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Ornamental *Curcuma* Species in Western Ghats of India

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Efforts for collection, characterization and classification of genetic resources of wild relatives of turmeric in India resulted in sampling a total of 105 accessions devoid of sessile tubers. Of these 40 accessions belonging to 13 identified species, two varieties and three unidentified entities were characterized and assessed in *in situ* and *ex situ* maintenance plots for their ornamental value. Among them *Curcuma mutabilis* and *C. inodora* topped the list with a score of 9 followed by *C. albiflora, C. oligantha* var. *oligantha, C. oligantha* var. *lutea, Curcuma* spp. 1 and 2 with a score of 8 each. *C. karnatakensis* and *C. thalakaveriensis* with a score of 7 each are also ahead of species such as *C. decipiens, C. coriacea, C. pseudomontana, C. neilgherrensis, C. kudagensis* and *Curcuma* sp. 3 with a score of 6. Falling under Sect. *Stolonifera C. vamana* had the lowest score of 5. The subjective assessment of the genetic erosion encountered with respect to the species and future problems and prospectus of their utilization for ornamental purpose is also dealt with, in brief.

Key Words: *Curcuma* spp., *Eucurcuma*, Germplasm, *Nontuberosa*, Ornamental, *Paracurcuma*, *Stolonifera*

Introduction

The genus *Curcuma* includes approximately 120 species (Skornickova and Sabu, 2002; Skornickova *et al.*, 2004) which are distributed in tropical and subtropical Asia. In India, the genus is represented by 40 species (Roxburgh 1820; Baker, 1890-1892; Velayudhan *et al.,* 1996; Sabu, 2006). The members are mainly distributed in East, North, East and Southern peninsular region. Based on morphological characters, the Indian *Curcuma* is divided into two subgenera-1) *Eucurcuma* containing three major sections – *Tuberosa, Nontuberosa* and *Stolonifera* (Velayudhan *et al.*, 1996) and *Paracurcuma* of Valeton (1918) containing two species. Western Ghats region lying parallel to Arabian seacoast and lying in states of Kerala, Tamil Nadu, Karnataka, Goa and Maharashtra is rich in *Curcuma* species belonging to the section *Nontuberosa* (characterized by the absence of sessile fingers). Apart from this, *C. vamana* of the section *Stolonifera* and *C. aurantiaca* Zjip and *C. ecalcarata* of the subgenus *Paracurcuma* have been reported from the region. *C. ecalcarata* Sivr. & Balach. is established as synonymous to *C. aurantiaca* Zijp (www.theplantlist org./tpl 1.1/record/kew-235216). While revising the genus *Curcuma* of Peninsular India, Sabu (2006) reported 20 species leaving one established species. Thus, other than eight finger-bearing species, 14 species such as *C. albiflora* Trimen, *C. aurantiaca* Zjip [syn. *C. ecalcarata* Sivar. & Indu], *C. bhatii* (R. M. Sm.) Skornickova & Sabu, *C. oligantha* Trimen, *C. cannanorensis* Ansari, VJ Nair & NC Nair, *C. karnatakensis* Amalraj, Velay. & VK Mural, *C. coriacea* Mangaly & Sabu, *C. decipiens* Dalzell, *C. inodora* Blatter, *C. kudagensis* Velay, Pillai & Amalraj syn. *C. thalakaveriensis* Velay Amalraj & Mural, *C. mutabilis* Skornickova, Sabu & Prasanth, *C. neilgherrensis* Wight, *C. vamana* Mangaly & Sabu and *C. pseudomontana* J Graham have been so far reported from the region (www.theplantlist org./tpl 1.1/record/kew-235216). Among these species though, *C. thalakaveriensis* Velay Amalraj & Mural is considered as a synonym of *C. kudagensis* in the recent working plant list of *Curcuma* species from Kew, these are treated separately here as these are quite different from each other in plant type, leaf shape and inflorescence length. Apart from this, *C. aurantiaca* (Velayudhan *et al.*, 1996) and *C. albiflora* Thwaites (Amlaraj *et al.*, 1991) have been reported from the region. Moreover, few more apparently distinct entities have also been located quite recently about which the present treatise refers them as species no. 1, 2, 3 and 4. The details of the above species without underground fingers as per the available working list of Kew (1994) is presented in Table 1 below.

