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Genetic diversity study of Odisha landraces of blackgram based on agromorphological and RAPD markers for YMV resistance

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ABSTRACT

Vigna mungo (L.) Hepper commonly known as black gram is an important pulse with high protein value cultivated through out India. Ten genotypes of Odisha and three released check varieties of black gram were analyzed for genetic diversity using agronomical characters and RAPD markers. Yellow Mosaic Virus (YMV) % showed significant variation of 1% to 85% of infection among the black gram genotypes. Cluster analysis of agronomic characters showed sub-cluster-I with high (~3.0% YMV) and sub-cluster-II with moderate resistance (~15.5% YMV) forming cluster-I. The highly susceptible TAU-1, Kaska local and Balangir local separating as cluster-II. A total 47.98% bands were polymorphic out of the 189 RAPD bands amplified. RAPD analysis showed cluster-I and cluster-II consisted of 10 genotypes and 3 genotypes respectively. Highly susceptible (sub-cluster-I) and moderately susceptible (sub-cluster-II) formed a cluster-I. All the high resistance four varieties namely Deogan local, Cheripalli local, Pendibari local, Kendrapara local (1% to 3% YMV) formed cluster II showing resistance and grain yield like of TU942, a released check variety. Thus, RAPD could distinguish a separate resistance varieties of Odisha genotypes recommended for breeding programme. Genetically heterogeneous group sub-cluster II of cluster I genotypes might the potential breeding partner to cross with susceptible varieties of sub- culture I of cluster I for black gram genetic improvement.

1. Introduction

The cultivation of black gram in India was recorded from ancient times and is one of the most highly prized pulses of India. It is very widely used in Punjabi cuisine and is often referred to as *maah di daal* in the native language by Punjabis. The coastal region in Andhra Pradesh is famous for black gram. The Guntur District ranks first in Andhra Pradesh for the production of black gram. Black gram has also been introduced to other tropical areas such as the Caribbean, Fiji, Mauritius, and Africa, mainly by Indian immigrants. It is grown in different agro-ecological cropping systems that occupy 5.44 mha in India with a an annual production of 3.56 mton having an average yield of 653 kg ha^{-1} during 2017-2018 (Anonymous, 2018). Black gram is a good source of protein (20.8 to 30.5%) and carbohydrate (56.5 to 63.7 %) and is a rich source of dietary protein in south Asian people (Bhaskara Reddy *et al.*, 2015, Suvan *et al.*, 2020).

Yellow Mosaic Disease (YMD) inflicts heavy yield losses in five economically important food legumes including black gram (*Vigna mungo*), soybean (*Glycine max*), mungbean (*Vigna radiata*), French bean (*Phaseolus vulgaris*) and moth bean (*Vigna aconitifolia*). Black gram, which is mainly cultivated in India, Myanmar, Thialand, Phillipines and Pakistan, is highly prone to YMD. The disease is caused by representative species of the genus *Begomovirus*. Based on several studies, it has been confirmed that at least two virus species causing YMD are prevalent in Indian sub-continent. One of these species, Mung-bean Yellow Mosaic India Virus (MYMIV) is commonly occurring in northern part of Indian sub-continent, while Mungbean Yellow Mosaic Virus (MYMV) is mostly

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confined to peninsular region of India (Malathi and John, 2008). Although, Madhya Pradesh, Rajasthan and Bihar states of India produce a certain amount of black gram, but yield potential of this crop is incredibly low and is overburden with a variety of diseases. Blackgram is susceptible to diseases like the yellow mosaic virus, powdery mildew, and *Cercospora* leaf spot. Crop loss due to powdery mildew (Singh, 2080). Mungbean yellow mosaic virus (MYMV) disease can cause severe yield losses which infects a number of legumes like french bean, black gram, pigeon pea, soybean and mung bean. The insect vector transmitted this disease by sweet-potato whitefly (*Bemicia tabaci*). It causes annual yield loss of 300 million USD damaging young leaves with faint yellow specks/ spots, flowers and pods (Malathi and John, 2008, Behera *et al.*, 2020). The dominant warm tropical climate in India favors year-round survival of the polyphagous whitefly vector in overlapping host range (Borah and Das Gupta, 2012) but the information in the Odisha context is very scanty. Management of this disease is the biggest challenge and research priority in MYMIV for mungbean crop is very important globally (Mishra *et al.*, 2020). Thus, evaluation of genotypes having resistance against MYMV is needed for successful breeding and improvement. Only a few genes have been reported which can be used for breeding begomovirus resistance and its use to introgress into popular black gram varieties. Hence, needs for genetic diversity analysis of natural YMV-resistant genotypes is needed for crop protection and improvement (García-Neria and Rivera-Bustamante, 2011). Hence, molecular markers guided breeding strategy for resistant genes is very important in increasing the accuracy and potency of choice of suitable parents in black gram breeding program.

The molecular genetic mechanisms controlling the organization and evolution of genomes of *Vigna* species are not clearly understood. Black gram is a self-pollinating plant and mostly diploid (2n=2x=22) having genome size of ~ 574 Mbp (Arumuganathan and Earle, 1991). RAPD and ISSR marker analysis for genetic diversity and SCAR marker for marker-assisted breeding in black gram and its use as resistance against YMV was reported earlier (Selvi *et al.*, 2006; Souframanien and Gopalakrishna, 2006, Prasanthi *et al.*, 2011, Vishalakshi *et al.*, 2017). RAPD and SSR analysis of different genotypes of black gram (Lavanya *et al.*, 2008; Vyas *et al.*, 2018, Veni *et al.*, 2019) and mungbean (Kaur *et al.*, 2018, Tripathy and Das, 2018) reported high genetic variation in Indian accessions. Crossability studies among cultivated black gram varieties on the basis of pollen fertility along with SSR markers was reported (Tondonba *et al.*, 2018). AFPL mapping of Indian germplasm showed high genetic variability even in a narrow agroclimatic zone (Sivaprakash *et al.*, 2004; Gupta and Gopalakrishna, 2009). Studies on disease-resistant gene have indicated a high level of polymorphism and presence of SSRs at certain loci (Yu and Saghai Maroof, 1996). Although genetic diversity of black gram through microsatellite markers was reported in different genotypes with little information on Odisha germplasm **(**Suvan *et al.*, 2020; Behera *et al.*, 2020; Sreethi Reddy *et al.*, 2008, Wang *et al.*, 2012, Naik *et al.*, 2017). Despite the efforts to spread improved released varieties by Indian Council of Agricultural Research, New Delhi of black gram varieties, local landraces are largely grown in Odisha for their wider adaptability. Such landraces have played an important role in the local food security and sustainable development of agriculture and thus use of genetic resources for genetic improvement in very important. Assessment of genetic diversity can provide information on the genetic distinctiveness. Thus, the present study deals with characterization of 10 landraces of black gram from Odisha and 3 released varieties were characterized for agro-morphological characters including YMV occurrence percentage clubbed with RAPD markers to investigate the genetic diversity, for the potential use of Odisha landraces to use as breeding partner in develop YMV resistant high yielding black gram varieties.

2. Materials and methods

2.1. Plant materials

Ten black gram landraces of Odisha and four check varieties of India were grown in on-field trial for study of adaptive variations during rabi seasons in two successive years (November, 2017 and 2018) at the Department of Botany, Utkal University, Odisha, India (Table 1). Seeds were treated with 0.002% fungicides for 2 h and showed in the plot and materials were grown in randomized block design. Agronomic practices were followed through various stages of crop growth with a basal dose of NPK (20 kg N + 40 kg P_2O_5 + 20 kg K_2O per ha) before seed showing and 7 to 10 interval watering. Agronomic characters were were recorded and depicted in (Table 1).

2.2. Agronomic parameters

The yield attributes, morphological and yield parameters of all genotypes of black gram were recorded by selecting randomly five plants in each replication for each genotype. Observation on days to 50% flowering and days to maturity was recorded on a plot basis. The agronomic characters recorded are shown in Table 1. Plant height, total number of main branches per plant, the number of days for pod maturity, the number of fully matured pods, the number of seeds per pod, the weight of grains per plant and 100-seed weight in (g) was taken randomly. YMV % scoring was done in different genotypes using a 0-9 scale (Lal *et al.*,

2005). Tolerance index was calculated as high tolerance (1-10% infection), moderately tolerant (21-30% infection) and moderately susceptible (31-50 % infection) and highly susceptible (>50% infection).

2.3. DNA extraction and quantification

DNA was isolated from leaves using CTAB method (Williams et al. 1090). Young leaves were ground in liquid nitrogen using mortar and pestle and suspended in CTAB extraction buffer [100 mM Tris HCl (pH 8.2), 20mM EDTA, 0.5M NaCl, 2% CTAB and 2% beta-mercaptoethanol] and was incubated in a water bath at 60°C for 1½ h. An equal volume of chloroform:isomayl alcohol was added after cooling down to room temperature; the mixture was emulsified for 15 min with gentle mixing and centrifuged at 10, 000 rpm for 20 min. The top aqueous phase was transferred into a new tube and DNA was precipitated with S! of its volume of chilled isopropanol. The thread of DNA was pooled out with a sterile glass loop or pellet was washed within 70% ethanol after centrifugation at 10,000 rpm for 10 min. The pellet was dried in a vacuum concentrator and dissolved with $T_{10}E_1$ (10 mM Tris HCl, 1 mM disodium EDTA, pH 8.0) and treated with RNase A (10 mg ml^{-1}). The DNA was precipitated with an equal volume of ethanol with 3 mM sodium acetate, air-dried, and dissolved in $T_{10}E_1$ buffer; concentration of DNA was checked in nanodrop machine. The DNA was diluted into a final concentration of 25 ng μl^{-1} using $T_{10}E_1$ buffer for use as a template for PCR amplification with different primers (Table 2).

2.4. PCR reaction and RAPD analysis

Randomly amplified polymorphic DNA (RAPD) profiles were generated by using different primers following the polymerase chain reaction (Saghai-Maroof et al. 1984). Each amplification reaction mixture contained 25 ng of template DNA, 200 µM of each dNTPs, 25 ng of primer, 0.5 unit of Taq DNA polymerase (Bangalore Genei Pvt. Ltd., Bangalore, India), and 10 × PCR assay buffer (50 mM KCl, 10 mM Tris HCl, 1.5 mM $MgCl_2$, pH 9.0) in a reaction volume of 25µl. The PCR reaction was carried out in a Gene amplification PCR system thermal cycler (GENEAMP-9700; Applied Biosystems, USA) with an initial denaturation at 94°C for 5 min, followed by 45 cycles of denaturation at 94°C for 1 min, annealing at 42°C for 1 min, and an extension at 72°C for 2 min; then a final extension at 72°C for 8 min and the amplification were stored at 4°C. The amplified products were separated in 1.5% agarose gel containing 0.5 ìg ml^{-1} ethidium bromide in TAE buffer (40 mM Tris-acetate, pH 8.0; 2 mM EDTA) at a constant 55 V for 60 to 80 min. A gel loading buffer [20 % (w/v) sucrose; 0.1 M EDTA, 1.0 % (w/v) SDS; 0.25 % (w/v) bromophenol blue; 0.25 % (w/v) xylene cyanol] was used as tracking dye. Amplified DNA fragments were visualized by staining gel with ethidium bromide solution and images were captured using a gel documentation system (Geldoc XR system, Biorad, USA) and photographed. The sizes of the amplified products were determined using Gene ruler 100 bp DNA ladder as the size standard to determine the DNA fragments.

2.5. Data analysis

Mean data, standard deviation and standard error were calculated for all the replicated agronomic and YMV% data. The coefficient of variation was calculated to compare the degree of variation from one data set value to the other data set of various genotypes values applying the formula (standard deviation/mean) × 100 to get a percentage value. ANOVA analysis was done among different agronomic parameters as well as YMV occurrence percentage in the field. The mean data of agronomic characters collected against all the genotypes of black gram were used as set of variables for similarity matrix. Phylogenetic analysis and cluster analysis were made using NTSYS version 1.7, Exeter Software, New York, USA and neighbor-joining methods were adapted (Rohlf, 2008). The visualization of presence or absence of the bands was taken into consideration in RAPD analysis. Amplified bands of RAPD primers were scored as present (1) or absent (0) in each landraces for each set of primers and only clear and reproducible bands were used in this study. A binary matrix was obtained from the RAPD profile using NTSYS-pc programme (Rohlf, 2008). Binary matrix was transformed into a similarity matrix using Jaccard's coefficient. From this matrix a phylogenetic dendrogram was obtained by cluster analysis following the method of Unweighted Pair Group Method with Arithmetic Mean (UPGMA) (Sneath and Sokal, 1973).

3. Result and discussion

3.1. Variation in agronomic characters

The plant height varied from 15.4 cm in Balangir local to 22.2 cm in Sudhasarangi local which is at per with released check variety Pundibari local. Genotype classification on height found semi-dwarf (~15.0 to ~18.8 cm) in 7 landraces and rest varied from ~21.0 to 24.0 cm (Table 1). The mean branch per plant found lowest in TAU-1 (2.1) and highest in Balangir local and Tigiria local (3.2cm). The days of 50% flowering found maximum in Deogaon local (88 days) which was found like a check variety TU 942. The pod length recorded showed a minimum of 3.9 cm in Deogaon local to a maximum of 5.5 cm in LBG-17. The number of seeds per pod found varied from 6 per pod in Balangir local and Deogaon local to 6.6 in Kendrapada local which found at per of Pundibari local, a check variety. Seed yield per plant

also varied from 2.955 g in Balangir local to ~4.6 g per plant in TU942 (a check variety) and 100 seed weight was 1.391 in Kaska local to 5.681 was recorded in a check variety Pundibari local (Table 1). Sudhasarangi local showed 100 seed weight of 5.05 g which was found similar to a check variety LBG-17 a susceptible released variety. The mean YMV was recorded as 25.46%. The genotypes found with high resistance with little infection in the field condition from ~1.0 to 3.0 % of infection in Odisha varieties like Kendrapada local, Cheripalli local, Deogaon local, which were as per the released check varieties like Pundibari local, TU942 with high resistance. The moderate resistant genotypes were Tigiria local (~8 %) and LBG-17 (15 %) infection (Table 1). The moderate susceptible genotypes recorded (Mohona local, Shergarh local) with 30% infection and highly susceptible with 42 to 85% infection (Sudhasarangi local, Balangir local, Kaska local) besides a check variety TAU-1 having 85 % infection.

An insight into phenotypic markers' analysis indicated that there was a distinct pattern of grouping of black gram genotypes based on agronomic characters. Morphological characters could form two clusters with high number of YMV resistance check varieties and landraces of Odisha in cluster-I. The high disease susceptible varieties formed cluster-II i.e. Kaska local and Balangir local with ~60% of disease incidence (Fig. 1). Such type of grouping and comparison of released YMV resistant variety although not reported earlier in black gram genotypes of Odisha except few reported in other genotypes of black gram and in other crops too (Dikshit et al. 2013) which is in accordance to our result. The yield potential and other agronomic characters showed that high to moderate resistance variety of Odisha like Kendrapada local having 5.89 g per 100 seed weight compared to released resistant check variety TU942 with 4.49 g seed weight per 100 seed which might be suitable for breeding purpose with susceptible varieties of Odisha.

3.2. RAPD marker derived phylogenetic analysis

Amplification with RAPD primers showed out of the 43 tested generated 189 unequivocal scorable DNA fragments out of which 84 found polymorphic (Table 2, Fig. 2). A total of 20 primers were amplified out of 43 primers tested that exhibited a wide range of variation with 47.98% of polymorphic bands. RAPD markers like 475 bp found monomorphic in OPA08 primer. YMV resistant genotypes like Deogaon local Shergarh local showed 550 bp marker in OPA-8 marker (Fig. 2). Likewise, OPN-04 showed 600 bp and 650 bp markers in LBG-17 and TU-942 check variety (Fig. 2). Cheripalli local, Kendrapada local highly resistant variety could produce some marker band of ~ 670 bp in OPF-12 primer. The moderately resistant variety Mohana local and Sudhsarangi local showed ~ 1200 bp marker in OPN-04 primer (Fig. 2).

Dendrogram constituted with RAPD markers showed a single common ancestry those basically formed cluster-I, and cluster-II forming a distinct group with the majority of moderate to highly susceptible varieties in cluster-I (Fig. 3) while cluster-II formed all the highly resistant landraces of Odisha (1.0 – 3.0% disease incidence) with resistant check varieties like Pendibari local and TU942. Cluster-I formed highly susceptible genotypes as a single group forming sub-cluster-I with 60 to 85% disease incidence in the field. In Odisha condition TAU1 was not able to show its resistance as release variety. Moderately susceptible varieties formed sub cluster-II with a range of YMV resistance from 8.5% in Tigiria local to 42% in Sudhasarangi local. Thus, local varieties like Kendrapara local, Deogaon local and Cheripalli local found highly YMV resistant and formed cluster-II along with check varieties Pendibari local and TU 942 could be used for breeding purpose with other genetically distinct groups (Fig. 3). So, RAPD markers have been used in many instances to assess the genetic variability in genetic resource utilization which is in accordance with our earlier report in black gram (Tripathy and Das, 2018) and other crops (Panigrahi *et al.,* 2015; Shelke and Das, 2015; Sahu *et al.*, 2016). It was evident from the fact that black gram landraces belong to different agro climatic-zones grouped into the same phylogenetic cluster. Powdery mildew resistance loci in mungbean was mapped earlier (Humphry *et al.*, 2003, Gupta *et al.*, 2013) in other genotypes and SSR polymorphism recorded in some Odisha genotypes (Behera *et al.*, 2020) is supported our findings in RAPD polymorphism. It was evident that, narrow genetic variability exists in sub cluster-I and sub cluster-II of cluster-I. High genetic variability of cluster-II with YMV resistance of local landraces found suitable for use in breeding with susceptible varieties to improve yield and YMV resistance. The established genotypes TU942 and Pendibari local further confirm their resistance in the ecological condition of Odisha and formed a distinct cluster-II which can be used for breeding with susceptible varieties of local genotypes of Odisha belongs to cluster-I. BAC and EST library development might be important for gene-based markers analysis (Miyagi *et al.*, 2004; Galeano *et al.*, 2009). A low level of DNA polymorphism was recorded earlier in black gram by (Gupta *et al.*, 2013) also in accordance with our study in genotypes of Odisha might be due to a narrow genetic base with less genetic diversity (Kumar *et al.*, 2011). Identification of a number of YMV markers as described in the result section is in accordance with the discovery of a 445 bp marker linked to the YMV tolerant gene in black gram variety TU942 and *V. mungo* var. *silvestris* using specific

Table 1

Different agronomical characters and YMV% in 13 genotypes of black gram.

Sl. No.	Genotypes	PH (±S.E.)	BP (±S.E.)	DF (±S.E.)	DM (±S.E.)	CP (±S.E.)	PP (±S.E.)	PL (±S.E.)	SP (±S.E.)	SY (±S.E.)	SW (±S.E.)	YMV% (±S.E.)
1	Balangir local	15.4±0.95	3.2±0.08	37±0.07	77±0.04	3.5±0.09	15.4±0.24	4.2±0.02	6.0±0.05	2.955±0.14	3.976±0.10	60.0 ±1.45
2	Cheripalli local	18.4±0.53	2.7±0.12	37±0.19	77±0.09	4.2±0.05	16.6±0.24	4.6±0.07	6.1±0.02	3.887±0.11	2.872±0.05	2.0 ±0.36
3	Deogaon local	16.3±1.02	2.0±0.31	38±0.15	88±0.03	3.4±0.08	13.2±0.45	3.9±0.02	6.0±0.08	3.384±0.15	3.151±0.10	3.0 ±0.09
4	Kaska local	16.2±0.85	2.1±0.09	38±0.71	77±0.08	3.5±0.03	12.6±0.13	4.8±0.04	6.5±0.02	2.990±0.14	1.391±0.06	60.0±2.15
5	Kendrapada local	24.2±1.35	2.3±0.05	37±0.08	77±0.03	6.1±0.07	22.6±0.21	4.6±0.07	6.6±0.05	3.886±0.11	5.897±0.06	1.0 ±0.08
6	Mohana local	18.8±0.45	2.0±0.04	37±0.07	79±0.03	6.1±0.05	22.5±0.13	4.6±0.05	6.5±0.02	3.898±0.11	5.009±0.06	30.0 ±1.25
7	Shergarh local	22.2±0.56	2.9±0.03	36±0.04	78±0.02	4.9±0.03	21.9±0.13	4.6±0.07	6.5±0.05	3.781±0.08	4.521±0.04	30.0 ±1.88
8	Sudhasarangi local	21.6±1.25	2.2±0.07	35±0.05	78±0.06	5.4±0.03	19.3±0.45	4.8±0.04	6.4±0.04	3.193±0.16	5.058±0.08	42.0 ±1.05
9	Tigiria local	22.0±0.46	3.2±0.04	37±0.11	76±0.09	5.5±0.07	23.5±0.45	4.7±0.02	6.3±0.08	3.857±0.08	2.082±0.05	8.5 ±0.25
10	Pundibari local	22.2±1.42	2.9±0.09	36±0.08	75±0.04	4.8±0.05	19.6±0.13	4.5±0.02	6.8±0.08	3.596±0.14	5.681±0.06	1.8 ±0.05
11	LBG-17	21.5±0.91	3.5±0.08	37±0.03	77±0.02	6.2±0.07	25.2±0.41	5.5±0.04	6.5±0.02	3.745±0.14	5.193±0.05	15.5 ±1.72
12	TU 942	18.2±0.23	2.0±0.02	40±0.16	84±0.04	3.5±0.05	19.1±0.45	4.5±0.06	6.3±0.04	4.613±0.16	4.680±0.08	1.8 ±0.09
13	TAU-1	20.6±0.94	1.2±0.06	37±0.12	76±0.02	3.5±0.05	8.6±0.13	4.8±0.06	6.1±0.04	3.728±0.16	4.496±0.06	85.0 ±1.36
	Average (Mean) ± S.D.	19.81±5.55	2.47±1.29	37.07±2.37	78.38±7.23	4.66±2.23	18.46±9.84	4.62±0.73	6.35±0.49	3.65 ±0.89	4.15±2.77	25.46 ±57.36

PH- Plant height (cm), BP- Number of branches per plant, DF-Days of 50% flowering, DM- Number of days for maturity, CP-Number of cluster of pods per plant, PP-Number of pods per plant, PL-Pod length (cm), SP-Number of seeds per pod, SY-Seed yield per plant (g), SW-100-seed weight (g), YMV %= Yellow mosaic virus infection percentage.

Table 2

RAPD profile and DNA polymorphism data generated in 13 blackgram landraces under study.

Primer name	Sequence (5'- 3')	No. of bands amplified	No. of poly-morphic	Polymorphic % bands	Size range of bands
OPA08	GTCACGTAGG	14	6	42.84	200-900
OPA11	CAATCGCCGT	11	8	72.72	250-1100
OPA14	TCTGTGCTGG	8	4	50.00	250-1200
OPD-08	GTGTCCCCCA	9	5	55.55	400-950
OPD-12	CACCGTATCC	10	6	60.00	300-850
OPE03	CCAGATGCAC	8	2	25.33	200–1150
OPF08	GGGATATCGG	5	2	40.00	300–1250
OPF10	GGAAGCTTGG	6	1	16.16	200–870
OPF12	ACGGTACCAG	14	6	42.85	340–1250
OPF13	GGCTGCAGAA	12	4	33.33	280–1120
OPF16	GGAGTACTGG	8	3	37.5	300–940
OPW02	ACCCCGCCAA	10	4	40.00	150–1280
OPW03	GTCCGGAGTG	6	3	50.00	230–1300
OPW05	GGCGGATAAG	9	4	44.00	200–1200
OPW06	AGGCCCGATG	6	2	33.33	250–1060
OPW08	GACTGCCTCT	11	6	54.54	270–1050
OPW11	CTGATGCGTG	10	3	30.00	350–900
OPN-04	GACCGACCCA	12	7	58.33	220-930
OPN-11	TCGCCGCAAA	8	3	37.50	150-1150
OPN-15	CAGCGACTGT	12	5	41.66	450-1240
		189	84	47.98	

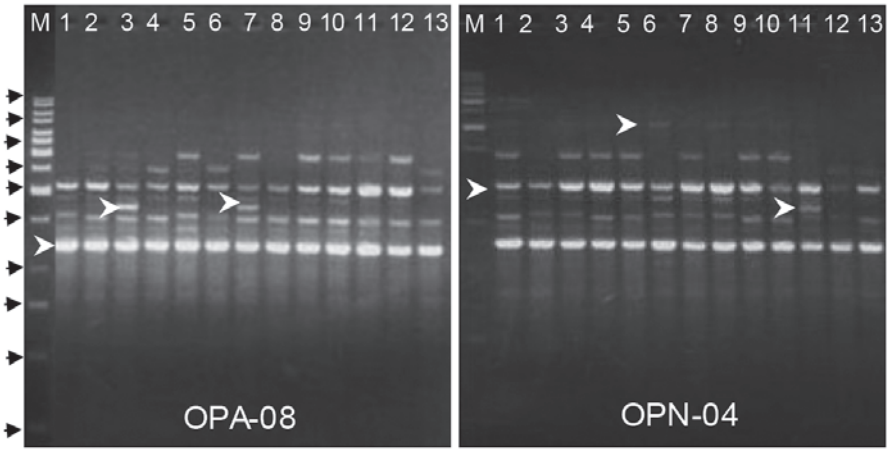

Fig.1 - RAPD Profile of 13 genotypes of black gram amplified with OPA-S and OPN-04 primers M=DNA molecular weight marker; 1-13 lane represent different genotypes as per Sl.No. of Table-1.

