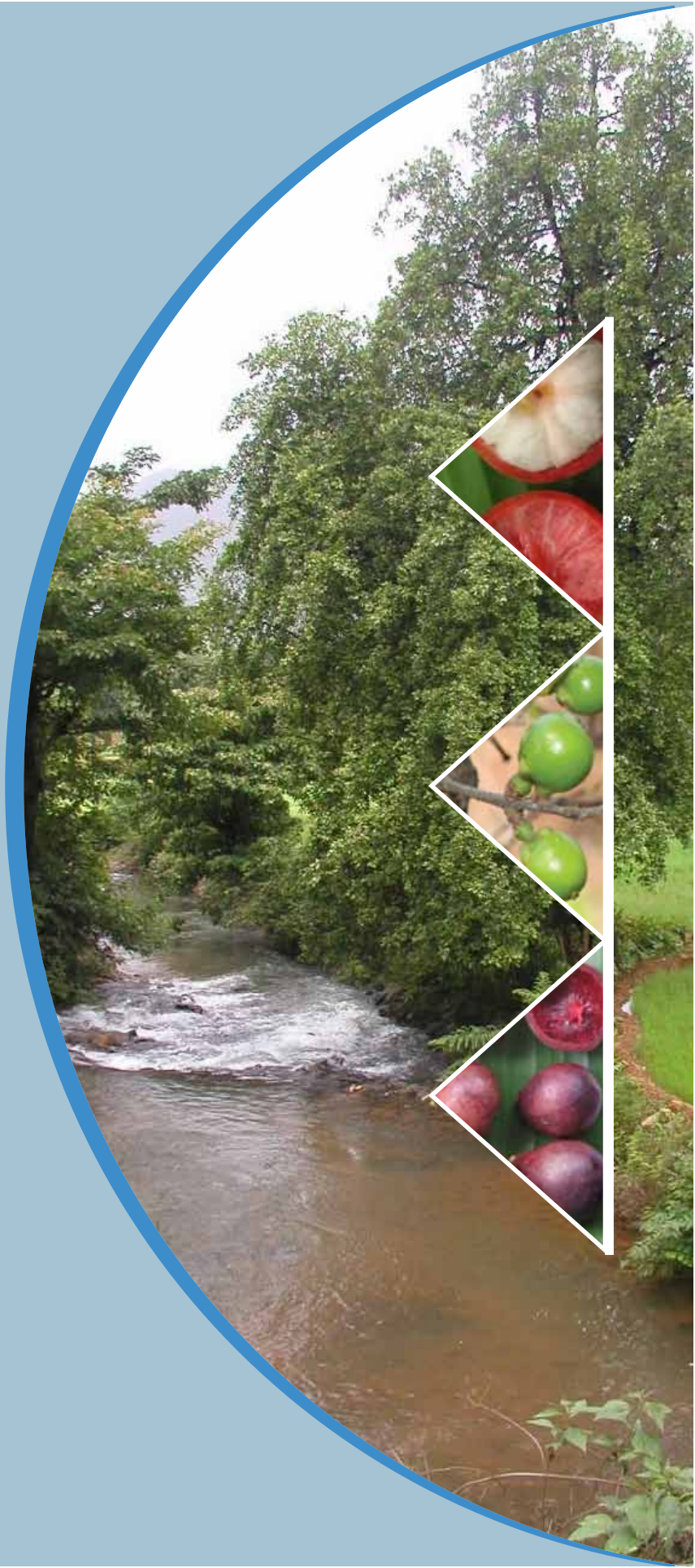
Accn.No	Taluka	Accessions
1	Pednem	Amerem 1
2		Amerem 2
3		Bagayat 1
4		Bagayat 2
5		Bagayat 5
6		Bandarwada 1
7		Bandarwada 2
8		Bandarwada 3
9		Malpe 1
10		Malpe 2
11		Malpe 3
12		Naibag 2
13		Parashte 1
14		Parashte 2
15		Parashte 3
16		Pednem 2
17		Pednem 3
18		Pednem Keri 1
19		Puraskadem 1
20		Puraskadem 2
21		Puraskadem 4
22		Satarda 10
23		Satarda 11
24		Satarda 4
25		Satarda 5
26		Satarda 6
27		Satarda 7
28		Satarda 9
29		Toxem 1
30		Toxem 2
31		Toxem 3
32		Toxem 4
33		Ugvem 3
34		Ugvem 5
35		Ugvem 6
36		Ugvem 7
37	Tiswadi	Curca 1
38		Divar 1
39		Karmali 3
40		Karmali 4
41		St Inez 1
42	Bicholim	Arvalem 1
43		Arvalem 2
44		Arvalem 3
45		Dimonem 1
46		Dimonem 2
47		Dimonem 4
48		Dimonem 5
49		Dimonem 6
50		Gola 2
51		Gola 20
52		Gola 27
53		Gola 3
54		Gola 35
55		Gola 38
56		Gola 40
57		Gola 5
58		Gola 7
59		Kasarpal 1
60		Kasarpal 10
61		Kasarpal 11
62		Kasarpal 12
63		Kasarpal 13
64		Kasarpal 14
65		Kasarpal 15
66		Kasarpal 2
67		Kasarpal 3
68		Kasarpal 4
69		Kasarpal 5
70		Kasarpal 8
71		Kharekazan 1
72		Kharekazan 2
73		Kharekazan 3