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Table 1. Taxonomic status of the species collected

Subgenus	Section	Species	Distribution
Paracurcuma	–	*Curcuma aurantiaca* Zjip syn. *C. ecalcarata* Sivar. & Balach.	West coast, lower Ghats
Eucurcuma	Nontuberosa	*C. albiflora* Thwaites	North Kerala, Karnataka.coast
-do-	-do-	C. *bhatii* (R. M. Sm.) Skornockova & Sabu	Udupi, Karnataka
-do-	-do-	*C. coriacea* Mangaly & Sabu	Idukki district, Kerala
-do-	-do-	*C. decipiens* Dalzell	All over Western Ghats
-do-	-do-	*C. oligantha* Trimen syn. *C. oligantha Trimen* var. *oligantha* K. G. Bhat	Konkan, N. Kerala and Karnataka
-do-	-do-	*C. cannanorensis* R. Ansari, V. J. Nair & N. C. Nair Syn. *C. oligantha* Trimen var. *lutea* (R. Ansari, V. J. Nair & N. C. Nair) K. G. Bhat	Konkan, N. Kerala and Karnataka
-do-	-do-	*C. karnatakensis* Amalraj, Velay & Mural.	Hilly Uttar Kannada
-do-	-do-	*C. kudagensis* Velay, Pillai & Amalraj Syn. *C. thalakaveriensis* Velay, Amalraj & Mural.	Coorg district of Karnataka
-do-	-do-	*C. mutabilis* Skornockova, M. sabu & Prasanth Kumar	Malappuram and Palakkad, Kerala
-do-	-do-	*C. inodora* Blatter	Karnataka and Konkan
-do-	-do-	*C. neilgherrensis* Wight	High lands of Western Ghats
-do-	-do-	*Curcuma* sp. 1	Central parts of Kerala
-do-	-do-	*Curcuma* sp. 2	Udupi, Karnataka
-do-	-do-	*Curcuma* sp. 3	Kudremukh, Chikmagalur
-do-	-do-	*Curcuma* sp. 4	
-do-	Stolonifera	*C. vamana* Mangaly & Sabu	Lower Ghats in midland Kerala

Attempts to collect, characterize and conserve the germplasm of *Curcuma longa* L. and its wild relatives in India by ICAR-National Bureau of Plant Genetic Resources in the past has resulted in amassing a total of 1856 accessions belonging to 32 species and several unidentified species. Sizable part of the collections represents the cultivated turmeric and other tuber bearing species of the genus from different parts of India. Usually the species without tubers are generally considered to be not economically useful. Meanwhile, Burch (1998) and Burch *et al.* (1987) reported the commercial use of some Zingiberaceae plants in United States of America. Khumkratok *et al.* (2012) and, Mood and Larsen (2001) reported the ornamental value of some of the South East Asian species of the genus such as *C. alismatifolia, C. aurantiaca, C. cordata, C. inodora, C. parviflora, C. roscoeana, C. alismatifolia, C. rabdota, C. bicolor* and *C. glans* which, have promoted the interest of horticulturists and growers in Thailand, Europe, Australia and United States. Kuehny *et al.* (2002) have also stressed the potential of *Curcuma* and *Kaempferia* for their use as potted plants. Most of these species have fine horticultural attributes and are offered in catalogues and Internet web sites. Though several species of horticultural value occur, these have not yet attracted much attention of horticulturists in India. Collection and preliminary characterization of various members of the genus from the Western Ghats have been carried out in the past pointing to the horticultural value of some of them with beautiful spikes, flowers and other positive attributes which demand more studies in this direction in the immediate future to utilize them (see Fig. 1a, 1b).

Materials and Methods

A total of 105 accessions belonging to 14 identified species (including two varieties), four unidentified entities (attempts are being made to identify these) without sessile fingers and one species bearing stolons on the rootstock have been collected in the past. Out of these 40 accessions belonging to *Curcuma albiflora* (1), *C. mutabilis* (3), *C. inodora* (6), *C. oligantha* (1), *C. cannanorensis* (2), *C. karnatakensis* (1), *C. thalakaveriensis* (1), *C. decipiens* (3), *C. coriacea* (1), *C. pseudomontana* (1), *C. neilgherrensis* (1), *C. kudagensis* (1), *C. vamana* (4), *C. ecalcarata* (2), *C. aurantiaca* (9) and unidentified species of *Curcuma* (3) have been observed for spike and flower characters (list of characters and states studied furnished below). Species 2 is a new species and is in process of publication. Species 3 is very distinct with better ornamental value; another specimen could not be collected from the locality or anywhere else afterwards. Unidentified *Curcuma* sp. 4 representing a single accession did not flower till the time of submitting the manuscript.

Passport information (descriptor No. 2-13) and qualitative and quantitative characters observed (descriptor No. 14-39) along with overall grade of each species in relation to its ornamental value based on a subjective score (1-9 scale) are furnished in Tables 2 and 3. Presently, a total of 39 accessions belonging to *C. aurantiaca* (9), *C. mutabilis* (4), *C. inodora* (6), *C. vamana* (4), *C. decipiens* (3), *C. pseudomontana* (1),