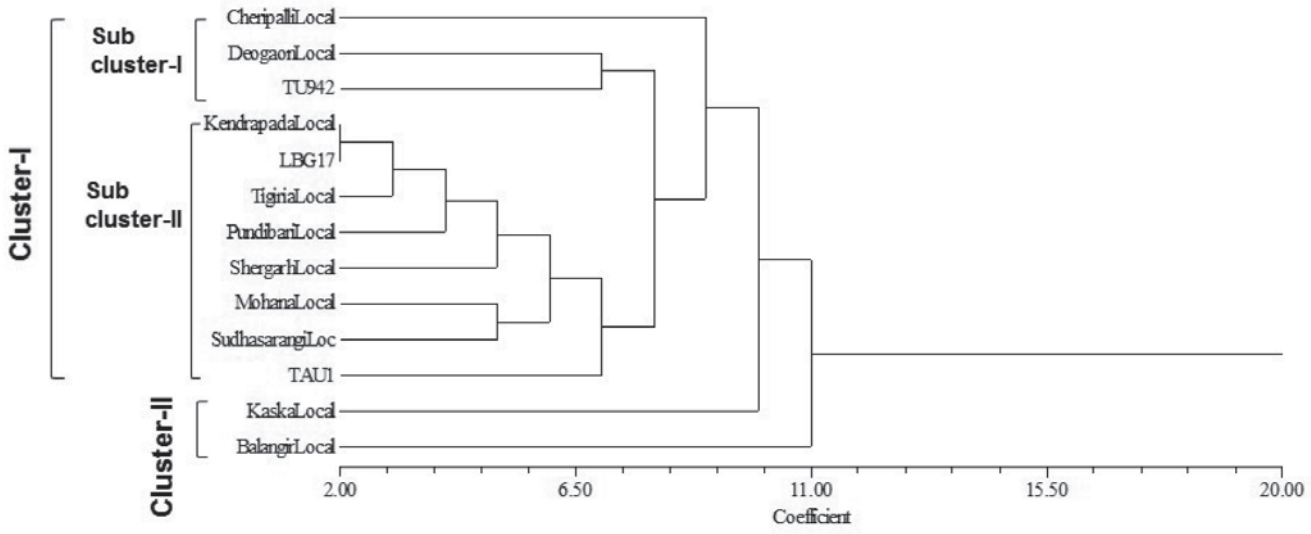

Fig.2 - Phylogenetic tree obtained from apronomic parameters of different genotypes of black gram.

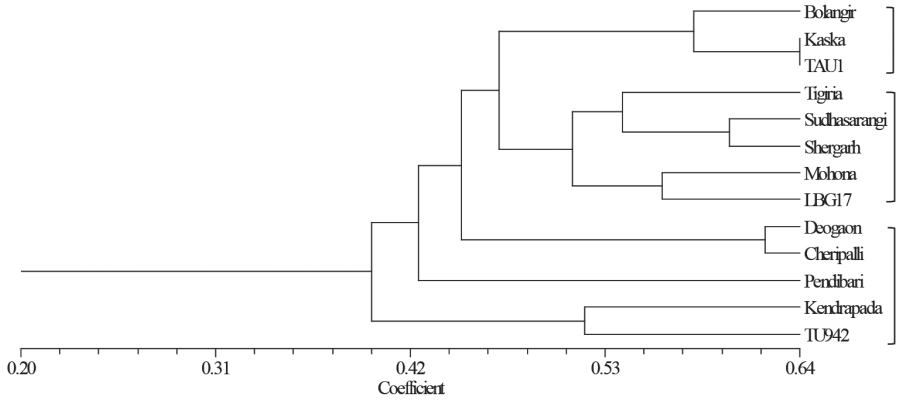

Fig.3 - Dendogram of genotypes of black gram constructed on the basis of RAPD data.

primers of (Basak *et al.*, 2004) also reconfirmed by Souframanien and Gopalakrishna (2006) can be developed through SSR study in Odisha landraces as reported earlier from mungbean, soybean, common bean, red gram, azuki bean (Sudha *et al.*, 2013; Rambabu *et al.*, 2018; Dhole and Reddy, 2013; Kaewwongwal *et al.*, 2015; Tondonba *et al.*, 2018; Kumar *et al.*, 2020; Suvan *et al.*, 2020). The selection of distinct YMV resistant genotypes from the distinct groups could be helpful for plant breeders in selecting parents for hybridization. The RAPD marker may be developed as SCAR marker from putatively YMV resistant genotypes in different individuals might be a potential genetic marker in future identification of registrant genotypes.

5. Conclusion

Genetic fingerprinting of black gram landraces by RAPD markers are useful methods for the analysis of genetic diversity of Indian germplasms particularly from Odisha besides different agronomic parameters and assessment of on-field YMV resistance. On the basis of morphological traits and RAPD markers, few genotypes of Odisha formed separate clusters having high resistance (Deogaon local, Cheripalli local and Kendrapara local) against YMV in Odisha condition compared to check variety TU942. Thus, the putative YMV resistance polymorphic RAPD loci found in this study can be used in developing SCAR markers to identify YMV resistant genotypes. Furthermore, the resistant Odisha landraces can be recommended for use in breeding to develop disease resistant varieties with high yielding.

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Optimization of *in vitro* root organ culture and co-culture of AM fungi *Claroideoglomus claroideum*

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ABSTRACT

Arbuscular mycorrhizal (AM) fungi, the obligate symbiont of plant roots require establishment of functional symbiosis with host to complete their life cycle. Among the various methods of mass production of AM inoculum, *in vitro* method in host root organ culture is a promising method to obtain contamination free high quality inoculum. Besides inoculum production, *in vitro* method provides opportunity for research in different aspects of host AM interaction. The present study was under taken to optimize the *in vitro* root organ culture of dicot plants *Solanum lycopersicum* and *Daucus carota,* monocot plants *Zea mays*, *Triticum aestivum* and *Sorghum bicolor* for co-culture of AM fungi *Claroideoglomus claroideum.* Optimization was carried out for root organ proliferation and AM fungi root colonization during co-culture under different cultural conditions such as media consistency and light.

1. Introduction

Arbuscular mycorrhizal (AM) fungi are obligate symbiont of plant roots (Brundrett and Brundrett, 2009) belonging to the phylum Glomeromycota (Schuessler *et al*., 2001). AM fungi cannot complete their life cycle without establishing functional symbiosis with host root. The AM symbiotic association provides carbon in form of sugar and lipid to the fungal partner (Luginbuehl *et al*., 2017), in return there is improvement in growth, mineral nutrition and water uptake (Lekberg and Koids, 2005; Tekaya *et al*., 2017), disease resistance (Jung *et al*., 2012; Berdeni, *et al*., 2018), abiotic stress tolerance of host plant (Porcel *et al*., 2012; Panigrahy *et al*., 2019). Considering the benefits of AM symbiosis, large scale mass production of AM fungal inoculum is imperative for sustainable agriculture.

Various methods are available for mass production of AM fungi (Akhtar and Abdullah, 2014). Conventional substrate based *in vivo* pot culture method is most cost effective and highly adapted large scale production system (Gaur and Adholeya, 2002). However, *in vivo* pot culture is open method and it cannot guarantee production of contamination free inoculum (Kumar and Yadav, 2018).The substrate free systems like hydroponic and aeroponics have been developed, but their high maintenance cost limit their use to small scale. The *in vitro* culture system on root organ culture can guarantee production of high quality pure AM fungi (Ijdo *et al*., 2011).

The first report on the *in vitro* root organ culture system was from the work of White (1943). Mosse and Hepper (1975) were the pioneers in establishing *in vitro* culture of AM fungi in root organ culture system. Subsequently several workers developed many *in vitro* system for culture of AM fungi (Declerck *et al*., 1996; Fortin *et al*., 2002; Voets *et al*., 2005). Besides large scale inoculum production, AM propagation in *in vitro* root organ culture system provide opportunity of research in mycelium

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development studies (Bago *et al*., 1998), functional aspects mycorrhizal root symbiosis (Debiane *et al*., 2009), sporulation dynamics (Ijdo *et al*., 2011), reproduction cycles and nutritional requirements of AM fungi (Labidi *et al*., 2011), secondary metabolite production (Kumar and Yadav, 2018) etc. Reports on *in vitro* culture of some species of AM are available (Mosse and Hepper, 1975; Chabot *et al*., 1992; Declerck *et al*. 2000; de Souza and Declerck, 2003) however, reports on *C. clareoidum* is scanty. Therefore, the present study was undertaken to develop a simple *in vitro* excised root organ culture system and optimize AM root colonization for subsequent mass production of AM spores.

2. Materials and methods

2.1 Mass production of starter culture of AM fungi

The pure culture of AM fungi *Claroideoglomus claroideum* (CMCC/AM-2705) was procured from Centre for Mycorrhizal Culture Collection (CMCC), TERI, New Delhi, India. Mass propagation of the starter culture was carried out in pot culture with *Zea mays*, *Triticum aestivum* and *Sorghum bicolor* as host plant. Substrate for pot culture constituted of dried soil and sand in the ratio 3:1 (v/v) which was mixed with organic manure at 2:1 ratio (v/v). The Potting mix was cleaned thoroughly by sieving in 2mm sieve and sterilized by autoclaving three times on alternate days at 120^{o}C in 15psi for 30 mins to kill the other mycorrhizal spore in the substrate. In 2 kg a poly pot 5 seeds of host plants were sown and after 7 days of seedling growth *C. claroideum* spores were inoculated into the pots. The pots were irrigated on alternated days and host plants were allowed to grow for 4 months for AM root colonization and sporulation.

2.2 Assessment of AM root colonization and spore density in pot culture

After 4 months of host plant growth, roots were collected by careful uprooting. Cleaned roots were cut into 1 cm length, pre-treated and stained with trypan blue following Phillips and Hyman (1970). Root colonization of AM fungi was observed under microscope and expressed as percentage of colonization (Giovannetti and Mosse, 1980). The extraction of AM spore from pot culture substrate was done by wet sieving and decantation technique (Gerdemann and Nicolson, 1963) followed by sucrose density gradient centrifugation (Daniel and Skipper, 1982). The extracted spores were counted under stereozoom microscope and spore density was expressed as number of spores / 100 g soil.

2.3 Seed collection and surface sterilization

Seeds of *Solanum lycopersicum* L., *Daucus carota* L., *Zea mays* L., *Triticum aestivum* L., and *Sorghum bicolor* (L.) Moench were collected from local market. The seeds were washed thoroughly under running tap water for 30 min, then immersed in an aqueous solution of 5% teepol and 7% sodium hypochlorite for 8-10 min, followed by washing with distilled water for 5-6 times. The explants were finally treated with 0.1% aqueous solution of mercuric chloride for 8-10 min for surface sterilization and washed 5-6 times with autoclaved distilled water.

2.4 Seed germination and development of explants

Surface sterilized seeds of dicot plant *S. lycopersicum* and *D. carota* were germinated *in vitro* in half strength MS (Murashige & Skoog, 1962) agar media (0.8% w/v). After two weeks of seedling growth, roots were excised to be used as explants for root organ culture. The seeds of monocot plants *Z. mays*, *T. aestivum* and *S. bicolor* were germinated *in vivo* in sterilized sand. After 10 days of seedling growth healthy roots were excised with sterilized scalpel and used as explants for *in vitro* root organ culture.

2.5 Optimization of in vitro root organ culture

The nutrient medium used for *in vitro* root organ culture is full strength MS with sucrose (3%). For optimization of root organ culture, the culture media was fortified with a range of concentrations (0.5-1.0 mgL^{-1}) of auxins like Indole Acetic Acid (IAA) or Indole Butyric Acid (IBA) separately. The pH of the culture medium was adjusted to 5.6-5.8 with either 0.1N HCl or 0.1N NaOH as per the requirement. The media was gelled with 0.8% (w/v) agar agar (Hi-media). Molten media (35ml) were dispensed into 150ml Erlenmeyer flasks. The flaks were capped with aluminum foil and autoclaved at 15psi at 121^{o}C for 20 min. for sterilization.

Excised root explants of *in vivo* germinated monocot plants *Z. mays*, *T. aestivum* and *S. bicolor* were cleaned by washing with distilled water several times. Surface sterilization of root explants were done by treatment with 0.1% (w/v) aqueous solution of $HgCl_2$ for 5 min. followed by washing with distilled water 5-6 times. Root explants of *in vitro* germinated *S. lycopersicum* and *D. carota* were washed with autoclaved distilled water to remove traces of the germinating media. The roots were the cut into 1cm length and inoculated to flaks containing sterilized media. All the operations including surface disinfection, inoculation and transfer of disinfected explants were conducted aseptically in laminar air flow chamber (Klenzaids, India). The inoculated flasks were maintained in the culture room at 25±1°C and 16 h photoperiod of 35-40 µmol m^{-2} s^{-1} irradiance level provided by cool white fluorescent tubes (Phillips, India) and 60% relative humidity.

2.6 In vitro co-culture of AM fungi and root organ

Arbuscular mycorrhizal spores were extracted from the soil substrate of mass propagated pot by Wet Sieving and Decantation technique (Gerdemann and Nicloson, 1963) followed by sucrose gradient centrifugation (Daniel and Skipper, 1982). The AM spores were subsequently surface sterilized in a solution of 0.05% Tween 20 (v/v) for 1 min., a solution of Chloramine T 2% (w/v) for 10 min., then in a solution of streptomycin (0.02% w/v) and gentamicin (0.01% w/v) for 10 min. (Bécard and Piché, 1992). Surface sterilization of the AM spores was carried out asceptically in laminar airflow cabinet. Viability of the surface sterilized AM spores were tested through spore germination in water agar petri plates.

The co-culture of root organ culture and AM fungi was carried out in AM fungi MS basal media (MS_0) containing sucrose (3% w/v) fortified with optimized concentration auxin (IAA / IBA) for different plant species such as *S. lycopersicum*s, *D. carota*, *Z. mays*, *T. aestivum* and *S. bicolor*. On the basis of their consistency 3 types media were prepared such as liquid, semisolid and porous. For the preparation of semi- solid media 0.8% agar was added as the gelling agent. For the porous media 40g of vermiculite was added per 100ml of MS_0 media. The *in vitro* proliferated roots which were used for the co culture experiment were cut in to 1cm (approx.) and inoculated into the flask containing sterilized culture media. The surface sterilized AM spores (approx. 100 no.) were inoculated ascetically into flask containing the root organ culture using a sterilized brush. The inoculated flasks were maintained in the culture room in same conditioned maintained for root organ culture. With respect to light condition 3 levels of irradiance were maintained such as dark, diffused light (10-15 µmol m^{-2} s^{-1}) and bright light (35-40 µmol m^{-2} s^{-1}) provided with cool white fluorescent tubes. For each condition 3 flasks with 5 root explants were taken and one set of flasks without AM inoculation was taken as control. Further, each set of experiment was repeated thrice.

2.7 Assessment of root morphology during co-culture

The changes in root morphology such as number of lateral roots induced and average length of lateral root proliferated were recorded after 30 and 60 days of co-culture in different cultural condition. The number of lateral root formed per explants were counted and expressed as number. Root length at stipulated day was measured and expressed in centimeter (cm).

2.8 Assessment of AM root colonization during co-culture

AM root colonization during co-culture was assessed at 30 and 60 days interval. For each culture condition, roots were cleaned with distilled water then cut into 1cm length. Root segments of replicate flaks were mixed together to get a composite sample. The root pre-treatment and staining (0.05% Trypan blue) was done as per Phillips and Hayman (1970). From the composite sample 50 root segments were observed and AM root colonization is express as percentage According to Giovannetti and Mosse (1980) by the formula:

$$\text{AM root colonization (\%)} = \frac{\text{No. of root segment with AM colonization}}{\text{Toral no. of root segments observed}} \times 100$$

3. Results

3.1 Mass production AM and root colonization in pot culture

After 4 months of pot culture, host plant roots were examined for AM colonization. It was observed that AM fungi root association was 100% in *Z. mays*, *T. aestivum* and *S. bicolor*. However, the spore density was 425, 562 and 700 per 100g soil in *Z. mays*, *T. aestivum* and *S. bicolor* respectively.

3.2 Optimization of in vitro *root organ culture*

Optimization of *in vitro* root organ proliferation of dicot plants *S. lycopersicum* and *D. carota*, monocot plants *Z. mays*, *T. aestivum* and *S. bicolor* were tested in a range of concentrations (0.25 to 1.5 mgL^{-1}) of IAA and IBA. *In vitro* root organ proliferation of in terms of highest number of lateral root per explants and highest root length was recorded for *S. lycopersicum* with IAA ($1mgL^{-1}$) and for *D. carota* IBA ($1mgL^{-1}$) (Table 1). For monocot explants optimum concentration of auxin for *in vitro* root proliferation was IAA ($1mgL^{-1}$) for *Z. mays*, IBA ($1mgL^{-1}$) for *T. aestivum* and *S. bicolor* within 30 days of culture (Table 2).

3.3 Effect of media consistency on root morphology during co-culture

The effect of different culture media consistency on the induction of lateral root and increase in the root length was assessed during co-culture under bright light condition. It was observed that highest number of lateral root was induced in semi solid media, followed by porous media and least number in liquid media. After 30 days of co-culture *D. carota* developed highest number (7.67) of lateral root in semi solid media, followed *S. lycopersicum* (6.2) in porous media under AM inoculated condition. After 60 days of co-culture *D. carota* among the dicot and *S. bicolor* could induce highest number of lateral roots in semi solid and porous media (Figure 1). With respect to root length, after 30 days of co-culture *S. lycoperiscum* showed maximum root length followed by *D. carota* in semi solid and porous

Table. 1

Effect of IAA and IBA concentration of on root organ proliferation of *Solanum lycopersicum and Daucus carota*

Explant Source	Auxin	Conc. of Auxin (mgL^{-1})	No of root lateral roots	Root length (cm)
Solanum lycopersicum	IAA	0.25	6.8 ± 2.75	2.28 ± 1.60
		0.5	7.13 ± 3.73	2.94 ± 1.79
		1.0	8.53 ± 5.31	3.26 ± 1.69
		1.5	5.86 ± 3.33	2.76 ± 0.24
	IBA	0.25	5.46 ± 3.33	2.16 ± 1.64
		0.5	6.06 ± 3.17	2.45 ± 1.76
		1.0	6.5 ± 2.18	2.82 ± 1.49
		1.5	5.62 ± 2.30	1.99 ± 1.70
Daucus carota	IAA	0.25	5.53 ± 2.58	1.62 ± 0.08
		0.5	7.66 ± 1.49	2.78 ± 1.81
		1.0	8.86 ± 3.44	2.90 ± 1.74
		1.5	7.25 ± 2.84	2.58 ± 1.28
	IBA	0.25	6.26 ± 3.30	2.67 ± 1.94
		0.5	7.2 ± 3.52	2.95 ± 1.99
		1.0	8.46 ± 2.89	3.64 ± 1.52
		1.5	6.4 ± 3.71	3.07 ± 1.86

Data(Mean± SE) pooled from 3 independent experiment each with 5 replicates.

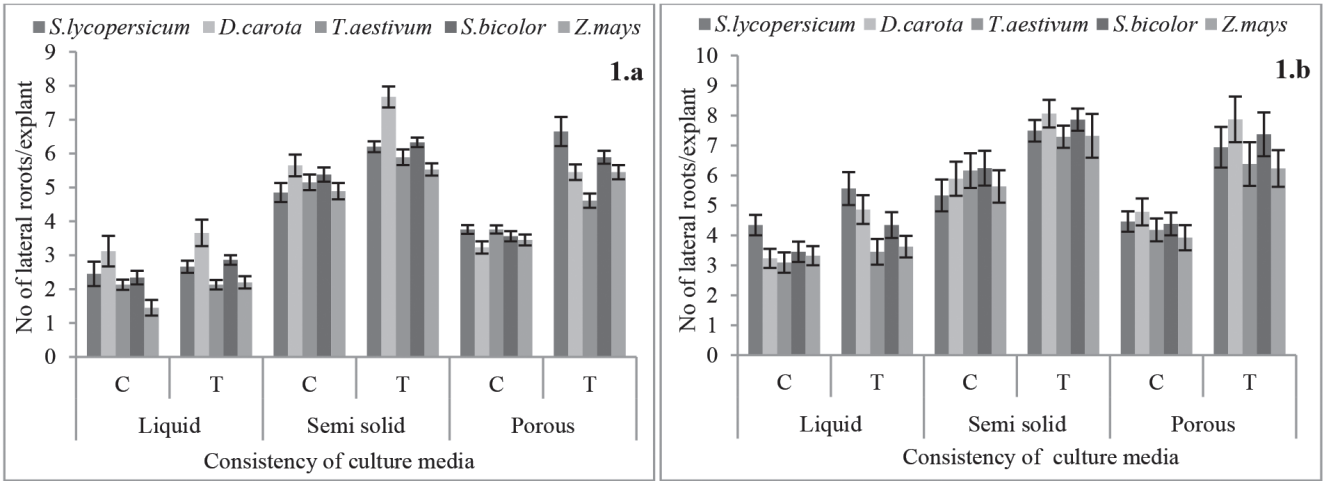


Figure 1. Number of lateral root per explant under different media consistency after 30 (a) and 60 (b) days of co-culture in bright light condition. (C: Uninoculated Control, T: Inoculated Treatment)

media. After 60 days of co-culture *D. carota* (7.68cm) had highest root length followed by *S. lycopersicum* (7.31cm) in semi solid media, however in porous media *S. lycopersicum* (6.87cm) showed highest root length followed by *D. carota* (6.54cm) which are statistically not significant. Among the monocots *Z. mays* had highest root growth in both semi solid and porous media after 30 and 60 days of co-culture. In general AM inoculated explants showed higher number of lateral roots and longer root length compared to the un-inoculated control (Figure 2).

3.4 Effect of light on root morphology during co-culture

Under different light conditions, highest number of lateral root induction was observed in *D. carota* under bright light condition followed diffused light condition after 30 and 60 days of co-culture. Among the monocot *Z. mays*

Table 2

Effect of IAA and IBA concentration of on root organ proliferation of *Zea mays*, *Triticum aestivum* and *Sorghum bicolor.*

Explant Source	Auxin	Conc. of Auxin (mgL^{-1})	No of root lateral roots	Root length (cm)
SZea mays	IAA	0.25	3.33 ± 1.87	1.69 ± 0.96
		0.5	5.66 ± 2.69	1.71± 0.65
		1.0	10.93 ± 4.07	3.53 ± 1.88
		1.5	4.93 ± 1.98	1.56 ± 0.98
	IBA	0.25	3.46±1.95	1.92±1.07
		0.5	5.73±2.18	2.06±1.42
		1.0	10.26±4.66	3.11±0.98
		1.5	4.66±1.79	1.79±0.90
Triticum aestivum	IAA	0.25	3.86 ± 1.45	1.58± 0.67
		0.5	6.06 ± 1.94	2.2 ± 0.72
		1.0	4.33 ± 2.12	1.56 ± 0.94
		1.5	3.73 ± 2.15	1.42±0.93
	IBA	0.25	3.73±2.15	1.64±0.89
		0.5	5.8±1.93	3.03±1.15
		1.0	4.46±2.09	2.38±1.39
		1.5	3.53±1.88	2.04±1.66
Sorghum bicolor	IAA	0.25	3.26 ± 2.18	1.42 ± 0.86
		0.5	5.33 ± 1.95	1.80 ± 0.84
		1.0	6.46 ± 3.39	2.32 ± 0.85
		1.5	3.55 ± 1.50	1.4 ± 0.74
	IBA	0.25	2.93±1.70	2.30±1.68
		0.5	4.66±1.63	2.49±1.462
		1.0	5.93±1.86	2.68±1.33
		1.5	3.4±1.54	2.24±1.74

Data (Mean± SE) pooled from 3 independent experiment each with 5 replicates.

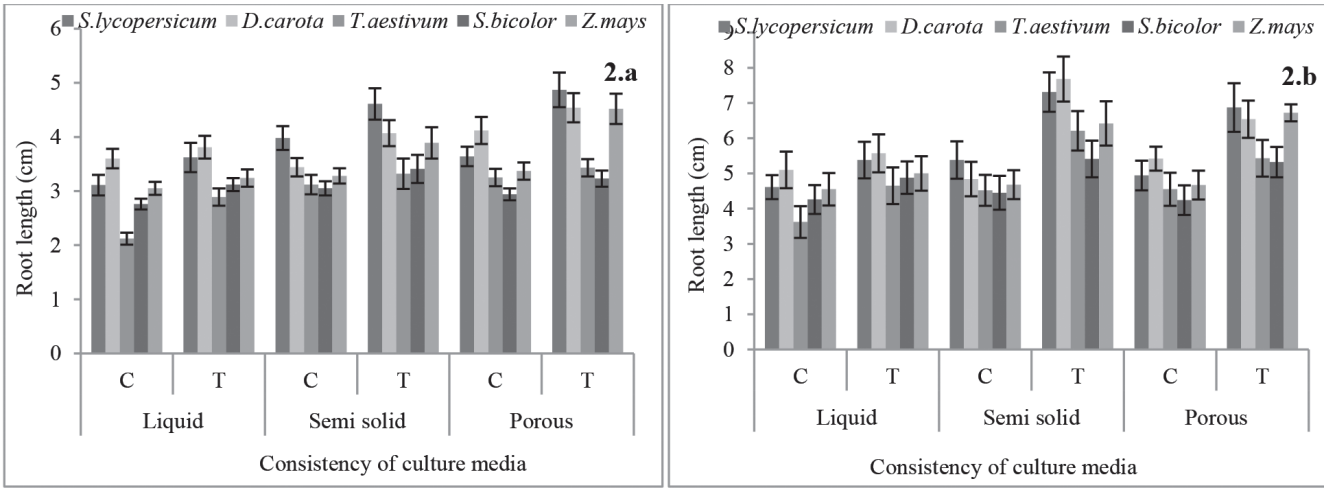


Figure 2. Root length (cm) of explants under different media consistency after 30 (a) and 60 (b) days of co-culture in bright light condition. (C: Uninoculated Control, T: Inoculated Treatment)

showed maximum number of lateral roots in all the light condition. Under dark conditions all the explants could induced least number of lateral roots (Figure 3).With reference to root length, all the explants showed higher root growth in bright light conditions followed by diffused light condition and least in dark condition in semi solid media. Among the dicots *S. lycopersicum* and among monocots *Z. mays* exhibited highest root growth after 30 and 60 days of co-culture.. The AM inoculated explants showed more number of lateral roots and more root length compared to their uninoculated control in all the light conditions (Figure 4).