74		Kharekazan 4
75		Kharekazan 5
76		Lakerem 1
77		Mattan 1
78		Maulinguem 1
79		Maulinguem 14
80		Maulinguem15
81		Maulinguem 16
82		Maulinguem 17
83		Maulinguem 18
84		Maulinguem 19
85		Maulinguem 20
86		Maulinguem 21
87		Mayem 1
88		Mayem 3
89		Mayem 4
90		Mayem 5
91		Mayem 6
92		Mayem 8
93		Mulgaon 1
94		Mulgaon 3
95		Mulgaon 4
96		Ona Maulinguem 1
97		Ona Maulinguem 2
98		Ona Maulinguem 3
99		Ona Maulinguem 4
100		Parye 2
101		Parye 1
102		Parye 3
103		Tulsimad 2
104		Curchorem 2
105		Curchorem 3
106		Curchorem 4
107		Curchorem 5
108		Curchorem 6
109		Curchorem 9
110		Curchorem 21
111	Bardez	Carrem 1
112		Carrem 2
113		Carrem 3
114		Carrem 4

115		Donwado 1
116		Madian 1
117		Madian 2
118		Maina 1
119		Mapusa 1
120		Mansher 1
121		Pomburpa 1
122		Siolim Oxel 1
123		Soccoro 1
124		Soccoro 2
125		Sodiem 1
126	Ponda	Borim 2
127		Conepriol 1
128		Conepriol 2
129		Conepriol 3
130		Dabbal 5
131		Dabbal 6
132		Dabbal 7
133		Dabbal 8
134		Dabbal 9
135		Farmagudi 2
136		Farmagudi 3
137		Khandola 1
138		Khandola 2
139		Khandola 5
140		Khandola 6
141		Khandola 7
142		Khandola 8
143		Khandola 9
144		Khazorda 1
145		Nirangal Gola 1
146		Ponda Keri 2
147		Ponda keri 3
148		Savoi 1
149		Savoi Kamini 1
150		Savoi Kamini 2
151		Savoi Kamini 3
152		Savoi Verem 1
153		Savoi Verem 3
154		Savoi Verem 4
155		Savoi Verem 5

156		Savoi Verem 6
157		Savoi Verem 9
158		TSP 1
159		TSP 2
160		TSP 3
161		Veling 1
162	Sattari	Dhave 1
163		Dhave 2
164		Dhave 3
165		Dhave 4
166		Dhave 5
167		Dhave 6
168		Dhave 7
169		Dhave 8
170		Dhave 9
171		Dabose 1
172		Dabose 2
173		Dabose 3
174		Dabose 4
175		Thane 1
176		Thane 3
177		Hedode 1
178		Volpoi 1
179	Salcette	Chandor 1
180		Chandor 2
181		Chandor 3
182		Curtorlim 1
183		Curtorlim 2
184		Curtorlim 3
185		Curtorlim 4
186		Dramapur 1
187		Manora 1
188		Nuvem 1
189	Quepem	Balli 2
190		Balli 3
191		Balli 4
192		Gokuldem 1
193		Kargegal 1
194		Padi 1
195		Padi 2
196		Padi 3
197		Quittol 1
198		Quittol 2
199		Quittol 3
200		Quittol 4
201		Soliem 1
202		Soliem 2
203		Soliem 3
204		Soliem 7
205		Xeldem 2
206		Xeldem 3
207	Canacona	Agaskhola 1
208		Canacona 1
209		Cotigaon 1
210		Cotigaon 2
211		Mashem 1
212		Mashem 2
213		Mashem 3
214		Mashem 4
215		Pedem 1
216		Pedem 2
217		Pedem 3
218		Pedem 5
219		Pedem 6
220		Pedem 7
221		Pedem 8
222		Poinguinim 2
223		Poinguinim 3
224		Poinguinim 4
225		Poinguinim 6
226		Poinguinim 7
227		Poinguinim 8
228		Poinguinim 9
229		Polem 1
230		Satorli 1
231		Shali 1
232		Shali 2
233		Shirate Khola 1
234		Shirate Khola 2
235		Shirate Khola 3
236		Shirate Khola 5
237		Shirate Khola 6

238		Shirate Khola 8
239		Shirate Khola 9
240		Shristal 1
241	Sanguem	Darbandora 1
242		Darbandora 6
243		Gurke 1
244		Khaluli 1
245		Khaluli 2
246		Khaluli 3
247		Khaluli 5
248		Khaluli 6
249		Madlawada 1
250		Margwadi 1
251		Margwadi 2
252		Margwadi 3
253		Margwadi 4
254		Netravali 1
255		Netravali 2
256		Netravali 3
257		Netravali 5
258		Netravali 7
259		Netravali 8
260		Netravali 9
261		Tambdi Surla 1
262		Tambdi Surla 2
263		Tambdi Surla 3
264	Murmugoa	Sancoale 1
265		Sancoale 2
266		Sancoale 3
267		Sancoale 4
268		Sancoale 5



ICAR RESEARCH COMPLEX FOR GOA

(Indian Council of Agricultural Research)

Old Goa - 403 402, Goa, India