Table 2. Parameters, descriptors and descriptor states used

S.No.	Passport information	Description
1	Species and varieites	As per the latest taxonomic position
2	Number of accessions collected	Total number collected by the station from 1978 to 2007
3	Number of accessions observed	Accessions observed as when in flowering condition
4	Distribution	Distribution of the species in Western Ghats and adjoing areas
5	Subgenus	Subgenus Paracurcuma Val. & Eucurcuma Val. (Valeton, 1917; Velayudhan *et al.,* 1996)
6	Section	1- Nontuberosa, 2- Stolonifera
7	Altitude	In meters from mean sea level
8	Soil type	1- Laterite, 2- Sandy loam, 3- Rocky
9	Rainfall	1-Low, 2- Medium, 3-High
10	Ecological niches	1-Undisturbed forests, 2-Disturbed forests, 3-Orchards & farms, 4-Road sides, 5-Open grasslands, 6-Open river side rocky places, 7-Shola grasslands
11	Time of Regeneration	Time given in serial number of months
12	Time of senescence	Time given in serial number of months
Characters observed both *in situ* and *ex situ*		
13	Flowering time	Serial number of months
14	Spike position	1-Central, 2-Lateral, 3- Both central & lateral
15	Spike size	1-Small, 2-Medium, 3-Large
16	Presence of coma	1- Present, 2-Absent
17	Coma bracts colour	1- White, 2-Light green, 3-Green, 4-Light purple, 5-Purple, 6-Voilet, 7-Pink, 8-Golden
18	Flower bracts colour	2-Light green, 3-Green, 4-Light purple, 5-Purple
19	Flower exertion	1-Less exerted, 2- Moderate, 3-High, 4-Very high
20	Flower size	1-Small, 2-Medium, 3-Large, 4-Very large
21	Corolla tube colour	1-White, 5-Purple, 7-Pink, 10- Cream, 11-Pale yellow, 12-Yellow, 13-Bright yellow
22	Corolla main lobe colour	1-White, 5-Purple, 6-Violet, 7-Pink, 9-Rose, 10-Cream, 11-Pale yellow, 12-Yellow, 13-Bright yellow, 14-Greenish white
23	Staminode colour	1-White, 4-Light purple, 5-Purple, 13-Bright yellow
24	Lip shape	1-Three lobed, 2-Suborbicular
25	Lip colour	1-White, 4-Light purple, 5-Purple, 6-Violet, 12-Yellow, 13-Bright yellow
26	Presence of fruit setting	1-Present, 2-Absent
27	Propagation in nature	1-By vegetative means, 2-By seeds
28	Spike longevity or life on plant	Given approximately in weeks
29	Appearance of spike	<1-Satisfactory, 1-Good, 2-Very good, 3-Excellent
30	Fauna affecting the natural population	1- Rats, 2-Wild boars
31	Adaptability to potted and shaded	1-Adapted, 2-Not easily adapted
32	Plant height	cm
33	Spike length	cm
34	Spike width	cm
35	Flower length	cm
36	Lip length	cm
37	Lip width	cm
38	Overall grade in relation to ornamental value of the species	1-9 scale based subjectively on the basis of ornamental value, mainly appearance of spikes and flowers, and adaptability under *ex situ* conditions

Table 3. Descriptor and descriptor states of *Curcuma* species of Western Ghats having ornamental value

1	2	3	4	5	6	7	8	9
S No	Species	Collected	Observed	Distribution	Subgenus	Section	Altitude (m)	Soil type
1	C. *albiflora*	4	1	1,2	Eucurcuma	Nontuberosa	10-600	1,2
2	*C. mutabilis*	4	3	1,2	Eucurcuma	Nontuberosa	40-100	2
3	*C. inodora*	11	6	2,4,5	Eucurcuma	Nontuberosa	10-101	1,2
4	*C. oligantha* Trimen var *oligantha*	6	1	1,2,4	Eucurcuma	Nontuberosa	10-600	1,2
5	*C. cannanorensis* syn *(Oligantha* var. *lutea)*	12	2	1,2	Eucurcuma	Nontuberosa	10-600	1,2
6	C. *karnatakensis*	9	1	2	Eucurcuma	Nontuberosa	100-600	2
7	*C. thalakaveriensis**	4	1	2	Eucurcuma	Nontuberosa	1001	3,2
8	*Curcuma* sp. 1	1	3	1,2	Eucurcuma	Nontuberosa	20-40	1
9	*Curcuma* sp. 3	1	1	2	Eucurcuma	Nontuberosa	>1000	2
10	*Curcuma* sp. 2	2	1	2	Eucurcuma	Nontuberosa	<10	1
11	*Curcuma* sp.4	1	0	2	Eucurcuma	Nontuberosa	601	2
12	C. *decipiens*	6	3	1,2	Eucurcuma	Nontuberosa	20-40	1
13	*C. coriacea*	2	1	1	Eucurcuma	Nontuberosa	100-1000	2
14	*C. pseudomontana*	10	1	1,2,3	Eucurcuma	Nontuberosa	200-1000	2, 3
15	*C. neilgherrensis*	4	1	1,2,3	Eucurcuma	Nontuberosa	>1000	2
16	C. *kudagensis*	7	1	2	Eucurcuma	Nontuberosa	>1000	2,3
17	*C. vamana*	6	4	1	Eucurcuma	Stolonifera	40-100	1,2
18	*C. ecalcarata***	2	1	1	Paracurcuma		10-100	1,2
19	*C. aurantiaca*	13	8	1,2	Paracurcuma		10-800	1,2
		105	40					