3.5 AM root colonization in co-culture

The AM root colonization of the explants in different media consistency and different light conditions were analyzed. For different media consistency, highest percentage of AM colonization was recorded in semi solid media followed by porous media and least colonization was observed in liquid media after 30 and 60 days of co-culture. Among the dicots *D. carota* in semi soil and porous media, but *S. lycopersicum* in liquid media showed highest percentage of AM colonization. Among the monocots highest percentage of AM colonization was recorded for *S. bicolor* in all the media consistency (Figure 5). Under different light conditions, highest percentage of AM colonization was found in dark condition followed by diffused light condition and least in bright light condition for all the explants. Among the dicots *D. carota* and among the monocots *S. bicolor* showed highest percentage of AM colonization in all the light condition after 30 and 60 days of co-culture (Figure 6).

6. Discussion

From the present study it was revealed that the AM fungi *C. claroideum* can form symbiotic association with roots of *Z. mays*, *T. aestivum* and *S. bicolor*. Many grass species have been used for mass production of AM fungi *in vivo* (Fracchia *et al*., 2001; Chaurasia and Khare 2005; Sun and Tang, 2012; Kadian *et al*., 2018). The fibrous root system of grasses provides larger surface area for AM fungi and root interactions. As AM fungal spore production has been reported to be influenced by plant species (Struble and Skipper, 1988), the present findings of highest spore AM production with *S. bicolor* is justified. Hence *S. bicolor* is most suitable among the three tested host for mass production of *C. claroideum* spore in pot culture.

The optimal auxin (IAA/ IBA) concentration for root organ proliferation of *S. lycopersicum* and *D. carota*, *Z. mays*, *T. aestivum* and *S. bicolor* was determined. For lateral root development, auxin is reported to be the dominant regulator (Benkova and Hejatko 2009; Fukaki and Tasaka 2009). Auxin in form of IAA and IBA has been used for successful *in vitro* root induction and proliferation in variety of plants (Shukla *et al*., 2009; Victório *et al*., 2012; Hanur and Krishnareddy, 2016). Optimum concentration of IAA /IBA for root proliferation varies from species to species under different *in vitro* cultural conditions (Tavares, *et al*., 2010). From the present study, optimum concentration of IAA and IBA for the *S. lycopersicum* and *D. carota*, *Z. mays*, *T. aestivum* and *S. bicolor* was found to be 1 mgL^{-1} in MS0, which was used in further experiment.

In the present findings higher number of lateral root and longer length of lateral root were found in AM inoculated root culture than non inoculated one. Root system architecture (RSA) gets frequent modification following AM interactions (Scannerini *et al*., 2001; Hodge *et al*., 2009). Despite fundamental differences in root system architecture of monocotyledons and dicotyledons (Osmont *et al*., 2007), in both lateral roots are preferentially colonized by AM fungi and their formation is induced upon symbiosis establishment (Gutjahr & Paszkowski, 2013). Lu & Wu (2017) reported AM inoculation increases number of lateral roots and root length in white clover *in vivo*. Formation of more number of lateral roots after AM colonization is reported in trifoliate orange (Chen, 2017). There are evidences of local elongation of root laterals following establishment of mycorrhiza (Yano *et al*., 1996, Torrisi *et al*, 1999), perhaps in order to increase the suitable sites for colonization (Harrison, 2005; Mukherjee and Ané, 2011). Thus, the present findings of higher number of lateral root and higher length of lateral root in AM inoculated root organ cultures than non inoculated explants is supported by the reports of above mentioned workers.

Under different light conditions highest number of lateral root and highest length of lateral root was observed in bright light and followed by diffused light and least in dark condition. Positive effect of white light on root elongation is reported by Salisbury *et al*., (2007) and Costigan *et al*., (2011). Auxin and sucrose are considered as a major player in light regulated root elongation (Sassi *et al*., 2012). Increase in the rate of *in vitro* root elongation under light condition than in darkness in some plant species has been observed (Vinterhalter, 1990; Monteuuis, 2000). Thus, bright light induced root proliferation in *in vitro* root organ culture as found in the present study is similar to the mentioned reports.

The highest rate of root proliferation and highest percentage of AM root colonization was observed in semi solid media followed by porous media and least in liquid media. Abd Ellatif *et al.*, (2019) reported that mycorrhizal

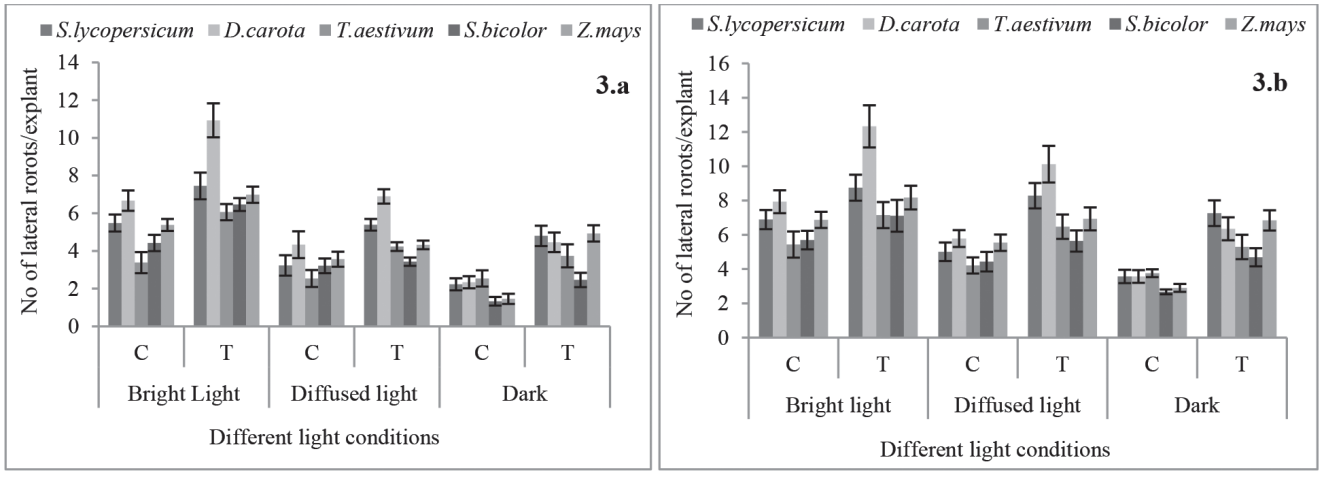


Figure 3. Number of lateral root per explants under different light conditions after 30 (a) and 60 (b) days of co-culture in semi solid media. (C: Uninoculated Control, T: Inoculated Treatment)

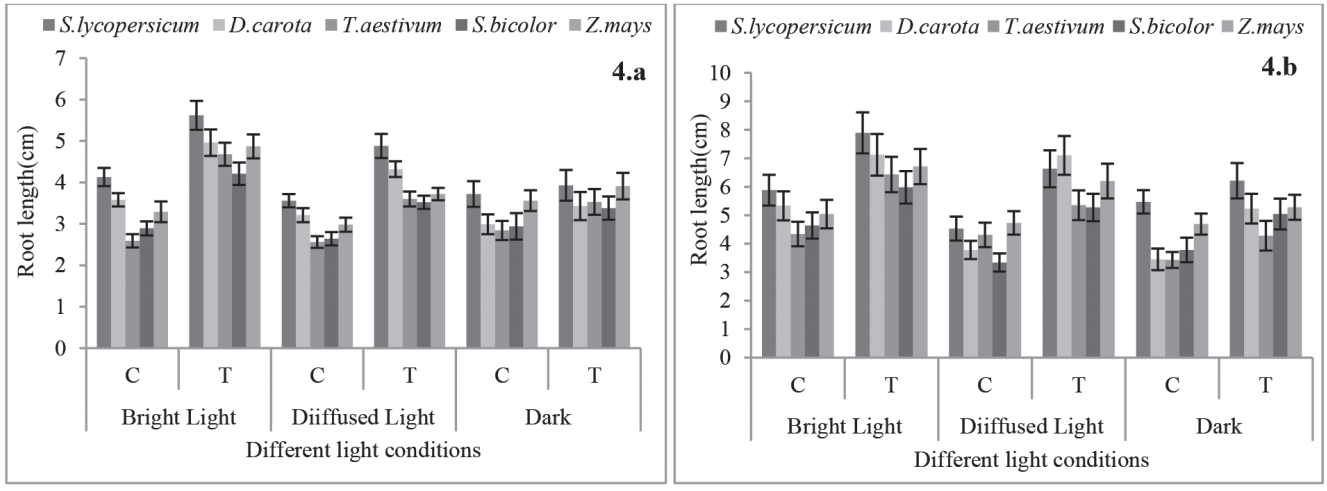


Figure 4. Root length (cm) of explants under different light conditions after 30 (a) and 60 (b) days of co-culture in semi solid media. (C: Uninoculated Control, T: Inoculated Treatment)

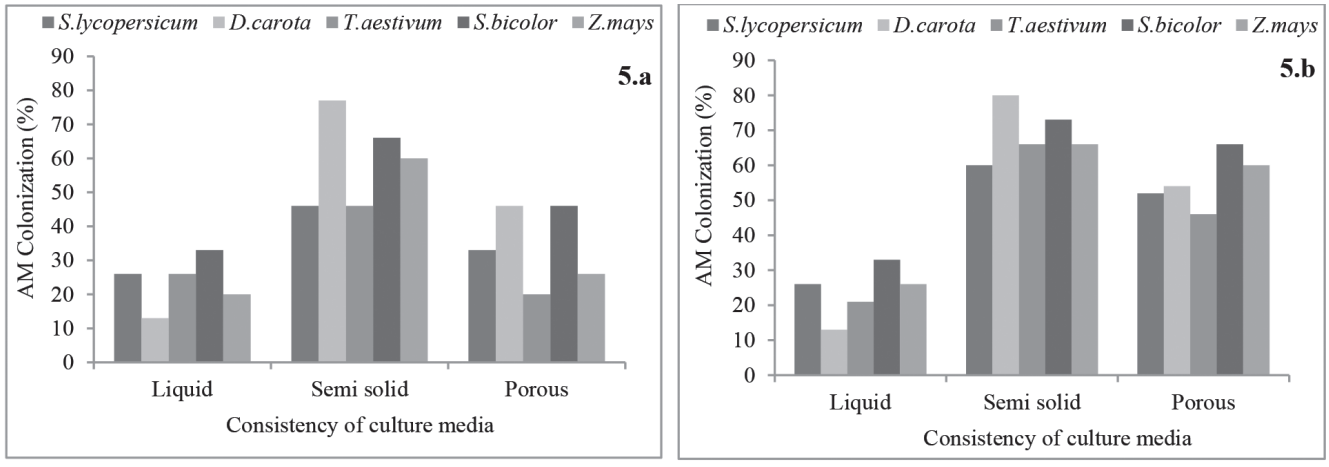


Figure 5. AM root colonization (%) in different media consistency after 30 (a) and 60 (b) days of co-culture in bright light condition.

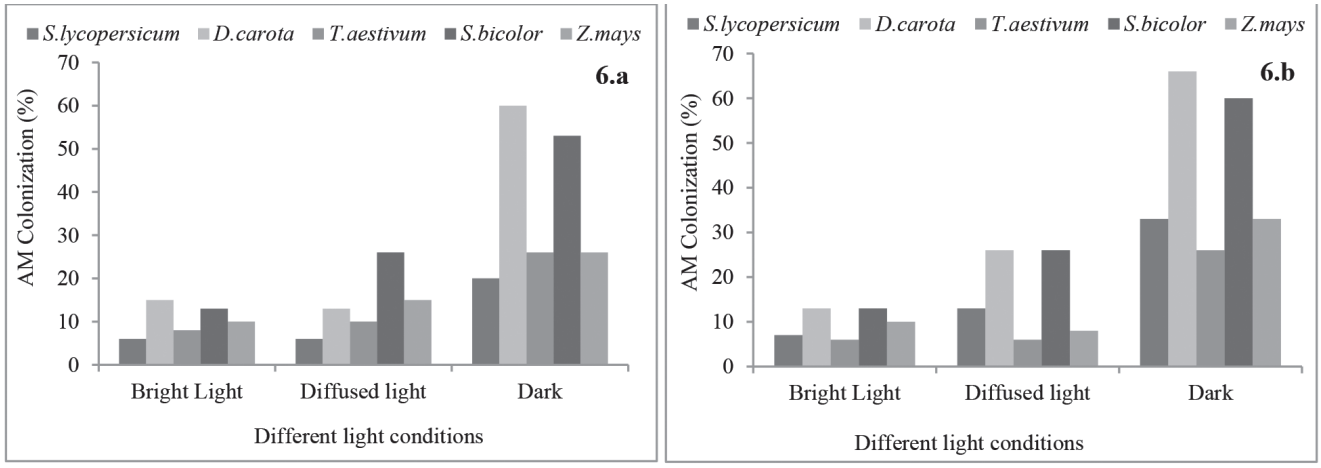


Figure 6. AM root colonization (%) in different light conditions after 30 (a) and 60 (b) days of co-culture in semi solid media.

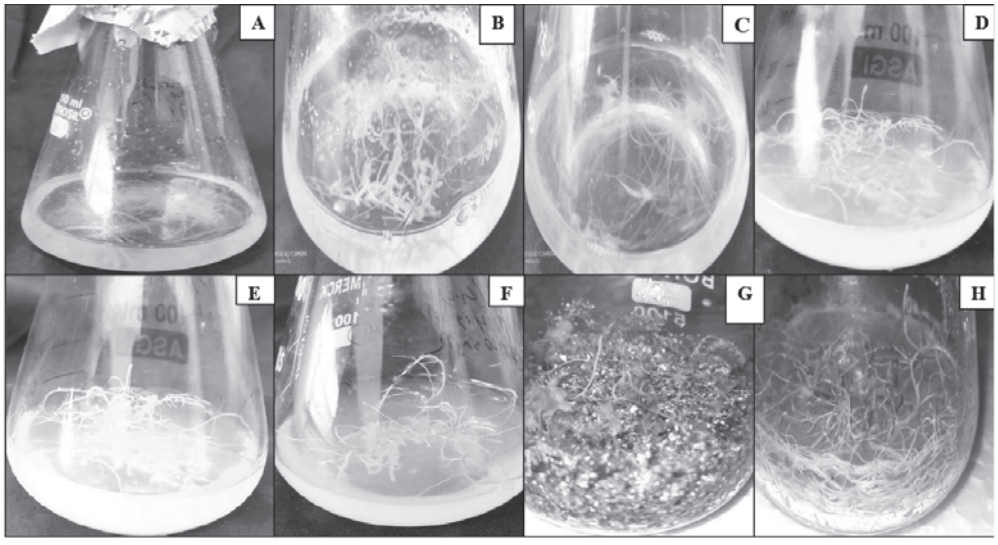
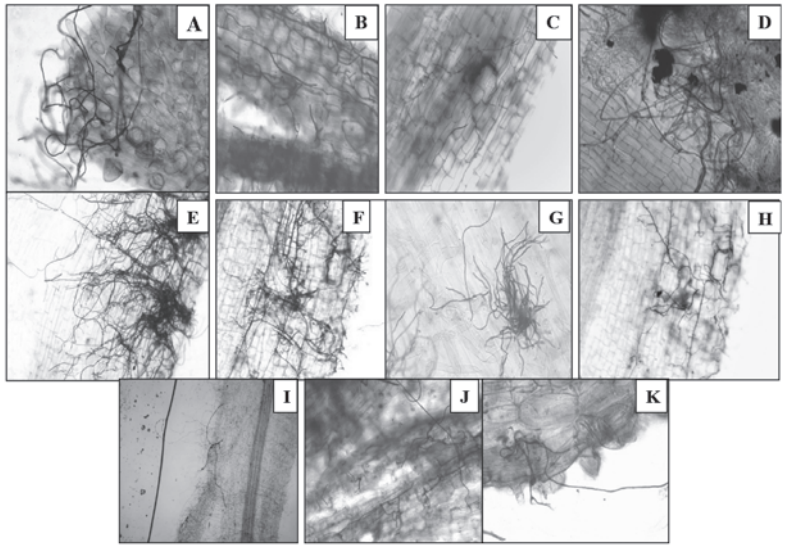


Photo plate 1: Co culture of AM spore with root organ culture in different culture conditions; Liquid media: *D. carota* (A), *S. lycopericum* (B) &*T. aestivum* (C), Semi solid media: *D. carota* (D), *S. bicolor* (E) & *Z. mays* (F), Porous media: *Z. mays* (G) & *D. carota* (H)



Photoplate 2: AM root colonization of *C. claroideum* in co-culture with *D. carota* (A &B), *S. lycopersicum* (C & D), *Z. mays* (E &F), *T. aestivum* (G & H) and *S. bicolor* (I, J & K)

colonization rate and arbuscular abundance of *S. lycopersicum* roots grown *in vitro* were recorded to be higher on solid media than in liquid media. According to the workers such finding might be because of the immobilization of spore inoculum on solid media resulting enhanced growth of hyphae. Besides, poor aeration in liquid media might hinder AM fungi development. *Glomus etunicatum* was reported to colonize better in culture media containing vermiculite than agar, which was most likely due to the vermiculite improved air diffusion through the media (Bressan, 2002). Since there is differential rate of AM root colonization in different media consistency, the present findings of higher *in vitro* root colonization of *C. claroideum* in media containing agar cannot be generalized for all AM species. As there is highest AM root colonization in semi solid media, which might have caused higher root proliferation in terms of higher number of lateral root and higher length of the lateral root in semi solid media than liquid media.

From the present study it was recorded that *C. claroideum in vitro* root colonization was better under dark condition than light condition. Higher level of photosynthetic photon stimulates root colonization by AM *Glomus intraradices* in *Solanum tuberosum* plantlets cultured in an *in vitro* tripartite system (Louche-Tessandier, 1999). The rate and maximum percentage of AM infection were found lower at high light intensities (15-2 0klux) than low ones (5-10klux) in *Allium cepa* by *Gigaspora calospora* (Furlan and Fortin, 1977). Hayman (1974) reported larger AM arbuscules at high light intensities than low one. Since there are reports on differential effect of light on AM root colonization, the present observation of higher *in vitro* root colonization of *C. claroideum* in dark than light condition cannot be generalized for the all the species of AM fungi.

7. Conclusion

From the present study it was concluded that semi solid and porous media are more suitable for root organ culture proliferation than liquid media during co culture with AM fungi *C. claroideum*. Among different light conditions bright light condition is most suitable for the root organ culture proliferation with the AM fungi. The AM root colonization occurred maximum in semi solid and porous media under dark condition. Hence, for root organ proliferation, initial co culture can be done in semi solid or porous media under bright light condition. Later, the co-culture should be kept in dark condition for better AM root colonization and subsequent sporulation.

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Taxonomic reassessment of the genus *Memecylon* L. (Melastomataceae) in Eastern Ghats, India

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ABSTRACT

The present paper enumerates 14 species and one variety of *Memecylon* primarily based on the herbarium specimens deposited in MH, CAL, RHT, RRPC, literature survey and field work. Furthermore, *Memecylon jadhavii* is treated as an invalid name.

1. Introduction

Memecylon L. is considered as a third largest genus in the family Melastomataceae (Stone, 2014). It comprising about 352 species distributed in the Old World tropics (POWO, 2020). The best diagnostic characters used for species delimitation are nature of stem, leaf shape and size, nature and position of inflorescence, pedicel length, calyx shape and nature of cohesion, presence or absence of disc rays, morphology of foliar sclereids and the nature of the embryo (Rao & Bhupal, 1974; Rao & Dakshni, 1963; Rao *et al.*, 1980; Kumar *et al.*, 2004; Stone *et al.*, 2014; Kottaimuthu and Vasudevan, 2015).

Clarke (1879) recognized 40 species and 27 varieties in Flora of British India, among them 15 species and nine varieties are found within the present political boundary of India (Karthigeyan *et al.*, 2016). According to the recent estimate, the genus is represented by 55 species in India (modified after Vadhyar *et al.*, 2020), of which maximum diversity is found in Peninsular India especially Western Ghats of Kerala and Tamil Nadu. But in Eastern Ghats, so far only eight (Reddy *et al.*, 2020) to nine species (Pullaiah *et al.*, 2007) of *Memecylon* are reported. However, the present communication enumerates 14 species and one variety of *Memecylon* mainly based on the herbarium specimens deposited in MH, CAL, RHT, RRPC coupled with literature survey and field work.

Systematic Enumeration

1. Memecylon bremeri M.B.Viswan. in Nordic J. Bot. 21(3): 256. 2001.

Type: —INDIA. Tamil Nadu, Salem District, Kollihills, 11''8' N and 78''20' E, Karavallicombai R.F., ±1,200 m, 2 April 1994, *M. B. Viswanathan 3* (holo.: MH)

Distribution: INDIA (Tamil Nadu).

Note: Critical analysis of the protologue of *M. bremeri* and *M. kollimalayanum* (Viswanathan, 2001) revealed the

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fact that type collections of both species are made on the same date from the same locality are with consecutive collection numbers. Moreover, the specimens collected by us from Karavallicombai, Kolli hills falls within the circumscription of *M. lushingtonii*. Further studies are needed to ascertain the specific status of the former species.

2. Memecylon capitellatum L., Sp. Pl. 1: 349. 1753; M.B.Viswan. in Bull. Bot. Surv. India 37: 127. 1995; Kottaim. *et al.* in Taprobanica 7(2): 114. 2015.

Type:—SRI LANKA. Paul Hermann *s. n.* (BM, barcode BM000621286!).

Memecylon edule Roxb. var. *laeta* C.B.Clarke in Hook., Fl. Brit. India 2: 564. 1879.

Type (lectotype designated by Kottaimuthu *et al.* 2015: 114):— SRI LANKA. Without locality data, 1854, *G.H.K. Thwaites* 1564, K-barcode K300357738!).

Distribution: INDIA (Tamil Nadu) and SRI LANKA.

Note: Bremer (1987) and POWO (2019) have given the areas of distribution for the species as Sri Lanka only. However, it is also reported from Eastern and Western Ghats of Tamil Nadu (Viswananthan, 1995; Kottaimuthu *et al.*, 2015)

3a. Memecylon edule Roxb., Pl. Coromandel 1(4): 59, t. 82. 1798; Pull. *et al.*, Fl. Eastern Ghats 3: 52. 2007; Britto, Fl. Central & North Tamil Nadu 2: 1282. 2019.

Type: —INDIA. Roxburgh, *Herb. Wallich No.* 4107A (K, barcode K001038141!).

Distribution: INDIA (Andaman, Andhra Pradesh, Assam, Kerala, Madhya Pradesh, Orissa, Tamil Nadu, Tripura). BANGLADESH, BORNEO, MALESIA and SRI LANKA.

Note: Leaves are used for the treatment of internal piles (Sankar *et al.*, 2012).

3b. Memecylon edule Roxb. var. **petiolatum** (Trimen ex Alston) M.Das Das, G.S.Giri, A.Pramanik & D.Maity in Feddes Repert. 129(1): 52. 2018; Britto, Fl. Central & North Tamil Nadu 2: 1283. 2019. *Memecylon petiolatum* Trimen ex Alston in Trimen, Hand-Book Fl. Ceylon vi. Suppl.: 126. 1931.

Lectotype (designated by Bremer 1979: 50):— SRI LANKA. *Trimen s.n.* (PDA).

Distribution: INDIA (Andhra Pradesh, Kerala & Tamil Nadu) and SRI LANKA.

4. Memecylon gracile Bedd., Fl. Sylv. S. India Forester's Man. Bot.: p. cxv. 1872; Pull. *et al.*, Fl. Eastern Ghats 3: 52. 2007.

Lectotype (designated by Das *et al*. 2016: 2):—INDIA. Travancore (Kerala), without precise locality: s. d., *Coll. ign.*, (MH).

Distribution: INDIA (Andhra Pradesh, Kerala & Tamil Nadu), Endemic.

Note: *M. gracile* differs from other species of *Memecylon* in this region by its characteristic ovate-lanceolate leaves with caudate apex and three flowered umbellate cymes.

5. Memecylon grande Retz., Observ. Bot. (Retzius) 4: 26. 1786; Pull. *et al.*, Fl. Eastern Ghats 3: 52. 2007.

Lectotype (designated by Bremer 1979: 23):— SRI LANKA, Koenig *s.n.* (LD).

Distribution: INDIA (Andhra Pradesh, Kerala & Tamil Nadu) and SRI LANKA.

Note: Bremer (1983) opined that reported occurrence of *M. grande* from India is due to misidentification. This species was included here on the authority of Pallithanam (2001) and Pullaiah *et al.* (2007) with some hesitation. Further explorations in the reported localities will resolve the distribution crisis.

6. Memecylon kollimalayanum M.B.Viswan. in Nordic J. Bot. 21(3): 253. 2001.

Type:—INDIA. Tamil Nadu, Salem District, Kollihills, 11"8' N and 78"20' E, Karavallicombai R.F., ±1200m, 2 April 1994, *M.B.Viswanathan 2* (holo.: MH).

Distribution: INDIA (Tamil Nadu).

Note: It is very difficult to delimit *M. kollimalayanum* and *M. bremeri* from *M. lushingtonii*. Hence following Das (2017), Britto (2019) has synonymised this species along with *M. mundanthuraianum, M. bremeri* and *M. courtallense* under *M. lushinntonii*. Further studies are needed to ascertain the specific status of these species.

7. Memecylon lushingtonii Gamble in Bull. Misc. Inform. Kew 1919(5): 227. 1919; Pull. *et al.*, Fl. Eastern Ghats 3: 53. 2007; Britto, Fl. Central & North Tamil Nadu 2: 1283. 2019.

Lectotype (designated by Das *et al*. 2016: 2):—INDIA. Madras (Andhra Pradesh): Cuddapah Dist.: Horsleykonda, 1212 m [4000 ft], July 1884, *J. S. Gamble 15110* (K, barcode K000859150!).

Distribution: INDIA (Andhra Pradesh, Karnataka, Kerala & Tamil Nadu), Endemic.

8. Memecylon madgolense Gamble in Bull. Misc. Inform. Kew 1919(5): 227. 1919; Pull. *et al.*, Fl. Eastern Ghats 3: 32.

2007; Britto, Fl. Central & North Tamil Nadu 2: 1284. 2019.

Lectotype (designated by Das *et al.* 2016: 2):—INDIA. Madras: Vizagapatnam, Machiput, Madgol hills, 969 m [3200ft], 6 June 1914, *A. W. Lushington s.n.*, (K, barcode K000357502!).

Distribution: INDIA (Andhra Pradesh & Tamil Nadu), Endemic.

Note: Pragasan & Parthasarathy (2009) rediscovered this species from Kolli Hills, Tamil Nadu.

9. Memecylon molestum Cogn. in A.DC. & C.DC., Monogr. Phan. 7: 1169. 1891; Pull. *et al.*, Fl. Eastern Ghats 3: 54. 2007. *Memecylon umbellatum* var. *molestum* (Cogn.) M.Das Das, D.Maity & A.Pramanik in Britto, Fl. Central & North Tamil Nadu 2: 1287. 2019.

Type:—INDIA. Tamil Nadu, Anamallay Mts., *Wight 1072* (K).

Distribution: INDIA (Andhra Pradesh, Karnataka, Kerala, & Tamil Nadu), Endemic.

10. Memecylon ovatum Sm. in Rees, Cycl. 23, no. 3. 1813; Britto, Fl. Central & North Tamil Nadu 2: 1285. 2019.

Type: — *Herb. Linnaeus* 161: 1 (holo: LINN!).

Distribution: INDIA (Andaman & Nicobar Islands, Andhra Pradesh, Bihar, Goa, Kerala, Maharashtra, Odisha & Tamil Nadu), BORNEO, JAVA MALESIA, MYANMAR, SUMATRA and THAI LAND.

Note: The species is often misidentified in the herbaria either as *M. edule* or *M. grande.*

11. Memecylon parvifolium Enum. Pl. Zeyl.: 113. 1859; Britto, Fl. Central & North Tamil Nadu 2: 1285. 2019.

Lectotype (designated by Bremer 1979: 28):—SRI LANKA, 6000 ft. (1828 m), Thwaites *C. P. 2955* (PDA).

Distribution: INDIA (Tamil Nadu) and SRI LANKA.

12. Memecylon royenii Blume, Mus. Bot. 1(23): 360. 1851; Murugan & Gopalan in Indian J. Forest. 29(1): 107. 2006; Kottaim. *et al.* in Int. J. Curr. Res. Biosci. Pl. Biol. 6(7): 27. 2019; Britto, Fl. Central & North Tamil Nadu 2: 1286. 2019.

Lectotype (designated by Bremer 1979: 19):— *Herb. Van Royen s. n.* (L, barcode L0052995!).

Distribution: INDIA (Andhra Pradesh, Kerala & Tamil Nadu) and SRI LANKA.

Note: Murugan & Gopalan (2006) first reported this Sri Lankan endemic species for India from Andhra Pradesh based on the specimens collected by Ellis and Chandrabose. Later, Rajendraprasad *et al.* (2006) have reported the species from the Western Ghats of Kerala. Recently this species was reported from the Sirumalai (Kottaimuthu *et al.*, 2019) and Kolli hills (Britto, 2019).

13. Memecylon talbotianum Brandis, Indian Trees: 336. 1906; M.B.Viswan. & Lakshmanan in Indian J. Forest. 13(2): 174. 1990; Pull. *et al.*, Fl. Eastern Ghats 3: 54. 2007; Britto, Fl. Central & North Tamil Nadu 2: 1286. 2019.

Lectotype (designated by Das *et al*. 2015: 210):—INDIA. Karnataka: Bombay, North Kanara District, Bunwasi (Banavasi), 2000 ft (600 m), 22 March 1896, *W.A. Talbot* 3568 (K, barcode K000859141!).

Distribution: INDIA (Goa, Karnataka, Kerala, Maharashtra & Tamil Nadu), Endemic.

14. Memecylon umbellatum Burm.f., Flora Indica 1768; Pull. *et al.*, Fl. Eastern Ghats 3: 54. 2007; Britto, Fl. Central & North Tamil Nadu 2: 1287. 2019.

Type:—SRI LANKA, Hermann Vol. 1 p. 17, left specimen (BM!).

Distribution: INDIA (Andhra Pradesh, Karnataka, Kerala, Pondicherry & Tamil Nadu) and SRI LANKA.

Note: Leaves are useful for the treatment of stomach ulcers and diabetes (Sankar *et al.*, 2012).

Excluded species

Memecylon jadhavii K.N.Reddy, C.S.Reddy & V.S.Raju in J. Econ. Taxon. Bot. 28(1): 165. 2004, *nom. inval.*

Note: Reddy *et al.* (2004) have described this species based on the specimens collected from Sapprala hills, Northern Eastern Ghats. However, they failed to specify the herbarium where type has been conserved hence it is an invalid name (Art. 37.7 of ICN, Turland *et al.*, 2018). However, POWO (2019), Roskov *et al.* (2019) and Singh *et al.* (2015) erroneously treated this species as an endemic species of Andhra Pradesh.

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An updated checklist of the macrophytes of Chilika Lagoon, its uninhabited islands and shoreline

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ABSTRACT

Chilika, the largest brackish water lagoon of Asia and the largest wintering ground of migratory birds in Indian sub-continent, is situated in coastal Odisha along the east coast of India. The biological diversity of plants of Chilika lagoon and its adjoining regions has been studied by several workers in the past but complete inventory of plant resources of this important Ramsar site has so far not been done. Based on exhaustive and multi-seasonal survey of the lagoon, its shoreline and uninhabited islands under the Integrated Coastal Zone Management Project from 2012-2020 and earlier studies by the present authors and others, an updated checklist of 884 species of flowering plants belonging to 537 genera and 130 families has been prepared and presented in this paper. Out of this, 80 species are reported here for the first time from Chilika lagoon and its adjoining regions. For each species, correct botanical name, family, local name (wherever available), flowering and fruiting time and locality of collection have been provided in the list.

1. Introduction

Studded like a zircon on the golden stretch of eastern seacoast of Orissa in India, Chilika lagoon is a unique assemblage of marine, brackish and fresh water eco-systems with estuarine characters. It was included as one of the first two wetlands of India under the Ramsar Convention in 1981 based on its unique biodiversity and socio-economic importance. The lagoon is an avian wonderland and a staging and wintering ground for more than 210 species of resident and migratory birds including many endangered taxa. Situated between 19^0 28' and 19^0 54' N latitude and 85^0 05' and 85^0 38' E longitude, Chilika is the largest brackish water lagoon in the east coast of India. This tropical wetland is a pear-shaped water body that runs parallel to the Bay of Bengal and is separated from it by a long barrier spit. The lagoon is connected to the sea through a long, constricted inlet channel with a comparatively smaller inlet. It also receives fresh water from 52 river and rivulets, which attribute to its brackish and estuarine character. The water-spread area of Chilika varies between 1165 sq.kms during monsoon to 906 sq.kms in summer. The lagoon can be broadly divided in to four ecological zones, (i) the southern zone, (ii) the central zone, (iii) the northern zone and (iv) the outer channel.

Chilika has a typical physiographic feature experiencing the dynamics of the coastal processes along with the riverine interface. Wave, current and tide, along with storms are the

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coastal processes, responsible for shoreline characteristics and coastal morphology. Chilika belongs to the category of micro-tidal coasts as it experiences tidal variation of less than 2 m, and as such, barrier island, sandy beach and beach ridges characterise the ecosystem. The area experiences a typically tropical monsoon climate with an average annual maximum and minimum temperature of 38.0 ^{0}c and 14.5 ^{0}c respectively. May is the hottest month of the year. It receives maximum rainfall by the influence of southwest monsoon during June to September and moderate rains by the northeast monsoons in November- December. The average annual rainfall of 1712 mm. is recorded at Satapada.

The relative humidity at Satapada was observed to be high due to its proximity to the seacoast and ranges from 39 to 96 % during different seasons of the year. The wind velocity is normally high during summer and low in winter. The wind mostly blows from north and northeasterly direction during October to February and from southerly and southwesterly direction during the period March-September.

The principal rock types encountered in and around Chilika are khondalites, unclassified granites and gneisses, charnockites, anorthosites, granulites, laterites and alluvium. The khondalites are essentially garnet-sillimanite schists with varying quantities of garnet as well as some quartz and feldspar. The soil of the catchment area of Chilika lagoon have been classified under the following broad soil groups (i) Red soils (Alfisols) (ii) Laterite soils (iii) Black soils (Vertisols) (iv) Brown forest soils and (v) Alluvial soils

Hydrologically, Chilika is influenced by three systems viz. Mahanadi river system, drainage from western catchments and the Bay of Bengal. The lagoon derives its estuarine character due to the fresh water inflow from as many as 52 rivers and rivulets. The salinity levels show marked variations with time and space. The northern and a part of the central sector as well as the outer channel turn into fresh water during the monsoon season. The southern sector remains almost mesohaline throughout the year and in outer channel and central sector the change of salinity level is quite abrupt. After opening of a new mouth in 2000 opposite to the village Sipakuda at a distance of 7.262 km from Satapada, there has been a marked improvement in the exchange of water between the sea and the lagoon and the salinity regime of the lagoon has been restored.

2. Past studies on flora and vegetation

Chilika lagoon, a unique tropical wetland with estuarine characters, has been a subject of study for a number of workers over last hundred years and provided an excellent opportunity for study of different aspects like hydrology, limnology, ecology, geomorphology, flora, fauna, fisheries etc.

Gupta and Khandelwal (1990, 1992, 1999), Khandelwal and Gupta, 1993, 1994) and Khandelwal *et al*. (2008) by use of fine resolution palynostratigraphy attempted to reconstruct the past mangrove vegetation of Chilika. Analysis of the pollen from a 5.5-meter deep profile from Balugaon they reported the existence of both core mangroves and the mangrove associates some 3100 years before present. They concluded that the mangrove associates dominated the area and the core mangroves were less diverse and sparsely distributed. The overall dominance of the pollens of the core mangrove taxa, viz., *Rhizophora, Ceriops, Bruguiera* and *Kandelia* were observed at a depth of 5.50-4.40m of the core sample. From this finding, they inferred that this zone originated some 700 years before present. Similarly, the mangrove associates like *Avicennia, Excoecaria, Acanthus, Lumnitzera, Terminalia,* etc. existed some 300 years before present. They had attributed the degradation and the subsequent disappearance of the mangroves due to the fluctuation of the water level leading to the recession in the tidal magnitude and at the same time increase in the fresh water discharge and biotic pressure.

Though the algae, diatoms and other algal forms occurring in Chilika have been studied in detail, no concerted attempt has yet been made to survey and document the higher plants of this region. Published literature on floristic study of this important wetland is scanty. While describing the fauna of the lagoon, Annandale & Kemp (1915) and Annandale (1922) have discussed about the vegetation and dominant plant species occurring in Chilika and its uninhabited islands. Biswas (1932) also made a brief mention of the dominant aquatic angiosperms and terrestrial plants inhabiting the islands while describing the algal flora. Narayanswami & Carter (1922) have supplemented this with an enumeration of 142 species of flowering plants and ferns occurring in Badakuda island alone. Haines (1921-1925) and Mooney (1950) have cited Chilika as locality of occurrence for few plant species in their treatise largely based on the collections of Dr. Alcock, Hooper, Prain's collector, Prof. P. Parija and his colleagues. Patnaik (1973 & 1980) studied the qualitative and quantitative distribution of the dominant submerged phanerogams in different parts of the lagoon in relation to different seasons, salinity levels, bathymetry, character of the substratum and other physico-chemical characteristics of the water. He dealt with the distribution of five important macrophytes viz. *Potamogeton pectinatus, Najas foveolata, Halophila ovalis, Ruppia maritima* and *Halophila beccarii* and discussed about the methods of utilization of these aquatic plants. An ecological analysis of

the strand vegetation of Orissa coast in general, including that of Chilika was made by Rao & Mukherjee (1975). Paul *et al.* (1980) published a note on the occurrence and distribution of five interesting plant species from the lagoon and its vicinity including *Rhamnus prostrata, Grewia bracteata* (=*Grewia obtusa*) and *Ludwigia hyssopifolia*. Based on the study of specimens available in different Indian herbaria, Mishra *et al.* (1983) reported the occurrence of three species namely, *Neptunia triquetra, Sesbania procumbens* and *Halophila beccarii* from Chilika and its environs as new plant records for the state of Orissa. However, occurrence of *Halophila beccarii* in the lagoon has been earlier reported by Patnaik (1973).

Rao (1970) enumerated 16 forest species with botanical description and utilitarian aspects, which are used in the fishing industry for making crafts, sails, canoes, floats, baskets, fishing rods, tanning of fishing nets and packing of fish, shrimp and crabs in the lagoon. Roy (1955) also brought out a similar publication on utility of the forest products of Orissa in fisheries of the lagoon.

The account of the flora and vegetation of the lagoon by Panigrahi (1988) was entirely based on the work of Narayanswamy and Carter (1922). Panda & Patnaik (1988) have made significant contributions to the floristic of this region in particular and based on their own collections, reported the occurrence of 352 angiospermic plant species belonging to 272 genera and 96 families. Of these, *Macrotyloma ciliatum* (Panda *et al.*, 1985) and *Heliotropium curassavicum* (Panda *et al.*, 1988) were reported to be new plants records for eastern India and Orissa respectively. Besides, many rare plants were found to occur along the coast and uninhabited islands of Chilika. Das *et al.* (1994) enumerated the aquatic plants of coastal Orissa including many from Chilika lagoon. Subsequently, Panda & Patnaik (2002) enumerated 546 species of angiospermic plants from Chilika lagoon and its immediate neighbourhood. The most comprehensive and extensive survey of the flora of this region was carried out by Panda *et al.* (2002) and a checklist of 711 species of angiospermic belonging to 492 genera and 119 families was brought out. Patnaik *et al.* (2003) analysed the flora and vegetation of Chilika and its neighbourhood with emphasis of floristic composition of special habitats.The taxonomy, diversity and distribution of sea grasses of Chilika lagoon was studied by Pattnaik *et al.* (2008) in response to fluctuation in salinity, hydrological parameters, substrate characteristics etc. They reported the occurrence of *Halodule uninervis*as a new record for East Coast of India and three other species such as *Haloduleuninervis, Halophila ovata* and *Halodule pinifolia* turned out to be new distributional record for Chilika lagoon.

3. Results and discussion

Recently, a multi-seasonal floristic inventory and quantitative assessment of vegetation of Chilika and its neighbourhood was undertaken during a period of four years from 2012 to 2016 under the Integrated Coastal Zone Management (ICZM) project and several species hitherto not reported from this area have been collected, identified and enumerated. Based on this work, Kar *et al.* (2016) reported the occurrence of 79 additional species for the flora of Chilika lagoon and its immediate neighborhood, bringing the total number of known taxa to 804 under 531 genera and 120 families. Subsequent field work carried out by the authors till May 2020, another 80 species have been added to the list of flowering plants of this region.

An updated checklist of 884 species of flowering plants belonging to 537 genera and 130 families has been prepared and presented in this paper. The family Poaceae was represented by 92 species followed by Fabaceae (80), Euphorbiaceae (42), Cyperaceae (41), Acanthaceae (35), Rubiaceae (30), Astearceae (27), Convolvulaceae (24), Malvaceae (18), Apocyanaceae (17) and Mimosaceae (17). The list of 10 dominant family and their composition is given in Table 1. In the enumeration, for each species, correct botanical name, family, local name (wherever available), flowering and fruiting time and localities of collection have been provided (Table 2).

Table 1

List of ten dominant angiospermic families in the flora of Chilika lagoon and its neighbourhood.

Sl. No.	Name of the family	No. of genera	No. of species
1	Poaceae	56	92
2	Fabaceae	34	80
3	Euphorbiaceae	23	42
4	Cyperaceae	11	41
5	Acanthaceae	20	35
6	Rubiaceae	17	30
7	Astearceae	25	27
8	Convolvulaceae	09	24
9	Malvaceae	08	18
10a	Apocyanaceae	13	17
10b	Mimosaceae	09	17

Table 2

Enumeration of macrophytes (angiosperms) collected from Chilika lagoon, its uninhabited islands and shoreline

Species Name	Local name	Flowering	Fruiting time	Locality of collection time
Dilleniaceae				
Dillenia indica L.	Oau	May-June	Sept.-Feb.	Inzanpur, Belapada, Nairi and Gurubahi.
Magnoliaceae				
Michelia champaca L.	Champa	Mar-Apr	July	Kankadakuda, Alanda and Vaseramundia
Annonaceae				
Alphonsea sclerocarpa Thw.		Feb.-April	July-Sept.	Ghantasila
Annona reticulata L.	Ramphala	June.	Dec.-Jan.	Keshpur, Samolo and Madhurja
Annona squamosa L.	Ata or Sitaphala	Mar-May	July-Sept.	Inzanpur, Sorana, Keshpur, Samolo and Madhurja
Desmos chinensis Lour.	Gaicheria	Apr-May	Sept.-Jan.	Baulabandha, Belapada and Madhurja
Polyalthia cerasoides (Roxb.) Bedd.	Potmossu	Apr-May.	June-Aug.	Samolo and Belapada.
Polyalthia longifolia (Sonn.) Thw.	Debadaru	Mar-Apr	July-Aug.	Madhurja, Charichhok and Janhikuda.
Polyalthia suberosa (Roxb.) Thw.	Lohaniamossu	Apr-May.	Aug.-Nov.	Bhusandapur, Madhurja and Janhikuda.
Uvariahamiltonii Hook. f. & Thoms.	Lakhankoli	May-July	Aug.-Sept.	Gopakuda
Menispermaceae				
Cissampelos pareira var. *hirsuta* (Buch.-Ham. ex DC.) Forman	Akanbindi	June-Nov.	Nov.-Jan.	Ghantasila, Sanakuda and Gopakuda.
Cocculus hirsutus (L.) Diels	Dahidahiya	Nov.-Apr	Mar-May	Khadiparbata, Sana adia and Belapada.
Stephania japonica (Thunb.) Miers.	Akannindi	May-June	Dec.	Gopakuda, Kalijugeswara and Khadiparbata.
Tiliacora acuminata (Lam.) Miers	Kalajatinoi	Apr-June	June-Dec.	Samolo, Madhurja and Sorana.
Tinospora cordifolia (Willd.) Hook. f. & Thoms.	Guluchilata	Aug.-Dec.	Mar-May	Ghantasila, Sorana and Inzanpur.
Nelumbonaceae				
Nelumbo nucifera Gaertn.	Padma	Apr-July	Dec-Jan	Rahanabeli, Bhusandpur, Mangalajodi and Kalupada
Nymphaeaceae				
Nymphaea nouchali Burm.f.	Dhala Kain	Year round		Rahanabeli, Bhusandpur and Mangalajodi
Nymphaea pubescens Willd	Nali Kain	Throughout the year		Rahanabeli and Bhusandapur.
Papaveraceae				
Argemone mexicana L.	Agara	Feb.-June.		Badakuda, Mirzapur and Golabahi.
Brassicaceae				
Rorippa indica (L.) Hiern.		Oct.-Apr		Keshpur, Inzanpur and Sorana.

Capparaceae				
Capparis brevispina DC.	Lepura, Nipura	Jan-Mar.	Apr-June	Rahanabeli, Samolo and Sanakuda.
Capparis floribunda Wight.		Apr-May	June-July	Rahanabeli, kalijugeswara and Sanakuda.
Capparis roxburghii DC.	Handiphuta	Apr-May		Sanakuda, Samolo and Rahanabeli
Capparis sepiaria L.	Kantikapali	Apr	Nov.-Dec.	Kalijugeswara, Badakuda and Samolo.
Capparis zeylanica L.	Asadua	Feb-Oct		Samolo and Rahanabeli.
Cleome aspera Koen. ex DC.			July-Nov.	Rambha and Keshpur.
Cleome monophylla L.	Ranga Sorisa	Feb-June.	Aug.-Dec.	Binchinipatna and Vasera.
Cleome rutidosperma DC.		Dec.-Feb.		Rambha, Pathara, Belapada and Nairi.
Cleome viscosa L.	Anasorisa	May-Oct.		Barkul, Chhtragadamasani, Narayani Petrol pump
Crateva adansonii DC	Varuna	Mar-Apr	Apr-June.	Kalijai, Kalijugeswara, Samolo and Ghantasila.
Crateva magna (Lour.) DC.	Varuna	Mar-Apr	May-June.	Kalupada, Kalijugeswara and Khadiparbata.
Maerua oblongifolia (Forssk.) A. Rich.		Dec-Feb.		Arakhakuda, Odialpur and Chandikhol.
Violaceae				
Hybanthus enneaspermus (L.) F. V. Muell.	Madan mastak	Throughout the year		Ghantasila, Keshpur and Chandokhol.
Flacourtiaceae				
Casearia elliptica Willd.	Khokhoda	Feb.-Aug.		Barkul and Nimuna
Flacourtia indica (Burm. f.) Merr.	Baincha	Dec.-Mar.	Mar-May	Sanakuda, Belapada and Chandikhol.
Flacourtia jangomas (Lour.) Raeusch.	Baincha	June	Oct.-Jan.	Samola Island
Polygalaceae				
Polygala arvensis Willd.	Meradu	June-Dec.		Kalijugeswara, Kalijai, Samoloa and Barunakuda.
Polygala crotalarioides Buch.-Ham.	Ajhaduagada	Apr-June		Sorana
Salomonia ciliata (L.) DC.		Aug.-Sept.		Palur, Kalupada, Bhusandapur and Gudinala.
Caryophyllaceae				
Polycarpaea corymbosa (L.) Lam.	Sanjat-jatia	Oct.-Feb.		Arakhakuda and Odialapur.
Polycarpon prostratum (Forssk.) Asch. & Schweinf.	Ghima	Nov.-May.		Kalupada, Palur, Sorana and Baulabandha.
Portulacaceae				
Portulaca oleracea L.	Badabalbalua	All seasons		Sorana, Madhurja and Balapada.
Portulaca quadrifida L.	Balbalua	All seasons		Alanda, Gadisagada, Nairi and Barunakuda.
Elatinaceae				
Bergia ammannioides Roxb.		Aug.-Mar.		Sabulia, Rambha and Barunakuda.
Bergia capensis L.		Sept.-Dec		Sorana, Nairi and Kalupada.
Clusiaceae				
Calophyllum inophyllum L.	Polang	Mar-June	Oct.-Nov.	Chandikhol and Talatala.