1	10	11	12	13	14	15	16	17	18
S No.	Rainfall	Ecological niche	Time of regeneration	Time of senescence	Flowering time	Spike position	Spike size	Presence of coma	Colour of coma bracts
1	3	1,2,3	4,5	11	4,5,6,7,8	3	1	2	
2	3	1,2,3,4	5,6	10,11	4,5,6,7,8,9	3	3	1,2	2,4
3	3	1,2,4	5,6	10,11	4,5,6,7,8	3	3	1	1,5
4	3	1,2,3,4	4,5	10,11	4,5,6,7,8	3	1	2	
5	3	1,2,3,4	4,5,6	10,11	4,5,6,7,8	3	1	2	
6	3	1,2,4	5,6	10,11	5,6,7,8	3	1	2	
7	3	5	4,5	10,11	5,6,7,9	3	1	1	1,2,5
8	3	2,3,4	4,5	10,11	6,7,8	1	1	1	1,5,6
9	2	4,5	5,6	10,11	5,6,7,8	3	2	1	1,7,8
10	3	3	5,6	10,11	5,6,7,8,9	3	2	1,2	4
11	3	6	5,6	10					
12	3	2,3,4	4,5	10,11	6,7,8	1	1,2	1	1,2,4
13	3	5	4,5	10,11	4,5	2	2	1	1,2,4
14	1,2,3	5	4,5	10,11	7,8,9	1	2	1	1,2,4
15	1,2,3	7	4,5	10,11	4,5	2	1,2	1	4,5,7
16	3	7	4,5	10,11	4,5	2	1	1	2,4
17	3	1,2	4,5	10,11	6,7,8	1	<1	1	2
18	3	1,2,4,8	4,5	10,11	6,7,9	1	2,3	1	1,2,7,9
19	3	1,2,4,8	4,5	10,11	6,7,10	1	2,3	1	1,2,7,9

1	19	20	21	22	23	24	25	26	27
S No.	Flower bract colour	Flower exertion	Flower size	Corolla tube colour	Corolla colour	Staminode colour	Lip shape	Lip colour	Fruits setting
1	2	4	1	10	1,7	1	1	1,12	1
2	2,4	4	3	10	1,13	1,12	1	1,12	1
3	2,5	3	3	5	5,6	4,5	1	4,5,6,12	1
4	2	4	1	10,11	14,5	1	1	1,12	1
5	2	4	1	11	11	13	1	13	1
6	2,5,	4	1	11	10,9	1	1	13	1
7	2,4,	4	1	12	11	13	1	13	1
8	1,5	3	1	5	5	13	2	13	1
9	2,7	3	2	12	12	13	1	13	3
10	3,4	3	2	1,7	1,7	1	1	13	1
11									
12	1,2,4	2	2	5	5	13	1	13	1
13	2,4	2	2	13	13	13	1	13	3
14	2,4	2	2	12	11, 5	13	1	13	1
15	2,5,7	3	2	11	12	12	1	12	1
16	2,5	3	1	11	11,5	13	2	13	1
17	2	1	1	10	10	12	2	12	1
18	1,2,8	2	3	11	12	13	1	13	1
19	1,2,8	2	3	11	12	13	1	13	1,3

1	28	29	30	31	32	33	34	35	36	37	38	39
S.No.	Propagation	Spike survival	Appearance of spike	Biotic factors	Adaptability to pots	Plant height	Spike length	Spike width	Flower length	Lip length	Lip width	Grade
1	1,2	1	2	1,2	1	58.0	7.0	6.0	5.0	1.6	1.8	8
2	1,2	>2	2	1,2	1	78.0	8.0		6.5	1.	1.8	9
3	1,2	>2	3	1,2	1	77.0	14	8.5	5.5	2.0	1.8	9
4	1,2	1	3	1,2	1	43.0	11.0	6.0	7.0	2.0	1.8	8
5	1,2	1	3	1,2	1	60.0	5.8	2.7	5.7	1.6	1.5	8
6	1,2	>2	1	1,2	1	52.0	9.0	7.5	7.6	2.6	2.2	7
7	1,2	2	1	1,2	1	83.0	18.0	5.0	6.1	2.3	1.7	7
8	1,2	2	1	1,2	1	51.5	10.0	4.2	5.0	1.5	1.8	7
9	1	>5	3	1,2	1	67.5	6.0	6.2	5.0	1.5	1.5	8
10	1,2	2	3	1,2	1	70.0	12.0	9.0	7.0	1.7	1.5	8
11				1,2	1							
12	1,2	>2	1	1,2	1	60.2	7.5	4.7	5.3	3.3	1.5	7
13	1	>2	1	1,2	1	55.0	5.0		6.0	2.0	2.0	6
14	1,2	>2	1	1,2	1	48.0	17.0	6.5	4.8	1.8	1.7	6
15	1,2	>2	1	1,2	2	65.0	10.5		5.7	2.2	2.5	7
16		<2	1	1,2	2	44.0	58.0	2.7	5.2	1.6	1.5	6
17	1,2	>2	<1	1,2	1	72.3	5.0	3.5	2.2	0.8	0.7	5
18	1,2	>3	1	1,2	1	58.0	5.4	6.2	5.3	1.7	1.5	8
19	1,2	>3	1	1,2	1	55.0	7.0	6.0	5.2	1.7	1.4	8