Bombacaceae				
Bombax ceiba L.	Simili	Jan.-Mar.	Mar-May	Gaurangapatna and Sanakuda.
Ceiba pentandra (L.) Gaertn.	Dhala Simili	Jan.-June.		Mirzapur, Nairi and Belapada.
Malvaceae				
Abelmoschus ficulneus (L.) Wight &Arn. ex Wight.	Jangali Bhendi	Oct-Nov.	Nov.-Mar.	Rambha and Barkul.
Abelmoschus manihot subsp. *tetraphyllus* (Roxb. ex Horn.) Borssum	Bana Bhendi	July-Oct.	Nov.-Jan.	Pathara, Sorana and Nairi
Abelmoschus moschatus Medic.	Bana Bhendi	Aug.-Nov.	Oct.-Jan.	Madhurja, Hatabaradi and Janhikuda.
Abutilon hirtum (Lam.) Sweet	Barkanghi	Oct-Apr		Barkul, Dangua and Kanakasankha.
Abutilon indicum (L). Sweet	Pedi-pedika	July-Apr		Barkul, Belapada and Madhurja.
Hibiscus ovalifolius (Forsk.) Vahl		Sept.-Oct.		Sabulia, Narayanapatna and Binchinipatna.
Hibiscus rosa-sinensis L.	Mondaro	Throughtout the year		Barkul, Nimuna, Nairi, Gurubahi and Belapada.
Hibiscus sabdariffa L.	Khattaplanga	July-Oct.	Oct-Feb.	Palur, Sorana, Gudinala and Nairi.
Hibiscus tiliaceus L.	Baniya, Halbali	Mar-Apr		Satapada and Baghamunda.
Malachra capitata (L.) L.		Apr-Dec.		Gudinala, Bhusandapur, Bidharpur and Hunjana.
*Pavonia odorata*Willd.		Aug.-Feb.		Barkul, Inzanpur and Palur.
Pavonia zeylanica (L.) Cav.		July-Dec.		Sanakuda, Keshpur, Palur and Kanakasankha.
Sida acuta Burm. f.	Bajramuli	Sept.-May.		Almost all Shoreline areas of Chilika.
Sida cordata (Burm.f.) Borssum	Bisiripi	Aug-Dec	Nov-Mar	Barkul, Inzanpur and Odialapur.
Sida cordifolia L.	Bisiripi	Aug.-Dec.	Oct.-Jan.	Kalupada, Mangalajodi and Bhusandapur.
Sida rhombifolia L.	Bajramuli	Aug.-Feb.		Upulialapur, Janhikuda and Belapada.
Thespesia populnea (L.) Soland ex Corr.	Porosopippali, Goya	Aug.-Jan.		Kalijai, Ghantasila and Kalijugeswar
Urena lobata L. subsp. *sinuata* (L.) Borssum	Kunguya, Lot lotti	Aug.-Dec.		Gurubahi and Janhikuda.
Sterculiaceae				
Guazuma ulmifolia Lam.	Debodaru	Apr-July	Oct.-Feb.	Palur canal, Vaseramundia and Chandikhol.
Helicteres isora L.	Modimodika	Apr-Dec.	Oct.-Jan.	Belapada and Janhikuda.
Melochia corchorifolia L.	Telpuri	July-Dec.		Chhatragada Masani, Barkul and Belapada.
Pterospermum xylocarpum (Gaertn.) Sant & Wagh.	Giringa	Oct.-Dec.	Apr-May.	Rahanabeli and Gaurangapatna.
Sterculia foetida L.		Mar-July.	Oct.-Jan.	Kalijugeswara, Sorana and Baulabandha.
Sterculia urens Roxb.	Genduli, Kodala	Dec.-Mar.	Apr-Aug	Madhurja, Satapada and Hunjana.
Sterculia villosa Roxb. ex. DC.	Kodalo	Jan.-Mar.	May-June	Gudinal, Dangua and Gopakuda.
Waltheria indica L.		Aug.-Jan.		Upulialapur and Bhusandapur.
Tiliaceae				
Corchorus aestuans L.	Bananalita	July-Sept.	Oct.-Dec.	Belapada, Keshpur and Madhurja.

Corchorus capsularis L.	Jhota	May-Nov.		Gurubahi, Janhikuda, Kanakasankha and Sabulia.
Corchorus fascicularis Lam.		July-Nov.		Kalijai, Belapada and Nimuna.
Grewia disperma Rottl.	Mirga Chara, Gara Bursu	June-Sept.	Oct.-Jan.	Kalijugeswara, Nimuna, Nairy and Sorana.
Grewia obtusa Wall. ex Gamble		April- July		Sabulia and Ghantasila
Grewia rhamnifolia Heyne ex Roth.		July-Sept.	Sept.-Nov.	Kalijugeswara, Gopakuda and Kalijai.
Grewia rothii DC.	Phulari, Mirigchara	Apr-June.	Sept.-Oct.	Kalijai, Kankadakuda and Adia.
Grewia sapida Roxb.	Burso	Feb.-Apr	Apr-May.	Chhatragadamasani, Gadisagada and Rahanabeli.
*Grewia tiliifolia*Vahl	Dhamana	Apr-June.	Sept.-Oct.	Nairi, Sorana, Madurja and Gaurangapatna.
Hugonia mystax L.	Chulijhinka	May-June.	Aug.-Oct.	Upulialapur, Sanakuda, Belapada and Madhurja.
Linum usitatissimum L.	Pesu	Oct.-Jan.		Keshpur, Madhurja and Hunjana.
Triumfetta pentandra		Aug-Sept.	Oct.-Nov.	Belapada, Inzanpur, Bhusandapur and Gaurangapatna.
Triumfetta rhomboidea Jacq.		July-Jan.		Samolo and Sanakuda
Malpighiaceae				
Aspidopterys indica (Roxb) Hochr.	Dholaatundi	Sept.-Oct.	Nov-Jan.	Krushnaprasad, Bidharpur and Gudinala.
Hiptage benghalensis (L.) Kurz	Madhabilata	Feb.-Mar.	Mar-May	Bhasramundia, Baulabandha and Nimuna
Zygophyllaceae				
Tribulus terrestris L.	Gokhara	All the year round		Pathara, Bhusandapur, Charichhok and Nairi shore
Oxalidaceae				
Biophytum sensitivum (L.) DC.	Chhotalajakuli	July-Dec		Belapada, Madhurja and Sabulia.
Oxalis corniculata L.	Ambiliti	All the year round		Kalupada, Inzanpur and Bhusandapur.
Rutaceae				
Aegle marmelos (L.) Corr.	Belo	Mar-Apr	Ripening next year	Rambha, Madhurja and Inzanpur.
Atalantia monophylla (L.) Corr.	Narguni	Feb.-Mar.	May-June	Kalijugeswara and Gurubahi.
Citrus medica L.	Lembu	Throughout the year		Ghantasila, Sanakuda, Nimuna, Nairi and Madhurja
Glycosmis mauritiana (Lam.) Tanaka	Lankabadam	Dec.-Feb.		Belapada, Chandikhol, Kalijai and Kalijugeswara.
Glycosmis pentaphylla (Retz.) DC.	Chaludhuakoli	Oct.-Dec.	Nov.-Apr	Samolo, Badakuda and Kalijugeswar.
Limonia acidissima L.	Kaitha,Kaintha	Feb.-Apr	Nov.-Jan.	Chandikhol, Talatala and Charichhok.
Murraya koenigii (L.) Spreng.	Bhursunga	Feb.-Apr	May-Sept.	Nairi, Belapada and Sorana.
Murraya paniculata (L.) Jack	Kamini	Apr-July	Dec.-Jan.	Samolo, Gurubahi and Sorana.
Toddalia asiatica (L.) Lam.	Tundpora	Aug.-Apr		Rambha, Gaurangapatna and Charichhok.
Simaroubaceae				
*Ailanthus excelsa*Roxb.	Mahala	Feb.-Mar.	May-July	Hunjana, Krushnaprasadgada and Hatabaradi.

Ochnaceae				
Ochna obtusata DC.	Bhuinchampa	Mar-May	June-July	Gopakuda, Kalijugeswara and Mirzapur.
Burseriaceae				
Commiphora caudata (Wight & Am.) Engl.	Gogul	May		Pathara, Odialpur and Belapada.
Protium serratum (Wall. ex Colebr.) Engl.	Nimburamoi	Mar-Apr	May-June	Gaurangapatna, Badakuda, Sabulia and Numuna
Meliaceae				
Azadirachta indica A. Juss.	Limba, Nima	Feb.-May	June-July	Nairi, Inzanpur, Barkul and Kalijugeswara.
Cipadessa baccifera (Roth) Miq.	Nalbali, Pittamari	Mar-June	May-Nov.	Barkul, Keshpur and Gaurangapatna.
Melia azedarach L.	Mahanimbo	Mar-June	Oct.-Dec.	Kalijai, Ghantasila, Sanakuda and Gurubahi.
Walsura trifoliata (A. Juss.) Harms	Mundika	Feb.-June		Kalupada, Bhusandapur and Nairi.
Celastraceae				
Cassine albens (Rottb.) Kuntze	Chauli	Sept.-Dec.	Dec.-Feb.	Ghantasila island
Celastrus paniculata Willd.	Pengu, Ping	Apr-June.	Oct.-Jan.	Khadiparbata and Kalijai.
Maytenus emarginatus (Willd.)	Ding Hou	Nov.-Dec.	Jan.-Mar	Kalijugeswara and Alanda.
Hippocrateaceae				
Reissantia indica (Willd.) Helle	Katha paharia	Apr-May.		Badakuda.
Salacia chinensis L.	Batra	Mar-Apr		Barunakuda, Bada adia, Bhaseramundia
Rhamnaceae				
Colubrina asiatica (L.) Brongn.		Dec.-Mar		Mirzapur and Odialapur
Gouania leptostachya DC.	Raktapitchali, Rangchero	Aug.-Sept.	Nov.-Dec.	Samolo, Kalupada, Inzannpur and Chhatragada
*Rhamnus prostrata*Jacq. ex Parker		May-Aug		Badakuda island
Scutia myrtina (Burm.f.) Kurz.		Apr-May.		Kalijugeswara, Samolo, Nairi and Kankadakuda.
Ventilagodenticulata Willd.	Pitchuli	Sept.-Nov.	Feb.-Apr	Baghamunda and Bidharapur.
Rhamnaceae				
Ziziphus mauritiana Lam.	Barokoli	Mar-Oct.	Jan.-Mar	Badakuda, Sorana, Ghantasila
Ziziphus mauritiana var. *fruticosa* (Haines) Sebastine. & A. N. Henry		Aug.-Feb.		Samolo, Sanakuda and Nairi
Ziziphus oenoplia (L.) Mill.	Kanteikoli	June-Sept.	Oct.-Jan.	Samolo, Ghantasila, Sanakuda and Badakuda.
Ziziphus xylopyrus (Retz.) Willd.	Gotha, Gotha bara	Mar-June.	Oct.-Jan.	Samolo, Pathara and Gaurangapatna.
Vitaceae				
Ampelocissus tomentosa (Roth) Planch.	Konjanoi/Katobhangonoi	July-Sept.	Sept.-Nov.	Kalijugeswar, Samolo and Ghantasila
Ampleocissus latifolia (Roxb.) Planch.	Kanjinai	June-Aug.	Aug.-Oct.	Gheekol, Diandein and Gaurangapatna.
Cayratia pedata (Lour.) Juss. ex Gagnep.	Pitapotala	Mar-Aug.		Ghantasila, Kalijugeswara and Khadiparbata.

Cayratia trifolia (L.) Domin.	Ambiliti	July-Aug.	Oct.-Nov.	Kalijugeswata, Ghantasila and Khadiparbata.
Cissus adnata Roxb.		Aug.-Jan.		Ghantasila and Kalijugeswar Island
Cissus quadrangula L.	Hadabhanga	Apr-Jan.		Kalijai, Ghantasila and Kalijugeswara.
Cissus vitiginea L.	Jangliangur	July-Oct.	Aug.-Nov.	Samolo, Gopakuda and Barunakuda.
Cyphostemma auriculatum (Roxb.) P.Singh & B.V. Shetty		May-Oct.		Ghantasila and Kalijugeswar
Sapindaceae				
Allophylus serratus (Roxb.) Kurz	Khandkoli	July-Aug.	Sept.-Oct.	Khadibarbata, Barunakuda and Kalijugeswara
Cardiospermum halicacabum L.	Phutphutika	Apr-Nov.		Sanakuda and Kalijugeswara.
Dodonaeaviscosa (L.) Jacq.	Mahada	Most part of the year		Chandikhol, Mirzapur and Alupatna.
Lepisanthes tetraphyllus (Vahl) Radlk.	Panikusum	Apr	Apr-May.	Samolo, Kalijugeswara and Kalijai.
Schleichera oleosa (Lour.) Oken.	Kusum	Feb.-Mar.	June-Aug.	Kankadakuda and Kalijai.
Anacardiaceae				
Anacardium occidentale L.	Kaju	Mar-Apr	Apr-May.	Chandikhol, Odialapur and Talatala.
Lannea coromandelica (Houtt.) Merr.	Mahi, Jia	Mar-Apr	Apr-June.	GaurangapatnaMathakona and Binchinipatna.
Mangifera indica L.	Amba	Jan-Mar.	Apr-May.	NarayaniPetol Pump, Belapada and Madhurja
Semecarpus anacardium L.	Bhalia	June-Sept.	Nov.-Dec.	Chandikhol, Alupatna and Talatala.
Caesalpiniaceae				
Bauhinia purpurea L.	Barada, Kuilari	Sept.-Feb.	Feb.-Mar.	Nairi, Sabulia and Bidharpur.
Caesalpinia bonduc (L.) Roxb.	Gila	Aug.-Oct.	Dec.-Apr	Kalijugeswara, Kalijai, Sanakuda and Madhurja.
Caesalpinia digyna Rottl	Gila, Tari	Jan-Mar.		Gaurangapatna, Madhurja and Baulabandha
Caesalpinia pulcherrima (L.) Sw.	Godibana	Most part of the year		Ghantasila and Gaurangapatna.
Cassia absus L.		Aug.- Nov.		Inzanpur, Chhtragadamasani, Belapada
Cassia fistula L.	Sunari	Apr-June	Most part	Nairi, Bidharapur and of the year Chhatragadamasani
Cassia mimosoides Lam.		Aug-Dec		Kalijugeswara, Gopahuda and Nimuna.
Cassia occidentalis L.	Bana Chakunda	Sept.-Nov.	Dec.-Feb.	Barkul, Nairi and Sorana.
Cassia siamea Lam.		Sept.-Dec.		Samolo, Hatabaradi and Kanakasankha.
Cassia tora L.	Chakundi	Sept.-Nov.	Nov.-Dec.	Almost all Islands and some shore areas of Chilika.
Delonix regia (Boj. ex Hook.) Raf.	Krusnhachuda	Apr-June.		Bhusandapur, Barkul and Rahanabeli.
Parkinsonia aculeata L.		Mainly Nov. -Mar.Most part of the year.		Gopakuda and Rambha.
Peltophorum pterocarpum (DC.) Backer ex K. Heyne	Radha chuda	Mar-May	Apr-Dec.	Gheekhol, Krushnaprasad, and Gurubahi.
Senna obtusifolia (L.) H.S.Irwin & Barneby		Sept.-Nov.	Nov.-Dec.	Belapada and Sanakuda
Tamarindus indica L.	Kaiyan, Tentuli	Apr-June.	Dec.-Mar.	Sanakuda, Kankadakuda and Hunjana.
Mimosaceae				
Acacia auriculiformis A. Cunn. ex Benth.	Akasi, Akasia	Most part of the year.		Madhurja, Gaurangapatna, Gurubahi

Acacia caesia (L.) Willd.	Dentari	Sept.-Oct.	Feb.-April	Samolo, Sanakuda, Gaurangapatna and Madhurja
Acacia leucophloea (Roxb.) Willd.	Gohira	Aug.-Oct.	Dec.	Samolo, Kalijugeswara and Adia.
Acacia nilotica Delile ssp. *indica* (Bent.) Brenan	Babul	Aug.-Dec.	Jan.-Apr	Belapada, Madhurja, Gaurangapatna, Ghantasila.
Acacia pennata (L.) Willd.	Dantari	May-Aug.	Oct.-Dec.	Odialapur, Inzanpur and Sorana.
Acacia polyacantha Willd.	Sami	Aug.-Sept.	Dec.-Apr	SamoloJ
Albizia lebbeck (L.) Benth.	Sirisa	Apr-June	Oct.-Jan.	Chhatragada Masani, Bidharpur and Sanakuda.
Albizia odoratissima (L. f.) Benth.	Kala siriso, Sirish	May-June	Nov.-Feb.	Rahanabeli and Baulabandha
Albizia procera (Roxb.) Benth.	Tentra	Aug.-Sept.	Dec. May	Baulabandha
Dichrostachys cinerea (L.) Wight &Arn.	Koiridyo	Apr-July	Nov.-Feb.	Sanakuda, Samolo and Gaurangapatna.
Leucaena leucocephala (Lam.) de Wit.	Subabul	May-June	Aug.-Oct.	Upulialapur, Bada adia and Bhaseramundia.
Mimosa pudica L.	Lajakuli	Aug. - May.		Kalupada, Mangalajodi and Bhusandapur.
Neptunia oleracea Lour.		Jan.-Nov.		Tinimuhani
Neptunia triquetra (Vahl) Benth.		May-Nov.		Balugaon and Nairi
Pithecellobium dulce (Roxb.) Benth.	Simakoian, Bilati Koian	Jan.-Mar.	Apr-June.	Kalipada, Sorana, Nairy, Madhurja, Gurubahi
Prosopis juliflora (Sw.) DC.		Oct.-Mar.	Feb.- May.	Ghantasila, Kalijugeswara and Bada adia.
Samanea saman (Jacq.) Merr.	Chakunda	Mar- Apr	May-July.	Inzanpur, Madhurja, Kalijai and Gopakuda.
Fabaceae				
Abrus precatorius L.	Kaincha	Aug.-Sept.	Nov.-Mar.	Upulialapur, Baulabandha and Dangua.
Aeschynomene americana L.		Oct.-Dec.		Nairi and Bhusandpur
Aeschynomene aspera L.	Sola	Aug.- Oct	Nov.-Jan.	Kalupada, Bhusandpur and Nimuna
Aeschynomene indica L.	Sola karana	July-Nov.		Belapada, Kalupada and Alupatna.
Alysicarpus monilifer (L.) DC.		Sept.-Jan.		Kalijugeswar and Ghantasila
Alysicarpus roxburghianus Thoth. & Pramanik		July- Sept.		Sorana.
Alysicarpus scariosus (Rottl. ex Spreng.) Grah. ex Thw.		Sept.-Nov.		Kalijugeswar and Kalijai
Alysicarpus vaginalis (L.) DC. Prod.		Sept.-Jan.		Odialapur, Badakuda, Patnasi and Alanda.
Atylosia scarabaeoides (L.) Benth.	Ban-Kolathia	Aug.-Jan.		Kalupada, Hunjana and Inzanpur.
Butea monosperma (Lam.) Taub.		Feb.-Apr	May-July	Luniput, Rambha, Samolo and Kalijugeswara.
Butea superba Roxb.	Lata palas	Mar-Apr	June-July	Kalijugeswara, Kankadakuda and Kalijai.
Cajanus cajan (L). Huth.	Arhar, Kandula	June-Sept.	Dec.-Feb.	Barkul, Madhurja and Gurubahi.
Cajanus volubilis (Blanco) Blanco.	Banakandula	Nov-Mar.		Bhusandapur
Canavalia maritima (Aub.) Thouars	Luna Simba	Aug.-Sept.		Arakhakuda and Mirzapur
Canavalia virosa (Roxb.) Wt. &Arn.	Maharada	Dec-Mar		Kalijugeswar, Gopakuda.
Clitoria ternatea L.	Aparajita	July-Oct.	Nov.-Dec.	Kalijugeswara, Sanakuda, Ghantasila and Keshpur.
Crotalaria albida Heyne ex Roth		Sept.-Jan.		Sanakuda, Samolo and Mirzapur

Crotalaria calycina Schrank		Sept.-Jan.		Samolo and Kalijugeswar
Crotalaria juncea L.	Choni, Chanapata	Aug.-Feb.		Hatabaradi, Mirzapur, Janhikuda and Baghamunda.
Crotalaria laburnifolia L.		Aug-Jan.		Khirisahi
Crotalaria nana Baker.		Nov-Dec.		Belapada and Samolo.
Crotalaria pallida Ait.	Jhunjhunika	Throughout the year		Samolo, Sanakuda and Nairi
Crotalaria prostrata Rottl	Vishnukarni	Sept -Apr		Samolo, Sanakuda and Barunakuda.
Crotalaria retusa L.		Aug.-March		Nairi and Kalupada
Crotalaria spectabilis Roth	Haridijilingi	Sept.-May		Chandikhol and Sanakuda
Crotalaria verrucosa L.	Jhunka	Oct.-May		Barkul, Samolo and Sanakuda.
Dalbergia paniculata Roxb.	Dhobani	Feb.-Oct.		Kalijugeswar and Ghantasila
Dalbergia rubiginosa Roxb.	Kanchanai	Mar-May	Apr- June.	Samolo, Ghntasila and Belapada.
*Dalbergia sissoo*Roxb.	Sisu	Mar-June	Nov-Feb.	Ghantasila
Derris scandens Lour.	Kentia, Mohagano	July-Feb.		Samolo and Upulialpur
Derris trifoliata Lour.	Ketia	Mar-Apr	Sept.-Oct.	Ghantasila and Barkul.
Desmodium biarticulatum (L.) Muell.		Aug.-Sept.		Alupatna, Baghamunda and Chandikhol.
Desmodium gangeticum (L.) DC.	Salaparni	May-June.		Binchinipatna, Sorana and Kansarimuhana.
Desmodium heterophyllum (Willd.) DC.	Lathna	May-Dec.		Gopakuda and Belapada
Desmodium triflorum (L.) DC.	Chhenakuradhia	Most part of the year.		Belapada, Bidharapur and Hunjana.
Dicerma biarticulatum (L.) DC.		Sept.-April		Baulabandha and Nimuna
Dolichos trilobus L.	Lata Kolatha	Sept.-Oct.	Nov.-Dec.	Gopakuda, Sanakuda and Ghantasila.
Dunbaria rotundifolia (Lour.) Merr.		Sept- Nov.		Baradihi
Erythrina suberosa Roxb.	Paldua, Chaldua	Mar-May	Apr-June	Ghantasila, Kalijugeswara and Kankadakuda.
Erythrina variegata L.	Paladhua	Mar-Apr	Apr- July	Kalijai, Sorana and Gurubahi.
Galactia tenuiflora (Klein. ex Willd.) Wight &Arn.	Bankolata	Sept.-Oct.	Oct.-Nov	Baulabandha
Gliricidia sepium (Jacq.) Kunth ex Walp.		Feb.-Apr	Apr-May	Kalijugeswara, Hunjana and Gurubahi.
Indigofera arrecta Hochst. ex A. Rich.		Sept.-Oct.	Nov.	Samolo, Gopakuda, Binchinipatna and Belapada.
Indigofera aspalathoides Vahl		Aug.		Samolo, Sanakuda, Mirzapur and Chandikhol.
Indigofera astragalina DC.		May-Dec.		Belapada, Nairy, Sabulia and Sorana.
Indigofera glabra L.		July-Nov		Barunakuda, Sipakuda and Arakhakuda.
Indigofera linifolia (L.f.) Retz.	Torki	Aug.-Jan.		Hunjana, Keshpur and Kanakasankha.
Indigofera linnaei Ali	Latahai	Aug.-Dec.		Samolo, Kankadakuda and Sanakuda
Indigofera nummularifolia (L.) Liv. ex Alston		Aug.-Dec.		Hunjana, Sabulia and Belapada.
Indigofera nummularifolia (L.) Livera ex Alston		Aug.-Dec.		Langaleswara and Odialpur
Indigofera tinctoria L.	Nili	Sept.-Oct.	Nov.-Jan.	Samolo, Khadiparbata, Barunakuda.

Indogofera prostrata Willd.		Sept.-Nov.		Baulabandha, Dangua and Keshpur.
Lablab purpureus (L.) Sweet	Simba	Nov-Feb		Barkul, Inzanpur, Nairy and Gurubahi.
Macrotyloma ciliatum (Willd.) Verdc.		Jan-Mar		Badakuda, Sanakuda and Ghantasila.
Macrotyloma uniflorum (Lam.) Verde.	Kolatha	Sept.-Nov.	Oct.-Dec.	Madhurja, Sabulia, Hatabaradia and Binchinipatna.
Mucuna monosperma DC. ex Wight	Baidanka	Nov.-Dec	Feb-Apr	Sorana
Mucuna pruriens (L.) DC.	Baidonka	Sept.-Nov.	Jan.-Apr	Sunderpara, Luniput and Sabulia.
Paracalyxscariosa (Roxb.) Ali.		Feb-Mar.	Mar-June.	Sanakuda Island
Pongamia pinnata (L.) Pierre	Karanjo	May-June	Dec.-Jan.	Ghantasila, Kalijugeswara, Kalijai, Badakuda
Pseudarthria viscida (L.) Wt&Arn.		Nov.-Feb.		Odiaplpur, Belapada and Hatabaradi
Psoralia corylifolia L.	Bakuchi	Dec-Feb		Rahanabelli
Rhynchosia capitata (Heyne ex Roth) DC.		Aug.-Oct.		Kankadakuda, Ghantasila and Samolo
Rhynchosia minima (L.) DC.		Sept.	Nov.	Nimuna, Belapda and Sanakuda
Rothia indica (L.) Druce	Papra	Nov.-Jan.		Chandikhol, Alupatna and Baghamunda.
Sesbania bispinosa (Jacq.) W. F. Wight	Tentua	Aug.-Oct.		Baulabandha and Hatabaradi
Sesbania grandiflora (L.) Poir.	Agasthi	Throughout the year		Nimuna and Charichhak
*Sesbania javanica*Miq.	Kathsola	Sept.-Dec.		Kalupada and Bhusandpur
Sesbania procumbens (Roxb.) Wight &Arn.		Oct.-Jan.		Balugoan, Odialpur, Talatala and Chandikhol.
Smithia confertaJ. E. Sm.		Sept.-Oct.	Nov.	Kanakasankha, Nimuna and Luniput
Smithia sensitiva Ait.		Sept-Nov.		Balipatapur
Stylosanthes fruticosa (Retz.) Alston.		Aug.-Sept.		Pathara, Odalapur and Arakhakuda.
Tephrosia maxima (L.) Pers.		Oct.-Jan		Sanakuda, Samolo, Barunahuda, Arakhakuda and Upulialapur.
Tephrosia purpurea (L.) Pers.	Bana Kolathia	Most part of the year.		Samolo and Keshpur.
Tephrosia villosa (L.) Pers.	Banokolthia	July-Apr		Samolo, Odialapur, Kankadakuda and Gheekhol.
Vigna adenantha (G.F.W. Meyer) Marechal *et al.*	Ban barbati	Sept.-Oct.	Oct.-Nov.	Barkul and Pathara.
Vigna mungo (L.) Hepper	Biri	Nov-Jan		Samolo, Pathara, Keshpur and Belapada
Vigna radiata (L.) Wilczek	Mungo	May-Dec.		Barkul
Vigna sublobata (Roxb.) Bairig.	Ban biri, Purburi	Sept.-Oct.	Oct.-Nov.	Ghantasila, Sanakuda and Gopakuda.
Vigna trilobata (L.) Verdc.	Sana muga	Sept.- Feb.		Badakuda, Keshpur and Nairy Jetty.
Zornia gibbosa Span.	Chhenakuradhia	Aug.-Dec.		Madhurja, Sanakuda and Gudinala.
Vahliaceae				
Vahlia dichotoma (Murray) Kuntze		Oct-Jan		Nandala, Barul, Rajhans, Belapada and Luniput.
Vahlia digyna (Murray) Kuntze				Gaurangapatna, Belapada and Luniput.