* Synonym of *C. kudagensis*; ** Synonym of *C. aurantiaca*

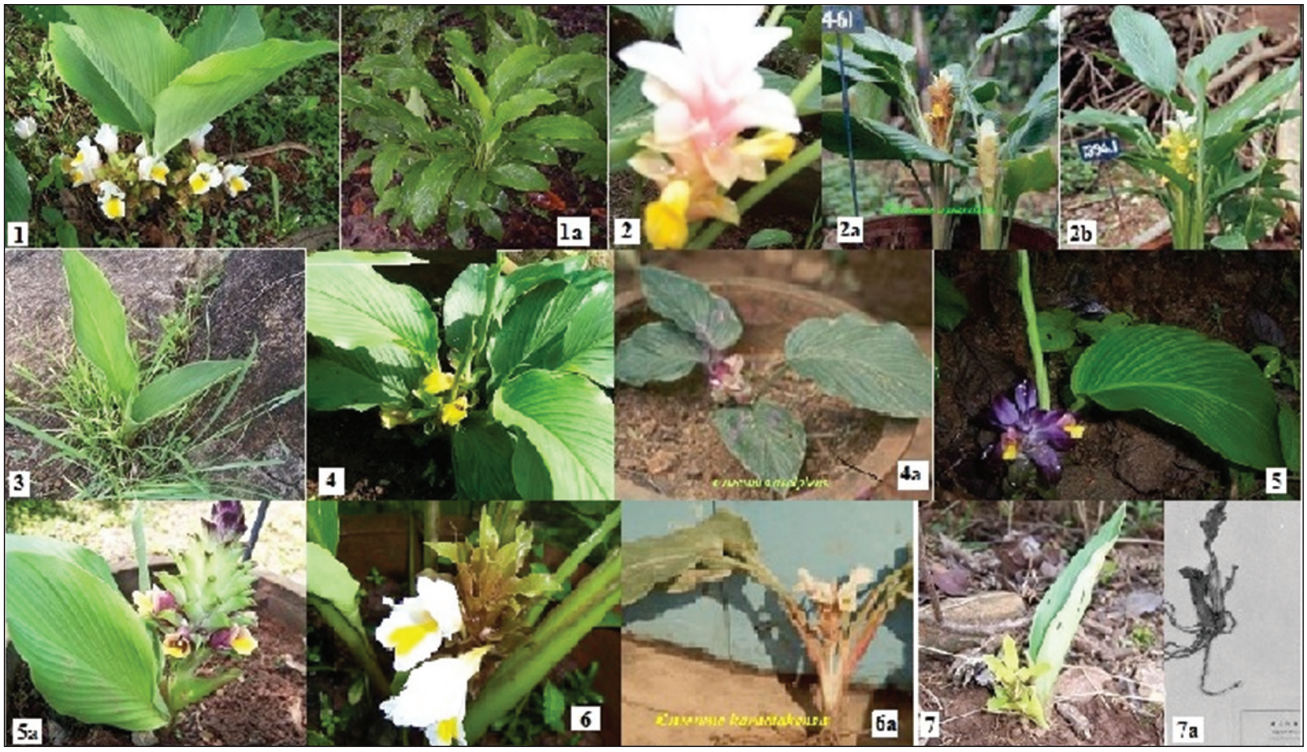

Fig. 1a.1-*C. albiflora*, 1a-*C. albiflora* (vegetative phase), 2, 2a, 2b-*C. aurantiaca* syn. *C. aurantiaca*, 3-*C. coriacea* (juvenile plant), 4 and 4a-*C. decipiens* (variants), 5 and 5a-*C. inodora* with varying colour of bracts and perianth, 6 and 6a-*C. karnatakensis*, 7 and 7a-*C. kudagensis*

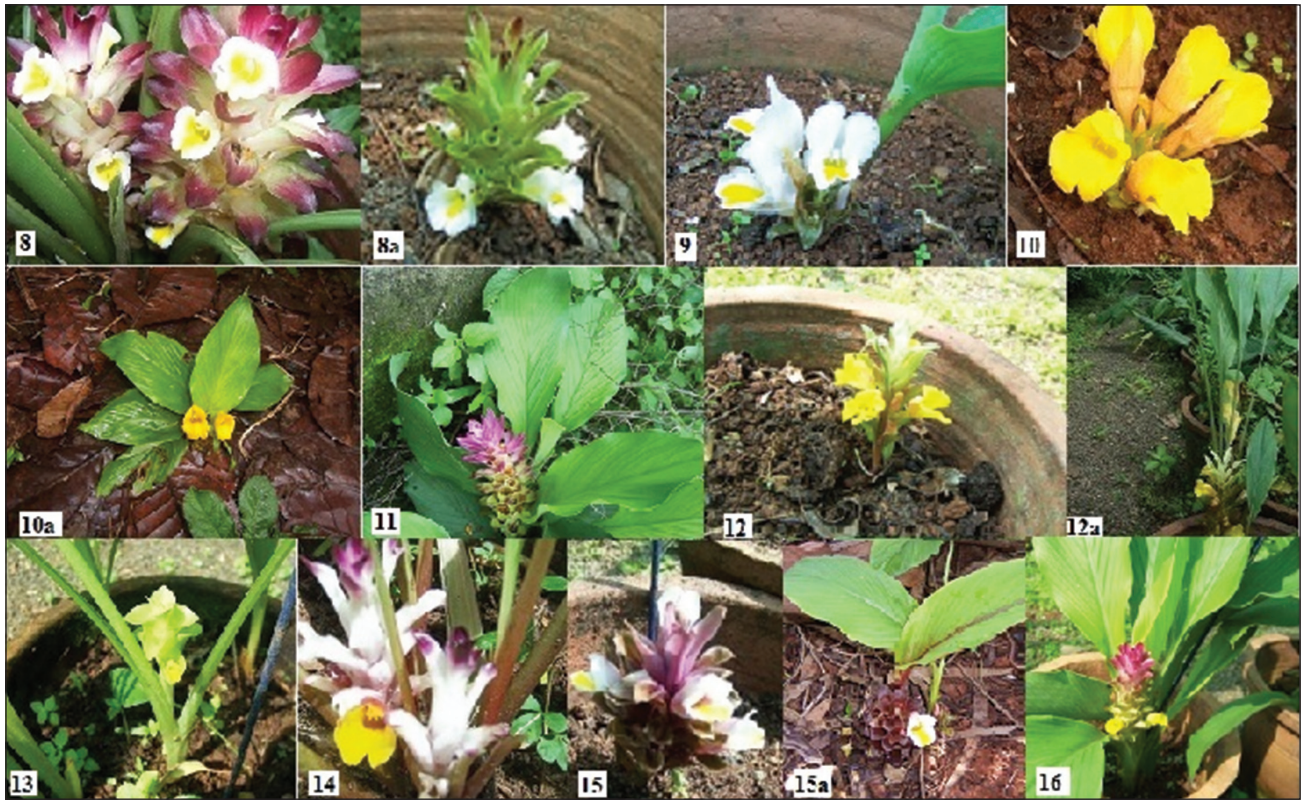

Fig. 1b.8 and 8a-*C. mutabilis*, 9-*C. oligantha*, 10 and 10a-*C. cannaniorensis*, 11-*C. pseudomotana*, 12 and 12a-*C. thalakaveriensis*, 13-*C. vamana*, 14-*Curcuma* sp.1, 15, 15a-*Curcuma* sp.2 and 16-*Curcuma* sp.

Table 3. Collections maintained in pots

Species	Collector No.	IC Number
Curcuma oligantha var. *oligantha*		248154, 329264
C. oligantha var. *lutea*		313105
C. albiflora		329329
C. mutabilis	A674	313104, 324420
C. inodora	VBR/01-1, V/04-38	248332, 405356, 248212, 427565
C. thalakaveriensis		313116
C. decipiens		248185, 322301
C. coriacea		210410A
C. karnatakensis		427581
C. aurantiaca	VJ/99-102	329264, 324455, 324807, 266541, 136936, 248187, 266516
Curcuma sp. 1	V/03-178	88952B
Curcuma sp. 2 (s)		329331
Curcuma sp. 3 (f)		329287
C. vamana		406444, 324067, 427596, 337513

C. oligantha var. *oligantha* (1), *C. oligantha* var. *lutea* (2), *C. albiflora* (1), *C. coriacea* (1), C. *thalakkaveriensis* (1), *Curcuma* sp. 1 (3v), *Curcuma* sp. 2 (1f), *Curcuma* sp. 3 (1s) and *Curcuma* sp. 4 (1CTCRI) are maintained in the pots under 25% shade. Also, availability of sample planting materials for research purpose is also furnished. Problems and future prospects of the genetic resources of the genus having potential for use as ornamentals are also discussed.