Rhizophoraceae				
Bruguiera gymnorrhiza (L.) Savigny	Kekra, Rasinia	Mar-Apr		Rambhartia.
Cassipourea ceylanica (Garden.) Aston.		Feb.		Sanakuda, Badakuda, Samolo and Ghantasila.
Ceriops decandra (Griff.) Ding Hou	Garani	Throughout the year.		Arakhakuda and Rambhartia
Kandelia candel (L.) Druce	Sinduka	Apr- June.		Arakhakuda and Rambhartia
Rhizophora mucronata Poir.	Rai	Apr- June.		Arakhakuda and Rambhartia
Combretaceae				
Calycopteris floribunda Lam.	DhalaAtundi	Mar-Apr	May.	Kalijai and Sorana.
Combretum albidum G. Don	Atudi	Feb-Mar	Apr-May	Ghantasila and Hunjana.
Combretum roxburghii Spreng.	Kala Atundi	Nov.-Feb.	Mar-June.	Gaurangapatna and Rambha.
Quisqualis indica L.	Madhu malati	Most part of the year.		Hunjana, Baghamunda and Alupatna.
Terminalia arjuna (Roxb. ex DC.) Wight. & Arn.	Arjuna	May-July	Oct.-Feb.	Kalupadaghat, Gurubahi and Gaurangapatna.
Terminalia bellirica (Gaertn.) Roxb.	Bahada	Mar-May	Oct.-Dec.	Kalijugeswara, Binchinipatna and Chandikhol.
*Terminalia catappa*L.	Desi Badam	March-May	Nov.-Dec.	Rambha and Sanakuda
Myrtaceae				
Callistemon citrinus (Curtis) Stapf	Bottle Brush	Most part of the year.		Barkul, Kalijai, Ghantasila and Samolo.
Eucalyptus citriodora Hook.	Bhujapatra	May-Aug.		Sanakuda Island
Eugenia rothii Panigr.	Sagadabatuakoli	Mar-June	July-Nov	Narayani Petrol Pump, Palur canal and Madhurja.
Psidium guajava L.	Pijuli	Most part of the year.		Ghantasila, Badakuda, Nairy and Bidharapur.
Syzygium cumini (L.) Skeels in U.S.D.A.	Jamukoli	Apr-May	July-Aug	Pathara, Bhaseramundia and Sanakuda.
Barringtoniaceae				
Barringtonia acutangula (L.) Gaertn.	Hinjala	Apr-June	Sept	Pathara, Belapada, Kalijugeswara and Bhusandapur.
Melastamataceae				
Melastoma malabathricum L.	Gangei	Feb-May	Nov-Dec	Nairi
Memecylon umbellatum Burm.	Niraisa Koli	Mar-June	Aug.- Sept.	Sanakuda, Samolo and Badakuda.
Osbeckia zeylanica L.f.		Mar.		Odialpur, Bhasera, Barunakuda and Samolo.
Lythraceae				
*Ammannia baccifera*L.	Ramdauni	Sept.-Nov.	Nov.-Mar.	Hunjana and Janhikuda.
Ammannia multiflora Roxb.		Sept.-Nov.	Nov.-Dec.	Kalupada, Inzanpur and Binchinipatna.
Lagerstroemia reginae Roxb.	Patali	Apr-Aug.	Sept.-Dec.	Rambha, Kalijugeswara and Madhurja.
Nesaea lanceolata (Heyne ex C.B.Cl.) Koehne		Nov.-Jan.		Baghamuna, Arakakuda and Alupatna.
Rotala indica (Willd.) Koehne	Badabadi	Oct-Dec		Gurubahi.
Rotala rosea (Poir.) Cook		July-Jan.		Rambha, Gaurangapatna and Madhurja.
Rotala rotundifolia (Buch.-Ham. ex Roxb.) Koehne.	Painlatkana		Jan.-May.	Kalupada, Gudinal and Sorana.

*Rotala verticillaris*L.		Dec.-Feb.		Talatala, Chandikhol and Odialapur
Punicaceae				
Punica granatum L.	Dalimba	Apr-May	July-Sept.	Ghantasila and Badakuda.
Onagraceae				
Ludwigia adscendens (L.) Hara.	Jagal	Dec-July		Bhusandapur, Rahanabeli and Pathara.
Ludwigia perennis Linn.	Bilalabanga	Oct.-Nov.	Nov.-Jan.	Kalupada, Mangalajodi and Bhusandapur.
Ludwigia hyssopifolia (G. Don) Excell		Oct.-Dec.	Dec.-Jan.	Kalupada and Bhusandpur
Ludwigia octovalvis (Jacq.) Raven		Oct.-April		Kalupada and Bhusandpur
Trapaceae				
Trapa natans Linn. var. *bispinosa* (Roxb.) Makino.	Pani Singada	June- Aug.	Oct	Kalupadaand Tampara.
Turneraceae				
Turnera ulmifolia L.		Most part of the year.		Madhurja, Rambha and Binchinipatna.
Passifloraceae				
Passiflora foetida L.	Bisiripi	Nov.-June.		Ghantasila, Kalijugeswara and Gurubahi.
Passiflora suberosa Linn.		Sept- Oct	Oct- Dec	Gopakuda, Samolo and Ugratara
Cucurbitaceae				
Coccinia grandis (L.) Voigt.	Kainchikakudi	Most part of the year.		Kalijugeswara, Kalijai and Nairi
*Cucumis trigonus*Roxb.	Bana Kakudi	Aug.-Oct.		Ghantasila, Madhurja and Rambha.
Diplocyclos palmatus (L.) Jeffrey.	Shivalingi	Oct-Jan		Gopakuda and Ghntasila.
*Luffa acutangula*var. *amara* (Roxb.) C. B. Clarke	Janni	Throughout the year		Nairi, Nimuna and Kanakasankha
Luffa aegyptiaca Mill.	Jani	Aug.-Nov.		Bidharpur, baulabandha and Nairi
Momordica charantia L.	Kalara	Throughout the year		Kanakasankha, Baulabandha and Nairi
Momordica dioica Roxb.	Kankada	Aug.- Sept.	Sept.- Nov.	Kankasankha, Sabulia and Rambha.
Mukia maderaspatana (L.) Roem.		Throughout the year		Nimuna and Sorana
Solena amplexicaulis (Lam.) Gandhi	Karakia, Bana kundri	Apr-Oct.	Nov.	Samolo and Sanakuda.
Trichosanthes cucumerina L.	Ban potol	June-May		Samolo, Madhurja and Nimuna
Trichosanthes tricuspidata Lour.	MahakalaPhala	Aug.-Sept.	Nov.- Dec.	Ghantasila, Gadisagada and Gurubahi.
Cactaceae				
Opuntia stricta var. *dillenii* (Ker- Gawl.) Benson	Nagphani	Jan- Sept.		Rambhartia, Gaurangapatna and Talatala
Cereus hexagonus Haw.				Kalijugeswar and Khadiparbata
Molluginaceae				
Gisekia pharnaceoides L.	Susni	Mar -July.		Arakhakuda, Mirzapur and Chandikhol
Glinus lotoides L.	GhodaPitasaga	Feb.-May.		Alupatna and Odialapur
Glinus oppositifolius (L.) A. DC.	Pitasag	Mar- Oct.		Charichhok, Keshpur and Barunakuda.

Mollugo pentaphylla L.	Pita saga	All the year round.		Rambha, Belapada and Sorana.
Mollugo nudicaulis Lam.		Feb.-Aug.		Madhurja and Nmirzapur
Mollugo cerviana (L.) Ser.		Aug.-March		Samilo and Barunakuda
Aiozaceae				
Sesuvium portulacastrum (L.) L.		Nov.-May		Kalijugeswara, Kalijai and Nairi
Trianthema portulacastrum L.	Ghodapuruni	July- Dec.		Parikuda, Belapada and Gaurangapatana
Trianthema triquetra Rottl. ex Willd.		June-Dec.		Parikuda and Chandikhol.
Apiaceae				
Centella asiatica (L.) Urban	Thalkudi, Ghodatapua	Most part of the year.		Belapada and Rambha.
Hydrocotyle sibthorpioides Lam.		Oct. -Mar.		Kalijugeswara, Adia and Khadiparbata.
Seseli diffusum (Roxb. ex Sm.) Sant. &Wagh.	Bhuinporisa	Feb.-Apr		Arakhakuda, Chandikhol and Mirzapur.
Alangiaceae				
Alangium salvifolium (L.f.) Wang.	Ankula	Mar- Apr	June-July.	Sanakuda, Barkul and Ghantasila.
Rubiaceae				
Benkara malabarica (Lam.) Tirveng.	Phiriki Kanta	Feb.-July	Oct-Dec.	Mirzapur, Alupatna and Janhikuda.
Canthium dicoccum (Gaertn.) Teijsm. & Binnend.	Dalasinga	Feb-Apr	Apr-May	Ghantasila, Samolo and Madhurja
Canthium parviflorum Lam.	Tuthudi	April-Jan		Sanakuda, Samolo and Hunjana
Catunaregam spinosa (Thunb.) Tirveng.	Mohana, Salara	Mar-June	Nov.-Jan.	Arakhakuda, Mirzapur and Alupatna.
Dentella repens (L.) J. R & G.Forst.		Apr- Oct.	Most part of the year.	Madhurja ang Charichhok.
Fagerlindia fasciculata (Roxb.) Tirveng.		Mar	Oct	Alanda, Gurubahi, Nimuna and Sabulia.
Hedyotis brachiata Wight		July.		Belapada, Sorana and Arakhakuda.
Hedyotis corymbosa (L.) Lam.	Gharpodia	June-Jan.		Gaurangapatna,Madhurja, Ghantasila & Sanakuda
*Hedyotis diffusa*Willd.	Bongamjoi	May- Nov.		Keshpur, Belapada and Samolo.
Hedyotis erecta Manilal & Sivarajan		May-Jan		Bhusandapur, Rambha and Nairi
*Hedyotis graminifolia*su bsp. *arenaria* (Haines) Deb & Dutta		Aug.-Oct.		Arakhakuda, Mirzapur and Barunakuda.
Hedyotis herbacea L.		Aug.-Jan.		Samolo and Kankadakuda.
Hedyotis nitida Wight &Arn.		Aug.-Nov.		Sorana, Kanakasankha and Palur.
Hedyotis ovatifolia Cav.		Aug.-Nov.		Keshpur, Pathara, Alanda.
Hedyotis pinifolia Wall. ex G. Don		Sept-Dec		Keshpur, Odialapur
Hedyotis puberula (G.Don) Arn.	Surbuli	Sept.- Mar.		Gollabandh and Badakuda.
Hydrophylax maritima L.		Mar-Nov.		Mirzapur, Janhikuda and Baghamunda.
*Ixora pavetta*Andr.	Telkurma	Mar-May	May-June.	Barkul, Mirzapur and Sabulia
Ixora undulata Roxb.	Tela Koruan	Apr- May	Aug-Sept.	Sanakuda Island of Chilika lagoon

Knoxia sumatrensis (Retz.) DC.		June-Jan.		Gopakuda, Sorana and Gudinala.
Meyna spinosa Roxb. ex Link.	Manta kanta, Nangal kanta	Apr-May	Aug.-Dec.	Rambha, Hunjana and Hatabaradi.
Mitracarpus villosus (Sw.) DC.		Sept- Mar.		Kanakasankha, Sabulia and Gheekhol.
Mitragynaparvifolia (Roxb.) Korth.	Mitikini, Keli-kadamba	May-June	Mar-Apr	Binchinipatna, Hunjana and Gaurangapatna.
Morinda pubescens Sm.	Achu, Aachhu	Apr-July	Nov.-Apr	Chilika islands and Rambha.
Pavetta indica L.		April-Nov.		Sanakuda, Gurubahi and Rahanabeli
Pavetta tomentosa Roxb.ex Sm.	Kukur-chalia	May-July	Nov-Dec.	Chhatragadamasani, Samolo and Sanakuda.
Spermacoce articularis L.f.	Solaganthi	July-Oct.	Sept.-Dec.	Samolo, Pathara, Mirzapur and Sanakuda
Spermacoce hispida L.	Sanagharpodia	July-Oct		Rambhartia, Chandikhol and Odialpur.
Spermacoce mauritiana Gideon		Throughout the year		Odialpur, Belapada and Madhurja
Spermacoce pusilla Wall.		July- Sept.	Oct.-Dec.	Odialpur, Baghamunda, Upulialapur and Bhasera
Spermacoce ramanii Sivar. & Nair		July-Sept.	Oct.-Dec.	Ghantshila.
Tamilnadia uliginosa (Retz.) Tirveng. & Sastre.	Tolaka, Telkur	Apr-July	Oct.-Jan.	Khadipatbata, Kalijai and Kalijugeswara.
Tarenna asiatica (L.) Kuntze ex Schum.	Jaujauka	Oct.-Nov	Nov.-Jan.	Nairi, Madhurja and Sabulia.
Astearceae				
Acanthospermum hispidum DC.	Sana Gokhara	Dec.-June		Keshpur, Pathara and Madhurja.
Ageratum conyzoides L.	Poksunga	All the year round.		Belapada. Nairy and Gaurangapatna.
Bidens bitenata (Lour.) Merr. & Sherff	Magha latenga	Sept. - Dec.		Keshpur, Belapada and Nairy.
Blainvillea acmella (L.) Philipson		Sept.-Jan.		Belapada, Madurja and Sorana.
Blumea aurita(L. f.) DC.	Pakasunga	Jan.-March		Madhurja and Nairi
Blumea lacera (Burm.f.) DC.	Pokasunga	Feb.-June.		Barkul, Inzanpur and Gadishagada.
Blumea oxyodonta DC.		Jan.-June		Odiapur and Samolo
Caesulia axillaris Roxb.	Jamjuria	Aug-Jan.		Kalupada, Inzanpur, Kansaria and Sorana
Centipeda minima (L.) A Braun & Asch.	Nakchika	Mar-Jan.		Mangalajodi, Bhusandapur and Nairi
Chromolaena odorata (L.) R. King & H. Robins	Pokasunga	Oct.-Dec.		Chandraput, Ghantasila, Badakuda
Eclipta prostrata (L.) L.	Kesatura	Aug- Dec.		Nairi Jetty, Sabulia and Samolo.
Elephantopus scaber L.	Mayur chulia	Aug.-Dec.		Kanakasankha, Palur, keshpur and Chandikhol.
Emilia sonchifolia (L.) DC	Sarkara	Aug.-Apr		Pathara, Keshpur and Nairi.
Enydra fluctuans Lour.	Hidimichi	Dec.- Feb.		Kalupada, Nairi, Sorana and Palur
Epaltes divaricata (L.) Cass.		Dec.-Mar.		Samolo, Badakuda and Baulabandha.
Gnaphalium polycaulon Pers.		Jan.-Apr		Mangalajodi, Nairi and Kankadakuda.
Grangea maderaspatana (L.) Poir.	Agnikumari	Jan.-Apr		Keshpur, Sorana and Baulabandha.
Launea sarmentosa (Willd.) Schultz-Bip. ex Kuntze.		Mar-Nov.		Goliabandha, Rambha and Madhurja.

Mikania micrantha Kunth		Jan.-April		Barkul, Samolo and Ghantasila
Parthenium hysterophorus L.	Nakachana	Oct.-Apr		Barkul, Nairi and Belapada.
Pentanema indicum (L.) Ling	Bana Sebati	Nov-June.		Bhaseramundia
Sphaeranthus indicus L.	Kadamba Bhuin	Nov.-Mar.		Kalupada and Bhusandapur.
Spilanthes paniculata Wall.		Oct-Feb.		Barakul
Synedrella nodiflora (L.) Gaertn.		Sept.-Feb.		Sanakuda and Belapada
Tridax procumbens L.	Bisalyakarani	All the year round.		Barkul, Sorana and Belapada.
Vernonia cinerea (L.) Less.	Pokasungo	Most part of the year		Gopakuda, Alupatna and Chandikhol
Xanthium indicum Koenig	Bada Gokhara	Throughout the year.		Upulialapur and Barkul.
Campanulaceae				
Sphenoclea zeylanica Gaertn.	Pani Maricha	Oct.- May.		Bhusandapur, Kalupada, Sorana and Kanakasankha.
Wahlenbergia marginata (Thunb.) A. DC.		Jan.-Apr		Gopakuda, Kalupada and Bhusandapur.
Lobeliaceae				
Lobelia alsinoides Lam.	Painmali	Sept.-Dec.		Diandein, Gadishagada and Nimuna.
Plumbaginaceae				
Plumbago zeylanica L.	Dhola Chitaparu	Sept.-Apr		Samolo and Kalijugeswara.
Myrsinaceae				
Aegiceras corniculatus (L.) Blanco.	Teluni, Kharsi	Feb.-Apr	June-Sept.	Ghantasila.
Sapotaceae				
Manilkara hexandra (Roxb.) Dubard	Khirni, Khirokuli	Nov.-Jan.	Mar- June.	Nimuna, Rahanabeli and Gaurangapatna.
Manilkara zapota (L.) P. Royen	Sapeta	Apr-July.	Feb- Mar	Nairi
Mimusops elengi L.	Baula, Bakula	Apr-May	Aug.-Sept.	Gaurangapatna and Alupatna.
Xantolis tomentosa (Roxb.) Rafin.	Kantabohul	Apr-June	Nov.-Feb.	Sorana, Gopakuda and Kalijugeswara.
Ebenaceae				
Diospyros chloroxylon Roxb.	Gourkasa, Kosai	June-July	Oct.-Dec.	Khadiparbata, Sorana and Gadisagada.
Diospyros ferrea (Willd.) Bakh.	Gaurkasa	Jan.-Mar	Mar-May	Sanakuda, Chhtragadamasani and Gurubahi
Diospyros montana Roxb.	Halda	Apr-June	Nov.-Mar.	Sanakuda and Arakhakuda.
Diospyros sylvatica Roxb.	Kalachua	Apr-July	Sept.-Mar	Samolo and Rambhartia.
Oleaceae				
Jasminum auriculatum Vahl.	Bana Malli, Jui	Apr-July	Dec-Feb	Sanakuda, Arakhakuda and Janhikuda.
Jasminum sambac (L.) Ait.	Malli	Apr-June	June-July	Ghantasila, Badakuda, Nimuna and Kanakasankha.
Jasminum scandens Vahl.	Ban malli	Nov.-Feb.	Mar-May	Alupatna and Chandikhol.
Nyctanthes arbor-tristis L.	Gangasiuli, Singadahara	Sept-Oct.	Dec-Jan.	Nairi, Gurubahi and Janhikuda.
Olax psittacorum (Lam.) Vahl	Bhadabhadalia	Mar-Aug.	Oct.-Dec.	Kalijai, Kalijugeswara and Madhurja.

Salvadoraceae				
Azima tetracantha Lam		Mar-May		Samolo, Ghantasila and Kalijugeswara.
Salvadora persica L.	Pilu, Mirga	Mar-May		Ghantasila, Kalijugeswara, Badakuda and Samolo
Apocynaceae				
Aganosma caryophyllata (Roxb. ex Sims) G. Don.	Malati	July-Sept	Feb.-Apr	Gopakuda and Sorana
Alstonia scholaris (L.) R. Br.	Chhatiana	Nov.- Jan.	May-Sept.	Chandikhol and Madhurja.
Anodendron paniculatum A. DC.		Feb.-April	Jan.-March	Nairi, Bhusandapur, Inzanpur and Nimuna
Carissa carandas L.	Karanda koli	Mar-Apr	July-Oct.	Ghantasila, Kalijugeswara and Sorana.
*Carissa inermis*Vahl.	Kerenda	Apr	May	Chandikhol, Alupatna and Pathara.
Carissa spinarum L.	Dudhakoli	Mar-May	Oct.-Dec.	Gurubahi and Janhikuda.
Cascabela thevetia (L.) Lippold	Koniyari, Koniarphula	Most part of the year.		Rambhartia and Ghantasila.
Catharanthus pusillus (Murr.) G. Don.		Aug-Jan		Gopakuda
Catharanthus roseus (L.) G. Don.	Sadabihari	All the year round.		Gurubahi, Madhurja and Alupatna.
Ervatamia divaricata (L.) Burkill	Tagar, Tarata	Most part of the year.		Arakhakuda and Bidharapur.
Holarrhenapubescens (Buch.-Ham.) Wall.ex G. Don	Indrajala, Koruan	May-July	Oct.-Feb.	Gurubahi, Baulabandha and Patnasi.
Ichnocarpus frutescens (L.) R. Br.	Suamanai, Dudhi lata	Sept.-Dec	Jan.-Apr	Charichhok and Ghantasila
Plumeria rubra L.	Kath champa	Most part of the year	Jan.-Feb.	Gurubahi, Nimuna village and Sabulia.
Rauvolfia serpentina (L.) Benth. ex Kurz.	Patala Garuda, Sarpagandha	May- Nov.		Gurubahi and Badakuda island.
Rauvolfia tetraphylla L.		Most part of the year.		Badakuda
Vallaris solanacea (Roth) Kuntze	Haparmalli	Apr-May	Nov.-Jan.	Keshpur, Sorana jetty, Samolo and Chandikhol.
Wrightia arborea (Dennst.) Mabb.	Bada kurei, Bada Koruan	Apr-July	Dec.- Feb	Rambha, Palur canal, Ghantasila and Gurubahi.
Periplocaceae				
Cryptolepis sinensis (Lour.) Merr.	Banshakhapuri	Sept.-Mar.		Rambha, Palur and Barkuda.
Hemidesmus indicus (L.) R.Br.	Anantamula	Aug.-Dec.	Dec.-Feb.	Kalijugeswara and Kankadakuda.
Asclepiadaceae				
Calotropis gigantea R.Br.	Arka, Arakha	Dec.-July	Feb.-June	Rambha, Madhurja and Mirzapur.
Calotropis procera (Ait.) R. Br.	Arka, Arakh	Mar-June		Barkul, Mirzapur and Alupatna.
Caralluma adscendens (Roxb.) Haw.		July-Dec.		Keshpur, Odialpur and Gaurangapatna.
Ceropegia candelabrum L.				Badakuda.
Gymnema sylvestre (Retz.) R. Br. ex Schult.	Gudamari	Aug.-Oct.	Jan.- Mar	Nimuna village and Sorana jetty.
Leptadenia reticulata (Retz.) Wight &Arn.	Koila saga	June-Oct.	Mar-Apr	Rambha, Satapada.
*Oxystelma esculenta (*L. f.) R. Br. ex Schult.	Dudhialata	Aug-Dec.		Barkul

Pentatropis capensis (L.f.) Bullock		Mar-June	Nov.	Ghantasila, Gopakuda
Pergularia daemia (Forssk.) Chiov.	Uturudi, Iturudi	Aug.-Dec.	Jan.-Apr	Kankadakuda and Nairi.
Sarcostemma acidum (Roxb.) Voigt.	Somlata			Ghantasila and Badakuda islands.
Tylophora indica (Burm. f.) Merr.	Swasamari			Ghantasila, Kalijugeswara and Gheekhol.
Strychnaceae				
Strychnos nux-vomica L.	Kochila, Kuchilla	Mar-Apr	Dec.-Jan.	Sanakuda and Hunjana.
Strychnos potatorum L. f.	Nirmali	May	Oct.-Dec.	Kalijugeswara, Badakuda and Nairi.
Spigeliaceae				
Mitrasacme pygmaea R. Br.			Sept-Nov.	Mangalajodi, Kalupada and Bhusandapur.
Gentianaceae				
Canscora decussata (Roxb.) Schult & Schult.f.	Painkimircha	Sept-Dec		Barkul, Keshpur and Baulabandha.
Canscora diffusa (Vahl) R. Br.		Dec- Mar		Nandala, Kalupadaghat
Menyanthaceae				
Nymphoides hydrophylla (Lour.) Kuntze	Paniseuli	Year round		Inzanpur and Northern part of Chilika.
Nymphoides indica (L.) Kuntze.		Year round		Kalupada and Bhusandapur.
Hydrophyllaceae				
Hydrolea zeylanica (L.) Vahl	Nilatara	Nov.- Apr		Upulialapur, Sabulia and Madhurja.
Hydrolea zeylanica var.*erecta* Haines		July-Aug	Sept-Nov	Nandala
Ehretiaceae				
Carmona retusa (Vahl) Masam.	Kujjipana	July-Dec		Badakuda, Keshpur and Belapada.
Ehretia laevis Roxb.	Masania	Jan.-Mar	Apr-May	Alupatna, Gheekhol and Binchinipatna.
Cordia dictotoma G. Forst.	Gualakoli	Mar-Apr	July-Sept.	Rambha, Madhurja, Gopakuda and Sabulia.
Cordia myxa L.		Mar-June	Sept-Nov	Hunjana
Boraginaceae				
Coldenia procumbens L.	Hansapadi	Most part of the year.		Kalupada, Sorana and Bidharapur.
Heliotropium curassavicum L.		Mar-Jan		Samolo, Barunakuda and Chandikhol.
Heliotropium indicum L.	Hatisundha	Most part of the year.		Sorana and Nairi
Heliotropium marifolium Retz.				Arakhakuda, Mirzapur and Odialpur.
Heliotropium strigosum Willd.		Throughout the year		Samolo, Kalijugeswara and Badakuda.
Convolvulaceae				
Argyreia cymosa (Roxb.) Sweet		Nov. Dec.	Feb.	Belapada, Hunjana and Sorana.
Argyreia nervosa (Burm.f.) Boj.	Brudhadaraka	July-Sept.	Nov.-Apr	Rambha, Madhurja, Sanakuda and Kalijugeswara.
Cressa cretica L.	Dahna	Feb-May		Barunakuda, Chandikhol and Arakhakuda.
Erycibe paniculata Roxb.	Dur koli	May-June	Mar-May	Gurubahi, Janhikuda and Samolo.