Result and Discussion

A total of 40 accessions belonging to 15 species (excluding three synonyms as per Table 1) and 3 unidentified entities were observed. A total of 38 parameters pertaining to passport information and qualitative characters are furnished in Table 2. Out of this, one unidentified entity *Curcuma* sp. 4 did not flower and was not considered here for its ornamental value.

C. oligantha Trimen with two varieties (now revised as *C. oligantha* Trimen and *C. cannanorensis* (Table 1) with two flowering seasons in a year, central and lateral spikes, absence of coma bracts, highly exerted, showy and large flowers with white in the first and bright yellow staminodes in the second, respectively and seed setting and good adaptability to potted conditions has wide distribution from North Kerala to Goa and borders of Maharashtra. These varieties possess an excellent potential for development as a tropical ornamental (9 grade) species. However, the short span of the spike in bloom requires further studies to improve them. *Curcuma* sp. 1, 2 and 3 identified as separate entities having some morphological similarities with *C. decipiens*, *C. albiflora* and *C. pseudomontana*, respectively, in some characters are also potential candidates (grade 8). Out of these, species 2 and 3 with very showy spikes and, lateral and central spikes during end of summer and main growing season and with fruit and seed setting may also be potential candidates for development as an ornamental species. *Curcuma* sp. 3 having a long duration of spike bearing and with light pinkish and golden coma and flower bracts bearing yellow showy flowers may be worth looking into. This has very restricted distribution in and around Kudremukh hills in Karnataka. Further exploration and collection in other parts of Karnataka at higher elevations may also be rewarding. *Curcuma* sp. 1 sharing the niches of *C. decipiens* in central Kerala in farmer's compounds, disturbed forests and roadsides on hard laterite soils under partial shade has small to medium central spikes, purple violet tipped coma and flower bracts, exerted flowers with bright yellow staminodes, seed setting, and moderate adaptability to potted condition. This was described as *C. vellanikkarensis* by Velayudhan *et al.* (1996) but is yet to be validated as a species. This entity is less robust and more erect than *C. decipiens* occurring in similar niches which also deserves attention as an ornamental species. The difference between *Curcuma* sp. 1 and *C. decipiens* is in the former as compared to elliptic lanceolate leaves with acute base ovate-elliptic leaves with rounded to cordate base and the extended flowering in latter. The second entity *i.e. Curcuma* sp. 2 is the strikingly beautiful plant having very restricted distribution in gardens and orchards in Udupi of Karnataka state. It has very interesting features such as erect and thin plant type, purple leaf midrib and light purple tint on the base of young leaves, exerted lateral and central spikes without coma bracts, purple flower bracts, exerted and large flowers with purple violet corolla and white large staminodes with bright yellow median band on lip.

C. karnatakensis and *C. mutabilis* are two related species as these have spreading semi-erect or horizontal leaf disposition, large elliptic ovate leaves, prominent veins on the leaves, both central and lateral spikes, absence of coma or if present, very obscure and even degenerated in the latter. The former occur in Karnataka especially in Dakshin and Uttar Kannada districts of Karnataka and the later in Palakkad and Malappuram districts of Kerala. These are adapted to lower foothills and occur very seldom in the midlands and never found in coastal areas. Both have white staminodes with rose tint in the former. Sabu (2006) gave two different types with white and yellow satminodes in the later. Both have good ornamental value (8 grade). *C. neilgherrensis*, *C. kudagensis* syn. *C. thalakaveriensis*, *C. coriacea* and *C. pseudomontana* are adapted to open grasslands in Ghats and have comparatively lesser showy spikes as compared to others. All have larger spikes, moderately exerted flowers. However, *C. thalakaveriensis* is more beautiful with tall, thin plants, narrow lanceolate and thicker leaves, very long thin inflorescences bearing flowers with bright yellow staminodes, lips, varying colours of coma bracts is of more ornamental value. Hence this has been treated here as a separate entity. Survey in certain pockets of Ghats at elevations above 1400m has indicated that the population of *C. neilgherrensis* and *C. kudagensis* are dwindling due to habitat destruction. *C. coriacea* has been found to occur at two places. *C. thalakaveriensis* in Thalakkavery of Coorg and in Kudremukh of Chikmagalur in Karnataka. *C. pseudomontana* is very common at 1000 m elevation in pockets of Ghats extending to Pockets in Kolli Hills in Tamil Nadu. Further, adaptability of these species to potted condition under shade in plains is very difficult especially in the case of *C. neilgherrensis* and *C. kudagensis* which usually occur in shola grasslands. Hence, low temperature and mist during the growing season followed by cold spell and then by summer season is needed for better growth of the species. Most of them are adapted to rocky and stony soils in grasslands, which are at times, subject to phenomenon of summer fire. *C. vamana* having the smallest plant type with very small rootstock giving forth branched stolons and bearing smallest green spikes and small yellow flowers is least valuable as an ornamental. However, it is adapted to very shady areas in low altitudes hence can also be considered for development as an ornamental in gardens along with other species. *C. ecalcarata*, a species reported from the coastal areas, midlands and mountainous areas at lower altitudes is similar to *C. aurantiaca* van Zijp in all respects. These entities treated here as separate entities are highly varying in plant height, leaf shape, coma and flower bract colours and, with bright yellow staminosdes and corolla. Both seed setting and non-seed setting plants have been found to occur in nature.