Evolvulus alsinoides (L.) L.	Bichhamalia	July-Feb.		Samolo, Belapada and Gaurangapatna
Evolvulus nummularius (L.) L.	Bichhamalia	July-Nov.		Kalupada, Sorana and Baulabandha.
Hewittia scandens (Milne) Mabberley		July-March		Sanakuda and Madhurja
Ipomoea alba L.	Kunja-lata	Sept.-Dec.		Keshpur, Chhatragadamasani.
Ipomoea aquatica Forsk.	Kalama saga	Nov-Feb.		Keshpur, Kanakasankha and Inzanpur.
Ipomoea carnea ssp. *fistulosa* (Mart.ex Choisy) Austin	Amari, Kalama	All the year round.		Samolo, Keshpur and Sabulia.
Ipomoea dichroa (Roem. & Schult.) Choisy		Nov.-April		Odialpur and Barunakuda
Ipomoea nil (L.) Roth.	Nila Kalama	Sept.-Nov.	Dec.-Feb.	Pathara, Madhurja and Belapada.
Ipomoea obscura Ker-Gawl.		Sept.-Apr		Barkul, Luniput and Gaurangapatna.
Ipomoea pes-caprae (L.) R. Br.	Kansari nata	Most part of the year.		Odialpur, Arakhakuda, Sipakuda and Samolo.
Ipomoea pes-tigridis L.	Bileipanjha	Aug.-Dec.		Samolo, Keshpur and Sabulia.
Ipomoea sepiaria Koenig ex Roxb.	Mushakani	Oct.-Apr		Rambha, Ghantasila and Sanakuda.
Jacquemontia paniculata(Burm.f.) Hall.f.		Throughout the year		Kanakasankha and Baulabandha
Merremia emarginata (Burm.f.) Hall. f.	Musakani	Sept.-Feb.		Belapada, Keshpur and Barakul.
Merremia hederacea (Burm.f.) Hall.		Sept.-Apr		Palur, Belapada, Sorana and Hunjana.
Merremia tridentata (L.) Hall.f.		July-Apr		Keshpur and Pathara.
Merremia tridentata ssp. hastata(Hall.f.) Ooststr.		June- March		Kanakasankha and madhurja
Merremia umbellata (L) Hall.f.	Paninai	Jan.-Apr		Kankadakuda and Kalijugeswara.
Porana paniculata Roxb.		Oct.-Dec.	Jan.	Kanakasankha, Sabulia and Gudinala.
Cuscutaceae				
Cuscuta reflexa Roxb.	Nirmuli	Oct.-Dec.	Dec.-Jan.	Chandikhol and Belapada.
Solanaceae				
Datura metel L.	Dudura	Throughout the year		Rahanabeli, Ghantasila and Nairi.
Datura stramonium L.	Dudura, Dhatura	July-Dec		Arakhakuda, Inzanpur and Nairi
Lycopersicon esculentum Mill.	Tomato	Throughout the year		Madhurja and Ghantasila
Nicotiana plumbaginifolia Viv.	Hemaraj	Apr- Oct.		Kalijugeswara, Khadiparbata and Kalijai.
Physalis minima L.	Tipai	Aug-Jan.		Alanda, Madhurja and Belapada
Solanum melongena L.	Baigan	Throughout the year		Badakuda, Sabulia, Kanakasankha and Keshpur
Solanum nigrum L.	Nunununia	Throughout the year		Rambha, Charichhok and Mirzapur
Solanum trilobatum L.	Nab-hiankuri	All the year.		Rambhartia, Rambha and Sipakuda
Solanum violaceum Ortega, Hort.	Bhejibaigan	Nearly all the year round.		Barkul, Rambha, Madhurja and Gurubahi
Solanum virginianum L.	Ankranti	Nearly all the year round.		Rambha, Mirzapur and Banamalipur

Scrophulariaceae				
Adenosma indianum (Lour.) Merr.	Rasnajadi	Sept- Nov.	Dec.-Jan.	Kalupada, Bhusandapur and Palur.
Angelonia salicariifolia Humb. & Bonpl.	Mahumaccha	Aug.-Feb.		Sorana, Nairi and Nimuna village
Bacopa floribunda (R. Br.) Wettst		Aug.-Dec.		Mirzapur, Madhurja and Samolo
Bacopa monnieri (L.) Pennell	Brahmi	Apr-Dec.		Kalupada, Bhusandapur and Palur canal.
Centranthera tranquebarica (Spreng.) Merr.		Aug.-Nov.		Dian dein and Baulabandha.
Limnophila heterophylla (Roxb.) Benth.	Ambakasia	Aug.-Nov.		Kalupada and Bhusandapur.
Limnophila indica (L.) Druce.	Keralata	Sept.-Feb.		Rahanabeli, Bhusandapur, Sorana.
Limnophila repens (Benth.) Benth.		Nov.-Feb.		Kankadakuda, Nairi and Palur.
Lindernia anagallis (Burm.f.) Pennell.		May-Dec.		Belapada, Arakhakuda and Madhurja.
Lindernia antipoda (L.) Alston		July-Nov		Odialpur, Keshpur, Belapada and Sabulia.
Lindernia ciliata (Colsm.) Pennell	Khetkura	Sept.-Nov.		Kalupada, Inzanpur and Nairi.
Lindernia crustacea (L.) F. V. Muell.		July-Dec.		Rambha, Belapada and Kharibandhamasani.
Lindernia parviflora (Roxb.) Haines.		Sept.-Apr		Madhurja.
Lindernia viscosa (Horn.) Bold.		Aug.-Oct.		Sorana, Nairi and Rahanabeli.
Mecardonia procumbens (Mill.) Small.		Most part of the year.		Kankadakuda, Badakuda and Gopakuda.
Scoparia dulcis L.	Khelapapada	Throughout the year		Rambha, Madhurja, Gurubahi, Nimuna
Sopubia delphinifolia (L.) G.Don.		Sept.-Nov.		Keshpur, Nimula and Sabulia.
Stemodia viscosa Roxb.		Oct-Jan.		Kalupadaghat
Striga angustifolia (D. Don) Saldanha		July-Nov.		Barkul, Gaurangapatna and Madhurja
Striga densiflora (Benth.) Benth.		Aug.-Oct.		Balugaon, Belapada and Kanakasankha
Lentibulariaceae				
Utricularia aurea Lour.	Bhatudiadala	Nov-Dec.		Kalupada, Mangalajodi and Bhusandapur
Utricularia polygaloides Edgew.		Nov.-Jan.		Kalupada and Bhusandpur
Utricularia stellaris L. f.	Bhaturiadala	Oct.-March		Bhusandpur and Tinimuhani
Pedaliaceae				
Pedalium murex L.	Gokshura	Aug.- Nov.		Odialpur, Belapada and Madhurja
Sesamum orientale L.	Khasa, Rasa	July-Dec.		Rambha and Madhurja
Acanthaceae				
Andrographis elongata (Vahl) T. Anders.		Oct.- May.		Ghantasila and Rambha.
Andrographis paniculata (Burm.f.) Wall.	Bhuinimba	Sept.-May.		Alupatna and Bidharpur.
Asystasia gangetica (L.) T. Anders.		Oct.-Dec.		Bhusandapur, Nimuna and Rahanabeli.
Barleria cristata L.	Banpatoli	Sept.-Feb.		Kalijugeswara, Khadiparbata and Kalijai

Barleria longiflora L.			Feb	Badakuda, Samolo and Belapada.
Barleria prionitis L.	Daskeranta	Oct.-Feb.		Arakhakuda and Barunakuda.
Barleria strigosa Willd.	Banmalli	Sept.-Nov.	Feb.-May	Janhikuda and Baghamunda.
Blepharis maderaspatensis (L.) Roth		Aug.-Mar.		Hunjana and Arakhakuda.
Blepharis repens (Vahl) Roth		Sept.-Jan.		Rambha, Palur, Madhurja and Gaurangapatna.
Dicliptera bupleuroides Nees.		Sept-Feb.		Belapada, Ghantasila and Gopakuda.
Dipteracanthus prostratus (Poir.) Nees		July- Jan.		Gurubahi, Chhatragadamasani and Inzanpur.
Dyschoriste depressa Nees in Wall.		Jan-Mar.	Mar- Apr	Rambha, Nairi and Gurubahi
Ecbolium viride (Forssk.) Alston		Aug.-Mar.		Madhurja and Gheekhol
Eranthemum capense L.		Sept-Mar.		Baulabandha, Kanakasankha and Gheekhol.
Hemiadelphis polysperma (Roxb.) Nees		Nov.-Mar.		Mangalajodi, Rahanabeli and Baulabandha.
Hemigraphis hirta (Vahl) T. Anders.		Mar-May		Mirzapur, Chandikhol and Pathara.
Hemigraphis latebrosa (Heyne ex Roth) Nees	Barengphul	Nov. -Apr		Gaurangapatna, Kalupada and Sabulia.
Hygrophila schulii (Buch.-Ham.) Almeida & Almeida	Koelekha	Oct. - Feb.		Upulialapur, Belapada and Madhurja.
Indoneesiella echioides (L.) Sreemadh.	Bad Bhuinnima	Aug.-Jan.		Ghantasila, Barunakuda and Kalijugeswara.
Justicia adhatoda L.	Basanga, Basak	June-Feb.		Sanakuda and Gurubahi
Justicia betonica L.		Oct.-Mar.		Nairi, Baulabandha, Gheehkol and Nimuna
Justicia glauca Rottl.		Sept.-Dec.		Kalupada, Inzanpur and Nairi.
*Justicia japonica*Thunb.		Sept.-Jan.		Rambha, Keshpur, Belapada and Nimuna
Justicia quinqueangularis Koenig exRoxb.		Most part of the year.		Samolo and Gaurangapatna.
Lepidagathis fasciculata (Retz.) Nees	Rasna	Jan.-June.		Sanakuda, Madhurja and Baulabandha
Lepidagathis hamiltoniana Nees.		Oct-Apr		Samolo, Keshpur and Chhatragadamasani.
Lepidagathis incurva Buch.-Ham.ex D.Don		Dec.-May.		Nairi, Kalupada and Bhusandapur.
Peristrophe paniculata (Forssk.) Brummitt.	Nasa bhaga	Nov.-Mar.		Sabulia and Kanaka sankha.
Phaulopsis imbricata (Forssk.) Sw.		Nov.-Mar.		Pathara, Upulialapur and Madhurja.
Ruellia tuberosa L.		June-Feb.		Samola, Sabulia and Kanakasankha
Rungia pectinata (L.) Nees	Sankha saga	Most part of the year		Kankasankha and Krushnaprasad.
Rungia repens (L.) Nees		Oct.-Mar.		Kalupada, Inzanpur and Baulabandha
Sericocalyx scaber (Nees) Bremek.	Khakusa	Jan.-May.		Belapad, Baulabandha and Keshpur.
Thunbergia fragrans Roxb.	Chakrakedar	Oct.-Mar.		Kadiparbata, Krushnapradad and Kalijugeswara.
Verbenaceae				
Clerodendrum inerme (L.) Gaertn.	Nutunga, Guhia	Most part of the year.		Sanakuda and Samolo.
Clerodendrum viscosum Vent.	Genguti, Kunti	Jan-Mar	Apr-July.	Barkul, Sorana and Nairi.
Gmelina arborea Roxb.	Gamhari	Mar-Apr	May-June	Kansarimuhana and Inzanpur

Lantana camara var. *aculeata* (L.) Moldenke	Naguari, Putus	All the year round.		Sanakuda, Gurubahi and Janhikuda.
Lippia javanica (Burm.f.) Spreng.	Naguari	Mar-Dec.		Pathara, Belapada and Sabulia.
Phyla nodiflora (L.) Greene	Gosingi	Most part of the year.		Kalijai, Kankadakuda and Pathara.
Premna corymbosa (Burm.f.) Rottl. & Willd.	Agnibathu	June-Feb.		Badakuda, Belapada, Nimuna and Madhurja
Premna latifolia Roxb.	Gandhana	Apr-June.		Ghantasila and Kalijugeswara.
Premna latifolia var. mucronata (Roxb.) C. B. Clarke	Gandhana	Apr-May	July-Sept	Baulabandha
*Premna serratifolia*L.	Ganiari	April-June	August	Samolo and Kalijugeswar
Premna tomentosa Willd.	Subundi, Jhandakai	March-April	May	Ghantasila and Madhurja
Stachytarpheta jamaicensis (L.) Vahl.	Jalajali	Apr-Nov.		Nimuna, Keshpur and Nairi.
Symphorema involucratum(Jacq.) Vahl		March-April	April-May	Keshpur, Samolo and Gaurangapatna
Tectona grandis L.	Saguan	July- Aug	Nov-Jan	Patnasi, Pathara, Chhatragada Masani.
Vitex negundo L.	Begunia	Most of the year.		Bidharapur and Belapada.
*Vitex trifolia*L.	Begundia	July		Hunjana, Samolo and Sanakuda
Lamiaceae				
Acrocephalus hispidus (L.) Nicolson & Sadasiv.		Sept.-Dec.		Kalupada, Sorana and Nairi.
Anisochilus carnosus (L.f.) Wall.	Bennia	Sept.-Feb.		Badakuda, Samolo and Kalijugeswara.
Anisomeles indica (L.) Kuntze		Sept.-Mar.		Kalijai, Ghantasila and Samolo.
Geniosporum tenuiflorum (L.) Merr.		June-Oct.		Golabandha, Charichhok and Odialpur.
Hyptis suaveolens (L.) Poit.	Ganga tulsi	Sept.- Jan.		Samolo, Ghantasila and Barunakuda.
Leonotis nepetifolia (L.) R.Br.	Kontasidha, Sidha	Oct.-Jan.		Sabulia, Gaurangapatna and Kanaka sankha.
Leucas aspera (Willd.) Link.	Gayasa	July-Jan.		Ghantasila, Sanakuda and Gudinala.
Leucas lavandulifolia Sm. Leucas stricta Benth.	Goisa	Aug.- June		Samolo, Nairi, Madhurja Barunakuda and Badakuda.
Ocimum basilicum L.	Durlabha	Sept.-June.		Ghantasila and Chandikhol.
Ocimum canum Sims.	Ganga tulsi, Ban tulsi	June- Mar.		Ghantasila and Sanakuda.
Ocimum gratissimum L.	Ban tulsi	Aug.-Apr		Sanakuda and Samolo.
Ocimum sanctum L.	Tulasi	Dec.-Jan.		Ghantasila, Gurubahi, Charichhok and Janhikuda
Orthosiphon pallidus Benth.	Gaya Tulasi	Aug.-Nov.		Bahgamunda, Luniput and Alupatna.
Pogostemon benghalensis (Burm.f.) Kurz	Gonda-dulia, Pakasunga	Jan.-April		Kalijugeswara and Sanakuda
Nyctaginaceae				
Boerhavia chinensis (L.) Asch. & Schweinf.		Aug.-Nov.		Barkul, Chhatragadamassni and Inzanpur.
Boerhavia diffusa L.	Puruni	Most part of the year.		Alupatna, Ghantasila and Khadiparbata.
*Bougainvillea spectabilis*Willd.	KagajaphulA	Throughout the year		Kalijugeswara and Arakhakuda.
Pisonia aculeata L.	Hathi Ankusa	Feb.-May.		Rambha, Samolo and Badakuda.

Amaranthaceae				
Achyranthes aspera L.	Apamarnga	Oct.-Feb.		Odialapur and Belapada.
Achyranthes bidentata Bl.		Aug.-Dec.		Keshpur, Pathara and Alupatna.
Aervalanata (L.) Juss. ex Schultes.	Paunsia	Aug.-Jan.		Nimuna. Sorana and Rahanabelli.
Aerva sanguinolenta (L.) Bl.	Chauladhua	Sept- May.		Samolo, Ghantasila and Keshpur.
Allmania nodiflora (L.) R. Br. ex Wight		July- Dec.		Khadibarbata and Alupatna.
Alternanthera ficoidea (L.) Beauv.		Sept-Dec.		Kalupadaghat, Mangalajodi and Madhurja
Alternanthera paronychioides St.-Hil.		Feb-Apr		Naiiri, Bhusandpur and Gaurangapatna
Alternanthera philoxeroides(Mart.) Griseb.	Aligator weed (E)	May-November		Kalupada, Barkul, Manglajodi
Alternanthera pungens Kunth		Aug-Feb		Kalupada, Belapada, Gurubahi
Alternanthera sessilis (L.) R.Br. ex DC.	Madaranga saga	July-Dec		Bhusandapur, Kalupada, Kankadakuda.
Amaranthus spinosus L.	Kanta Leutia	Most of the year.		Kalupada, Mangalajodi and Rahanabeli.
Amaranthus viridis Linn.	Leutia	Throughout the year		Keshpur, Ghantasila and Gaurangapatna.
Celosia argentea L.	Nahanga saga	Aug.-Jan.		Sabulia and Madhurja.
Centrostachys aquatica (R. Br.) Wall. ex Moq.		July-Dec.		Keshpur and Madhurja
Digera muricata (L.) Mart.	Gungatiya	Aug.-Nov.		Kalijugeswara, Khadiparbata and Kalijai.
Gomphrena celosioides Mart.		Throughout the year		Arakhakuda, Belapada and Keshpur.
Pupalia lappacea (L.) Juss	Jatjatia	Aug.- Jan.		Gadisagada and Nimuna village.
Trichuriella monsoniae (L. f.) Bennet				Odialpur, Gaurangapatha and Bhusandapur.
Chenopodiaceae				
Salicornia brachiata Roxb.		Aug.- Mar.		Satapada, Nalabana, Malatikuda, Badakuda
Suaeda maritima (L.) Dumort.	Giriya	Apr-Dec.		Arakhakuda, Sipakuda, Odialpur and Banamalipur.
Basellaceae				
Basella alba L.	Poi	Throughout the year		Ghantasila, Kalijugeswara and Gopakuda.
Aristolochiaceae				
Aristolochia indica L.	Panairi, Oyidi	July-Oct.	Nov.-Feb.	Ghantasila and Khadiparbata.
Polygonaceae				
*Polygonum barbatum*L.		Throughout the year		Kalupada and Bhusandapur
Polygonum glabrum Willd.		Sept-Feb		Sunderpara, Nalabana and Mangalajodi
Polygonum hydropiper L.		Dec		Belapada, Palur and Rahanabeli
Polygonum plebeium R.Br.	Muthi Saga	Jan- May		Rahanabeli, Kanakasankha and Patnasi
*Polygonum pulchrum*Bl.		Throughout the year		Rambha and Sabulia
Rumex martitimus L.		Mar-Apr		Kalupada, Hunjana and Bhusandapur

Piperaceae				
Peperomia pellucida (L.) Kunth		Aug.-Feb.		Ghantasila
Lauraceae				
Cassytha filiformis L.	Nirmul	Oct-Feb		Sanakuda, Keshpur and Madurja.
Litsea glutinosa (Lour.) Robyns.	Lodha, Patraraj	June- July	Sept.-Nov.	Hunjana, Hatabaradi and Sabulia.
Hernandiaceae				
Gyrocarpus americanus Jacq.		Jan.-Feb.	Apr-May.	Ghantasila.
Loranthaceae				
Dendrophthoe falcata (L.f.) Etting.	Madang	Nov.-Apr		Gurubahi, Gheekhol and Dangua.
Viscum articulatum Burm. f.	Malang	Dec.-Jan.	March-April	Ghantasila and Badakuda
Euphorbiaceae				
Acalypha indica L.	Indramaricha	July-Dec.		Madhurja and Mirzapur.
Acalypha lanceolata Wild.		Aug. - Nov.		Chandikhol, Arakhakuda and Baghamunda.
Antidesma ghaesembilla Gaertn.	Katha Marmuri	Apr-June	Sept.-Oct.	Pathara and Keshpur.
Baliospermum montanum (Willd.) Muell.- Arg.	Danti	Oct-Apr		Sorana, Sabulia and Gaurangapatna.
Breynia retusa (Dennst.) Alston.	Jajan	Apr-Aug.		Kalijugeswara and Badakuda.
Breynia vitis-idaea (Burm.f.) Fischer.	Jajan, Jhanjika	Mar-Feb.		Samolo, Kalijai and Sanakuda.
Bridelia retusa (L.) Spreng.	Kasi	Aug.-Oct.	Sept.-Jan.	Samolo, Barunakuda and Gopakuda.
Chrozophora prostrata Dalz.		Jan.-May.		Upulialapur, Hatabaradi and Sabulia.
Chrozopho rarottleri (Geisel.) Juss.		Most part of the year.		Barkul and Diandein.
Croton bonplandianus Baill.	Lankamaricha	All the year round.		Odialapur, Belapada and Barkul.
Croton caudatus Geisel.	Furudi	Apr-Aug.		Nimuna, Kansari and Rambha.
Dimorphocalyx glabellus Thw.	Gaigutia	Mar-Apr		Ghantasila
Euphorbia antiquorum L.	Dokanasiju	Dec.-Apr		Sorana, Sanakuda.
Euphorbia caducifolia Haines	Khirsiju	Jan.-Apr		Kalijai, Kankadakuda and Kalijugeswara.
Euphorbia hirta L.	Chita-kutei	Throughout the year.		Ghantasila and Belapada.
Euphorbia ligularia Roxb.	Siju	Mar-Apr		Samolo, Keshpur and Charichhok.
Euphorbia rosea Retz.		Oct		Samolo, Kalijugeswara and Barunakuda.
Euphorbia thymifolia L.	Kalijat Patra-siju	Most part of the year.		Talatala, Charichhok and Chandikhol.
Euphorbia tirucalli L.	Khadi Siju	July-Oct.		Barkul, Chhatragadamasani and Hatabaradi.
Excoecaria agallocha L.	Guan, Gaugoa	May-June.		Baghamunda, Rambhartia and Mirzapur.
Homonoia riparia Lour.	Pani begonia	Mar-Apr		Gurubahi and Nairi jetty.
Jatropha curcas L.	Gaccha Baigaba	May-Oct.	Most part of the year.	Chhatragadamasani, Bidharapur and Samolo.