Out of a total of 40 accessions observed, based on the overall grade assigned in relation to ornamental value *C. mutabilis* and *C. inodora* with 3 and 6 accessions, respectively have topped the list with the highest score of 9 followed by *C. albiflora*, *C. oligantha* var. *oligantha*, *C. oligantha* var. *lutea*, *C. aurantiaca*, *C. ecalcarata*, *Curcuma* sp. 2 and 3 with a score of 8, and *C. karnatakensis* and *C. thalakaveriensis* with a score of 7 are also ahead of other species such as *C. decipiens*, *C. coriacea*, *C. pseudomontana*, *C. neigherrensis*, *C. kudageneis* and *Curcuma* sp.1with a score of 6. *C. vamana* had the lowest score of 5. The results indicated clear cut difference between C. *kudagensis* and *C. thalakaveriensis* which is presently considered as a synonym of the earlier.

All the species reported in this communication occur in areas with medium to high rainfall, received mostly from South West monsoon and, to a lesser extent from North East monsoon. Total annual precipitation varies from 1500 mm in Bababudangiri hills to over 4000 mm in Agumbe Ghat in Karnataka. Soil, which is acidic in nature, varies from fine sandy in coastal plains on the West Coast to laterite in midlands and plateaus, and sandy loam in forest areas. Altitude generally varies from 5 m to as high as 2000 m and the latitude from $10^{o}6$ to $16^{o}5$ N lat. and from $72^{o}5$ to $76^{o}4$ E long. where, there is a grater concentration of species without sessile tubers. Maximum concentration of the species can be noticed in North Kerala, Coastal and hilly Karnataka, Goa and Southern districts of Maharashtra and this large area can be considered as the hot-spot for *Curcuma* spp. falling under aforementioned three sections.

Genetic Erosion

Genetic erosion of various species under the treatise is possible in case of highly niche specific population which is either very small or it remains as individuals. There is no threat for many of the species such as *C. aurantiaca*, *C. oligantha*, *C. cannanorensis*, *C. inodora*, *C. mutabilis* and *C. karnatakensis* having very frequent occurrence of large populations in pockets. Some of the species from Karnataka grow rather luxuriantly along the

highways in grassy slopes, under grasses and bushes, and sharp edges of ghat roads and in grasslands on stony soils. However, species such as *C. thalakaveriensis* and *C. kudagensis* having very restricted occurrence in pockets of hilly grasslands in Kudremukh hills, Thalakavery and Bababudangiri hills in Karnataka are under threat of erosion due to habitat destruction. *C. neilgherrensis* and *C. pseudomontana* having wider distribution in sholay grasslands and lower tropical grasslands respectively in Western Ghats are also facing threat of erosion. Ecological niche of *C. vamana*, the only species under the section *Stolonifera* from India, is confined to specific locations under disturbed forests at lower elevations of foothills and midlands in Central Kerala and it is under threat. Similarly, *C. mutabilis* population noticed in lower slopes and along disturbed forest roads in Malappuram and Palakkad districts of Kerala faces threat due to deforestation and plantation activities.

Future Problems and Prospects

Several species such as *C. oligantha*, *C. inodora*, *C. albiflora*, *C. karnatakensis*, *C. mutabilis*, *C. thalakaveriensis* and other entities such as *Curcuma* sp. 1, 2 and 3 have very high potential for their improvement as ornamentals in tropics. Before undertaking any serious attempt in this direction, taxonomic identity of the unidentified entities is a problem as their population is very thin and is represented by few plants at a site posing problem in validating these entities as new species. They flower two times in a year and bear stunningly beautiful spikes and flowers. *Curcuma* sp. 3, the only entity having very long flowering duration, appears to be an ideal genetic base for transfer to others, bearing more beautiful inflorescence. Detailed studies on adaptability and cultural techniques based on the ecology, physiology, seed setting and germination, studies on vegetative regeneration and mass propagation, cultural techniques are to be immediately worked out in these species as done by Kuehny *et al.* (2002) in some ornamental gingers. These species are adapted to different temperature regimes, altitudes and rain fall pattern in tropics and may be useful in developing exquisitely beautiful garden plants under different climatic regimes. Use of the spikes as cut flowers in some of these may be worked out as the flowers remain only for a day or two but flowers are produced continuously for a period varying from one week to over one month.

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