Jatropha gossypifolia L.	Baigoba	July-Oct.		Barkul, Belapada and Nairi.
Mallotus nudiflorus (L.) Kulju & Welzen	Panigambhari	Jan-Mar.	Sept-Nov	Madhurja
Mallotus philippensis (Lam.) Muell.-Arg	Kapilagundi	Oct-Nov	Feb-Mar.	Talatala
Micrococca mercurialis (L.) Benth.		Aug.-Sept.		Barunakuda.
Pedilanthus tithymaloides (L.) Point.	Kharsiju	April-Aug.		Khadiparbata and Gaurangapatna
Phyllanthus acidus (L.) Skeels	Narakoli	May.	June- Oct.	Sorana
Phyllanthus emblica L.	Anola, Amla	Feb.-May	Oct.-Apr	Ghantasila.
Phyllanthus fraternus Webster	Bhuianla	July-Oct		Badkuda island and Barkul
Phyllanthus maderaspatensis L.		Oct-Apr		Chandraput, Arakhakuda
Phyllanthus reticulatus Poir.	Jandakhai	Most part of the year.		Samolo and Madhurja
Phyllanthus rotundifolius Klein ex Willd.		May-Oct.		Janhikuda and Alupatna.
Phyllanthus urinaria L.	Bhuin amla	July-Dec.		Bidharpur, Gurubahi and Nimuna
Phyllanthus virgatus Forst.	Bhuiaonla	July-Feb.		Bidharapur, Samolo, Sanakuda and Sorana.
Ricinus communis L.	Jada, Gaba	Most part of the year.		Sanakuda
Sauropus bacciformis (L.) Airy Shaw	Bila Nadia	Most part of the year.		Upulialapur, Keshpur, Samolo and Rambha.
Sebastiania chamaelea (L.) Muell.- Arg.		Most part of the year.		Kalijugeswara and Kankadakuda
Securinega virosa (Roxb. ex Willd.) Baill.	Jajanga	May-Oct.		Nairi, Samolo, Madhurja and Nairi
Suregada multiflora (Juss.) Baill.	Khakkada, Khakra	Mar-Aug.		Ghantasila, Kalijai and Kalijugeswara.
Synadenium grantii Hook.	Patra siju	Jan- Apr		Barakul
Tragia involucrata L.	Bichhuati	Nov.-Apr		Kalijugeswara, Sanakuda, Samolo, Barunakuda.
Ulmaceae				
Holoptelea integrifolia (Roxb.) Planch.	Daurang, Charla	March-April	May-June	Ghantasila and Sanakuda
Trema orientalis(L.) Bl.	Jivani, Kharkas	Most part of the year		Bidharpur, Sanakuda and Samolo
Moraceae				
Artocarpus heterophyllus Lam.	Panasa	Dec.-Feb.	June-July.	Nairi and Gurubahi.
Artocarpus lacucha Roxb. ex Buch.-Ham.	Jeutha	Troughout the year		Madhurja, Gurubahi and Belapada
Ficus arnottiana (Miq.) Ann.	Paras pipal, Plokhyo	June-Sept.		Ghantasila
Ficus benghalensis L.	Bara	All the year round		Belapada, Samolo, Sanakuda, Nairi and Rambha
Ficus benjamina L.	Jilipukar			Ghantasila, Kalijai, Baulabandha and Chandikhol
Ficus benjamina var. nuda (Miq.) Barrett.		Feb.-June		Rambha and Samolo
Ficus hispida L.	Dimiri, Baidimiri	Nov.-July.		Kalijai, Madhurja and Nimuna
Ficus microcarpa L.	Jida		Oct.-Apr	Kankadakuda, Kalijugeswara and Gopakuda
Ficus religiosa L.	Aswatta, Ostha		June-Oct.	Badakuda, Gopakuda and Kalupada.
Ficus rumphii Bl.	Jhida	Throughout the year		Khadiparbara and Sanakuda

Ficus tinctoria Forst.f.	Jhirang, Jari	Nov.-Apr		Kalijugeswara, Madhurja and Hatabaradi.
Ficus virens Ait.	Pakoda, Kuajuri	March-Dec.		Ghantasila
Plecospermum spinosum Trecul.	Banabanaka	Jan-Apr		Krushnaprasad
Streblus asper Lour	Sahada	Mar-Apr	May-June	Sanakuda, Kalijai, Nairi, Samolo and Inzanpur.
Streblus taxoides (Heyne ex Roth) Kurz	Jhumpuri	Mar-June		Khadiparbata
Urticaceae				
Laportea interrupta (L.) Chew.	Ghodabichuati	Aug.-Oct.		Kalijugeswara, Nimuna and Soarana.
Pilea microphylla (L.) Liebm.		Throughout the year		Kalijai, Ghantasila and Kalijugeswar
Pouzolzia pentandra (Roxb.) Bennett		Aug.-Oct.	Oct.-Dec.	Sorana, Inzanpur, Rahanabeli and Kanakasankha.
Pouzolzia zeylanica (L.) Benn.		Aug.-Nov.		Samolo and Madhurja
Casuarinaceae				
Casuarina equisetifolia L.	Jhanu	Apr-May	June onwards.	Talatala, Arakhakuda and Alupatna.
Ceratophyllaceae				
Ceratophyllum demersum Linn.	Chingudiadala	Jan-Mar		Kalupada, baulabandha and sorana
Hydrocharitaceae				
Blyxa echinosperma (C.B.Cl.) Hook.f.		Nov.- Feb.		Kalupada and Rahanabeli.
Halophila beccarii Aschers.		Nov- Jan.		Satapada, Nalabana and Odialpur
Halophila ovalis (R.Br.) Hook.f.		Throughout the year.		Keshpur, Odialapur, Talatala, Arakhakuda
Halophila ovata Asch.		Throughout the year		Khirisahi and Nalabana.
Hydrilla verticillata (Linn. f.) Royle	Bora Jhangi	Oct-Jan		Kalupada and Bhusandapur
Nechamandra alternifolia (Roxb.) Thw.		Oct.-Feb		Tinimuhani
Ottelia alismoides (L) Pees.	Panikundri	Dec.- Jan.		Rahanabeli, Sorana and Kalupada.
Vallisneria natans (Lour.) Hara	Eel-grass	Oct-Apr		Kalupada, Mangalajodi and Bhusandapur.
Orchidaceae				
Acampe praemorsa (Roxb.) Blatter & Mc Cann.	Kano-kato	Apr-June	Oct-Dec.	Binchinipatna and Ghantasila.
Cymbidium aloeifolium (L.) Sw.		May- June	Aug.-Apr	Ghantasila and Samolo.
Vanda tessellata (Roxb.) Hook. ex G. Don	Malang; Kankata	Mar-May	May-Mar.	Rambha and Ghantasila.
Costaceae				
Costus speciosus (Koenig) Sm.	Gaigobara, Kaukauka	July-Dec		Gopakuda, Kalijugeswara and Inzanpur
Zingiberaceae				
Globba racemosa Sm.		Aug.-Sept.		Madhurja, Gaurangapatna and Hunjana.
Zingiber zerumbet (L.) Sm.	Gada, Parsukedar			Keshpur, Belapada and Badakuda.
Amaryllidaceae				
Crinum defixum Ker-Gawl.	Kondai	June-Nov.		Klaupada, Sorana, Nimuna and Gudinala.

Agavaceae				
Agave sisalana Perrine ex Engelm.	Sisul	Jan.- Mar.		Kalupada, Mangalajodi and Baulabandha.
Sanseveria cylindrica Bojer.				Chandikhol and Arakhakuda.
Sansevieria roxburghiana Schult. & Schult.	Murga	June- July	Dec	Arakhakuda and Mirzapur.
Hypoxidaceae				
Curculigo orchioides Gaertn.	Kali musli	Apr-Sept.		Badakuda, Diandein, Dangua and Gheekhol.
Dioscoreaceae				
Dioscorea alata L.	Khamboalu	Oct-Dec.		Sorana, Gadishagada and Binchinipatna.
*Dioscorea bulbifera*L.	Pitakanda/Pita Alu	Aug.-Sept.	Nov.-Dec.	Badakuda, Madhurja and Samolo
Dioscorea hamiltonii Hook.f.	Palru, Sutaalu	Sept.-Oct.	Dec.-Feb.	Madhurja, Gaurangapatna, Rambha and Sabulia.
Dioscorea oppositifolia L.	Panialu	Aug.-Sept.	Nov.	Sabulia, Kanakasankha and Madhurja.
Dioscorea pentaphylla L.	Pittalokanda	Oct.-Dec.		Gheekhol, Madhurja and Kanakasankha.
Dioscorea wallichii Hook. f.	Phalokanda, Tunga Alu	Oct.-Nov.	Dec.-Feb.	Madhurja and Belapada
Liliaceae				
Asparagus racemosus Willd.	Satabari	Sept.-Oct.	Nov. - Dec.	Ghantasila, Mathakona and Gurubahi.
Gloriosa superba L.	Panchangulia, Nangalia	Sept.-Nov.	Nov.- Dec.	Ghantasila and Rambha.
Smilacaceae				
Smilax zeylanica L.	Muturi	Apr-July	Oct-Jan.	Gaurangapatna, Banamalipur and Gheekhol.
Pontederiaceae				
Eichhornia crassipes (Mart.) Solms	Bilatidala	Most part of the year		Kalupada and Vaseramundia.
Monochoria hastata (L.) Solms.	Kajalpatia	Apr-Sept		Kalupada, Palur Canal and Bhusandapur.
Monochoria vaginalis (Burm.f.) Presl.	Mirmira	Aug-Nov.		Kalupada, Sorana and Palur canal.
Commelinaceae				
Commelina benghalensis L.	Kaniseera	July-Jan.		Belapada, Kanakasankha and Nairi.
Commelina diffusa Burm.f.		Aug.-Nov.		Kankadakuda, Kalupada and Bhusandapur
Commelina erecta L.	Kanisiri	Aug.-Dec.		Belapada, Madhurja, Sorana and Nairi.
Commelina longifolia Lam.				Pathara, Chhtragadamasani and Nimuna
Commelinapaludosa BI.		July-Oct		Inzanpur, Madhurja, Palur and Gopakuda
Cyanotis cristata (L.) D.Don.		Sept.-Nov.		Kalupada, Bhusandapur and Sorana.
Murdania nudiflora (L.) Brenan		Aug.-Nov.		Samolo, Kalupada, Kanakasankha and Belapada.
Murdannia spirata (L.) Brueck.		Sept.-Dec.		Nimuna, Sabulia, Palur and Belapda.
Murdannia vaginata (L.) Brueck.		July-Oct.		Kalupada and Nairi
Tonningia axillaris (L.) Kuntze		July-Jan.		Kalupada and Bhusandapur.

Arecaceae				
Borassus flabellifer L.	Tala	Mar-May	Aug	Sanakuda, Samolo, Charichhok and Talatala.
Calamus guruba Buch.-Ham.	Kanta Beta	Mar-Apr	Dec-Jan.	Gopakuda
Calamus viminalis Willd.	Pani Beta	Sept.-Oct.	Mar-Apr	Mangalajodi, Baulabandha and Kalijugeswara.
Cocos nucifera L.	Nadia	Throughout theyear		Barkul, Inzanpur, Pathara, Nairi and Sorana.
Phoenix acaulis Buch.-Ham.ex Roxb.	BhuinKhajuri	Apr	May-June.	Sanakuda, Talatala and Mirzapur.
Phoenix sylvestris (L.) Roxb.	Khajuri	May-Oct.		Talatala, Mirzapur and Alupatna.
Pandanaceae				
Pandanus odorifer (Forssk.) Kuntze	Kia	July- Oct	Throughout the year	Keshpur, Inzanpur, Sorana, Nairi and Chandikhol.
Typhaceae				
Typha angustata Bory & Chaub.	Hangla, Santara	Throughout the year		Inzanpur, Barkul and Kalupada.
Araceae				
Amorphophallus paeoniifolius var. *campanulatus* (Decne) Sivadasan	Olua	Apr-June	Nov	Nimuna, Sorana, Madhurja and Sabulia.
Colocasia esculenta (L.) Schott in Schoot & Endl.	Saru, Bansaru	June-Nov.		Belapada, Keshpur, Madurja and Sorana.
Pistia stratiotes L.	Borajhanji	May-June.	Nov.- Dec.	Kalupada and Bhusandapur.
Scindapsus officinalis (Roxb.) Schott	Gajapipali	June-July	Jan	Rambha, Baulabandha and Nairi.
Typhonium trilobatum (L.) Schott	Ghekul			Pathara, Keshpur, Palur and Badakuda.
Lemna perpusilla Torr.		May-Jan.		Kalupada and Bhusandpur
Lemnaceae				
Spirodela polyrhiza (L.) Schleiden		Sept.-April		Bhusandapur and Tinimuhani
Alismataceae				
Limnophyton obtusifolium (L.) Miq.		Feb-Aug.		Kalupadaghat
Sagittaria guayanensis H.B.K.		Aug-Nov.		Kalupada, Mangalajodi and Bhusandapur.
Sagittaria trifolia L.				Belapada, Kanakasankha and Pathara.
Cymodoceaceae				
Cymodocea serrulata (R.Br.) Asch. & Magnus.		May-June		Pathara
Potamogetonaceae				
Halodule pinifolia (Miki) Hartog		Feb- Mar.		Satapada, Khirisahi and Odialapur.
Halodule uninervis (Forssk.) Aschers.		June-July.		Arakhakuda, Sipakuda and Keshpur
Potamogeton crispus L.		May- Oct.		Kalupada and Mangalajodi.
Potamogeton nodosus Poir.		Throughout theyear		Keshpur, Odialapur
Potamogeton octandrus Poir.		Dec.-Mar.		Mangalajodi

Stuckenia pectinata (L.) Börner	Charidala	Nov.-Jan.	Nairi, Kalupadaghat, Satapada, Nalabana
Aponogetonaceae			
Aponogeton natans (L.) Engl. & Krause	Ghechu	Sept-Nov	Bhusandapur
Aponogeton undulatus Roxb.			Kalupada and Bhusandapur.
Ruppiaceae			
Ruppia maritima L.		Jan.-May.	Keshpurand Samolo.
Najadaceae			
Najas graminea Dell.		Sept.-Oct.	Bhusandpur
Najas indica (Willd.) Cham.		Apr-May.	Kalijugeswara, Kansari and Keshpur.
Najas marina L.		Sept-Nov.	Kalupadaghat
Najas minor All.		March	Bhusandpur and Kalupada
Eriocaulaceae			
Eriocaulon quinquangulare Linn.	Nakachana	Aug-Feb.	Patanasi and Sorana
Cyperaceae			
Bulbostylis barbata (Rottb.) C.B.Cl.		July-Nov	Baghamunda, Mirzapur and Satapada
Cyperus arenarius Retz.		July-May.	Chandikhol, Odialpur and Barunakuda.
*Cyperus castaneus*Willd.		Aug.-Dec.	Sorana, Barkul and Bhusandapur
Cyperus compressus L.		July-Dec.	Keshpur, Madhurja, Gudinala and Hunjana.
Cyperus cuspidatus Kulth.		Sept.-Nov.	Barkul, Inzanpur, Rahanabeli and Nairi
*Cyperus diffusus*Vahl		June-Nov.	Sorana, Kalupada and Nairi.
Cyperus distans Linn.		Aug-Nov.	Alupatana, Chandraput, Balugaon, Kalupadaghat
Cyperus dubius Rottb.		Aug.-Oct.	Barunakuda and Mirzapur
Cyperus halpan Linn.		July-Nov.	Barkuda and Barkul.
Cyperus imbricatus Retz		July- Nov.	Palur, Gheekhol, Nairi and Kalupada.
Cyperus iria Linn.		Aug-Jan.	Arakhakuda, Rambha, Pathara
*Cyperus kyllinga*Endl.		July- Mar.	Odialapur and Madhurja.
*Cyperus pilosus*Vahl		Aug- Dec.	Madhurja, Belapada and Baulabandha.
Cyperus platystylis R.Br.		Apr-Feb.	Chhatragadamasani, Inzanpur, Sorana and Nairi.
Cyperus polystachyos Rottb.		Feb.-Oct.	Samolo, Barunakuda, Mirzapur and Banamalipur.
Cyperus rotundus L.	Mutha, Motha	July-Dec.	Sorana, Nairi, Barkul, Sabulia and Madhurja.
Cyperus triceps Endl.		May-Dec.	Rambha, Gaurangapatna, Belapada and Kalupada.
Eleocharis dulcis (Burm. f.) Henschef	Chadchadi	July-Dec.	Nuapada
Eleocharis geniculata (L.) Roem. & Schult.		June-Jan.	Nimuna and Bhusandpur
Fimbristylis acuminata Vahl		July-Nov.	Khadiparbata, Kalijugeswara and Alanda.

Fimbristylis aestivalis (Retz.) Vahl.		Apr, May.		Kalijugeswara, Sanakuda and Nimuna.
Fimbristylis bisumbellata (Forssk.) Bubani		July-Dec.		Barkuda, Barunakuda and Sorana.
Fimbristylis dichotoma (L.) Vahl.	Bada swanli	July-Nov.		Nimuna, Baulabandha, Balapada
Fimbristylis dipsacea (Rottlb.) C. B. Clarke		May-Oct.		Belapada, Upulialpur and Samolo
Fimbristylis ferruginea (L.) Vahl		Oct.-May		Kanakasankha and Nairi
Fimbristylis miliacea (L.) Vahl.	Swanli	Oct.-Jan.		Kalupada, Sorana, Gudinala and Palur.
Fimbristylis ovata (Burm.f.) Kern.	Marmari	June-Dec.		Barkul, Belapada and Chhatragadamasani.
Fimbristylis schoenoides (Retz.) Vahl.	Kesarimalang	Sept.-Nov.		Palur, Gudinala and Bhusandapur.
Fimbristylis umbellaris (Lam.) Vahl		Aug.-Sept.		Mangalajodi and Keshpur
Fimbristylis cymosa var. *spathacea* (Roth) T.Koyama				Baulabandha and Hunjana
Fuirena ciliaris (L.) Roxb.		Oct-Jan.		Kalupada, Gudinala, Alanda and Sorana.
Fuirena umbellata Rottb.		Sept-Dec.		Rambha, Keshpur, Gudinala and Mangalajodi.
Kyllinga tenuifolia Steud.		July-Sept.	Sept-Oct	Gopakuda and Upulialpur
Mariscus paniceus (Rottb.) Vahl		June-Aug.		Badakuda, Sunderpara and Bidharpur.
Pycreus flavidus (Retz.) T. Koyama		Sept.-April		Baulabandha and Nairi
Pycreus polystachyos (Rottb.) P. Beauv.		Throughout the year		Upulialpur and Gaurangapatna
Rikliella squarrosa (Linn.) Raynal		Aug-Dec.		Odialpur, Upulialapur, Barunakuda and Samolo
Schoenoplectus articulatus (Linn.) Palla	Kanri, Gaichara	Dec. - Apr		Rambha, Sorana, Kalupada and Nairi.
Schoenoplectus littoralis (Schrader) Palla	Simpala, Sipala Ghas	Oct.-Jan.		Nairi, Sorana, Parikuda
Schoenoplectus supinus ssp.*lateriflorus*(J. F. Gmel.) T. Koyama		Aug.-Feb.		Rambha and Palur
Scleria terrestris (L.) Fassett		Oct.-May.		Gopakuda, Gurubahi, Janhikuda and Sabulia.
Poaceae				
Alloteropsis cimicina (L.) Sapf		Aug.-Oct.		Belapada, Kalupada and Sorana.
Aristida setacea Retz.	Ghoda-Ianji	Aug.-Feb.		Patnasi, Alanda and Odialapur.
Bambusa arundinacea (Retz.) Willd.	Kantabanso			Bidharapur and Chhatragadamasani
Bambusa vulgaris Schrad.	Sundrogai	July-Feb.		Barkul and Hunjana
Bothriochloa bladhii (Retz.) S.T.Blake	Gondabena	Aug.-Feb.		Kalupada, Barunakuda and Hunjana.
Bothriochloa pertusa (L.) A. Camus	Basana	Sept-Mar.		Sabulia, Kanakasankha and Nairi.
Brachiaria distachya (L.) Stapf.Chandikhol.		Sept.-Dec.		Barunakuda, Odialapur and
Brachiaria mutica (Forssk.) Stapf	Paraghasa	Throught out the year		Sorana
Brachiaria ramosa (L.) Stapf.	Banspalli	May-Dec.		Baulabandha, Gheekhol and Madhurja.
Brachiaria remota (Retz.) Haines		July-Nov.		Nimuna and Inzanpur
Chionachne koenigii (Spreng.) Thw.	Phulainr	Aug.-Jan		Gopakuda and Nairi

Chloris barbata Sw.	Jargigandi	Sept.-Jan.	Nairi, Kalupada and Nimuna
Chloris dolichostachya Lagasca.		Oct-Dec.	Kalijugeswara, Khadiparbata, Barunakuda.
Chrysopogon aciculatus (Retz.) Trin.	Guguchia	July-Nov.	Sorana, Inzanpur, Barkul and Nairi.
Coelachne simpliciuscula (Wt. &Arn. ex Steud.) Munro ex Benth.		Oct.-April	Gheekhol and Kalupada
Coixlacryma-jobi L.	Gargada, Gargara	Sept-Feb.	Barkul, Inzanpur and Mirzapur.
Cynodon arcuatus J. S. Presl.		March-Sept.	Inzanpur, Baulabandha and Bhusandpur
Cynodon barberi Rang. & Tad.		Through out the year.	Keshpur, Hunjana and Talatala.
Cynodon dactylon (L.) Pers.	Dubaghas	Most part of the year.	Barkul, Nimuna village, Sabulia and Madhurja.
Cyrtococcum accrescens (Trin.) Stapf		Sept.-Oct.	Bidharpur
Cyrtococcum trigonum (Retz.) A. Camus		Sept-Mar.	Rambha, Palur and Keshpur.
Dactyloctenium aegyptium (L.) P. Beauv.	Kakudia	Sept.-Mar.	Sanakuda, Belapada and Alupatna.
Dendrocalamus strictus	Saliabanso	Nov. (sporadically every year)	Samolo, Sanakuda and Odialpur.
Digitaria ciliaris (Retz.) Koeler	Makur-jali	June-Apr	Arakhakuda and Nimuna
Digitaria longiflora (Retz.) Pers.		July-Dec.	Chhatragada and Nairi
Dimeria ornithopoda Trin.		Oct.-Dec.	Ghantasila
Dinebra retroflexa (Vahl) Panzer		Aug.-Nov.	Sorana and Kankadakuda.
Diplachne fusca (L.) P. Beauv.		Aug-Nov.	Parikuda, Odialpur and Mirzapur.
Echinochloa colona (L.) Link.	Suan, Suanghas	Most part of the year.	Odialapur, Barunakuda and Alupatana.
Echinochloa stagnina (Retz.) P. Beauv.	Jhipa	Mar-Oct.	Sabulia, Hunjana and Sorana.
Eleusine coracana (L.) Gaertn.	Mandiya, Ragi	Aug.-Nov.	Gaurangapatna, Palur and Rambha.
Eleusine indica (L.) Gaertn.	Ana mandia	Aug. - Feb.	Chhatragadamasani and Inzanpur.
Elytrophorus spicatus (Willd.) A. Camus		Dec.-Feb.	Keshpr and Rahanabeli
Eragrostis ciliaris (L.) R.Br.			Badakuda, Samolo and Alupatna.
Eragrostis ciliata (Roxb.) Nees		Nov.-Feb.	Rahanabeli and Madhurja
Eragrostis coarctata Stapf in Hook.f.	Kujijhipa, Ghirananja	Sept.-Apr	Badakuda, Mirzapur and Odialapur.
Eragrostis gangetica (Roxb.) Steud.	Kankra chare	Sept-Feb.	Kalupada, Baulabandha and Bhusandapur.
Eragrostis japonica (Thunb.) Trin.		Oct.-Jan.	Palur, Kankasankha and Gurubahi.
Eragrostis pilosa (L.) P.Beauv.		July- Dec.	Kalupada, Mangalajodi and Kalijugeswara.
Eragrostis tremula (Lam.) Hochst. ex Steud.			Barunakuda, Chandikhol and Mirzapur.
Eragrostis unioloides (Retz.) Nees ex Steud.	Phurphuri	July-Mar.	Hatabaradi, Kalupada and Diandein.
Eriochloa procera (Retz.) Hubbard	Kharaghas	Aug.-Mar.	Arakhakuda, Nimuna and Sorana.
Hackenochloa granularis L.	Trinpali, Kangni	Aug.-Dec.	Barunakuda and Gopakuda
Hemarthria compressa (L.) R.Br.	Gopkena	Aug.-Oct.	Kalijugeswara, kankadakuda and Palur.

Heteropogon contortus (L.) P. Beauv.	Sinkola, Dauria	Sept.-Jan.	Belapada, Dangua, Bidharpur and Hunjana.
Hygroryza aristata (Retz.) Nees ex Wight & Arn.		Oct.	Nimuna, Hatabaradi, Baghamunda and Janhikuda
Hymenachne acutigluma (Steud.) Gilliland		Oct.-Feb.	Kalupada and Bhusandapur.
Imperata cylindrica (L.) Raeusch.	Chhana ghasa	Most part of the year.	Kalupada, Baulabandha and Nairi.
Isachne globosa (Thunb.) Kuntze		Sept.-Nov.	Keshpur and Rahanabeli
Ischaemum indicum (Houtt.) Merr.	Kander	Oct.-Feb.	Hunjana, Binchinipatna and Pathara.
Ischemum rugosum Salisb.	Tuli	Sept.-Feb.	Upulialpur and Gaurangapatna
Iseilema prostratum (L.) Anderss.		Aug.-Dec.	Hunjana and Binchinipatna and Madhurja.
Isleima laxum Hack.	Pandasual	Sept.-Jan.	Nairi and Nimuna
Leersia hexandra Sw.		July-Feb.	Belapada and Odialapur.
Microchloa indica (L. f.) P. Beauv.		Aug.-Sept.	Hatabaradi and Baulabandha
Myriostachya wightiana (Nees ex Steud.) Hook.f		Apr-Sept.	Arakhakuda, Sipakuda, Janhikuda and Baghamunda.
Oplismenus burmannii (Retz.) P. Beauv.	Kangodia	Oct-Nov.	Kalijugeswara, Gopakuda, Khadiparbata and Kalijai.
Oplismenus compositus (L.) P. Beauv.	Kauguria, Mohara	Oct.-Dec.	Bidharapur, Rahanabeli and Gudinala.
Oropetum thomaeum (L. f.) Trin.		Sept.-Dec.	Samolo and Mirzapur
Oryza rufipogon Griff.	Balunga	Sept. - Nov.	Barunakuda, Pathara, Keshpur and Madhurja.
Oryza sativa L.	Dhana	Sept.-Jan. and also Apr-May	Keshpur, Gaurangapatna, Inzanpur and Barkul.
*Panicum brevifolium*L.		Oct.- Nov.	Rambha, Belapada and Keshpur
Panicum notatum Retz.		Sept.-Dec.	Gurubahi, Barunakuada, Baghamunda and Pathara.
Panicum paludosum Roxb.	Dalakrighas	Aug.-Nov.	Parikud, Alupatna, Kalupada and Sorana.
Panicum psilopodium Trin.		July-Jan.	Hatabaradi, Hunjana and Madhurja.
Panicum repens L.	Pani dal, Reda	July- Dec.	Sanakuda.
Panicum walense Mez		Aug.-Nov.	Pathara and Odialpur
Paspalidium flavidum (Retz.) A. Camus	Bilainangi	July-Oct.	Kalupada, Sorana and Patnasi
Paspalidium geminatum (Forssk.) Stapf		July-Apr	Kalupada, Patnasi and Chhatragadamasani.
Paspalum distichum L.		Apr-Nov	Keshpur, Odialapur
Paspalum scrobiculatum L.	Kodo, Kodua	Most part of the year.	Mangalajodi, Kalupada and Bhusandapur.
*Paspalum vaginatum*Sw.		Oct-March	Ghantasila and Rambha
*Pennisetum pedicellatum*Trin.		Oct.-Jan.	Pathara, Alanda, Barunakuda and Sanakuda.
Pennisetum polystachyon(L.) Schult.		Oct.-Dec.	Hatabaradi and Sabulia
Perotis indica (L.) Kuntze		Aug.-Nov.	Samolo, Rambhartia, Arakhakuda and Chandikhol.
Phragmites karka (Retz.) Trin.	Nala ghasa	Sept.-Feb.	Kalupad, to Bhusandapur
Porteresia coarctata (Roxb.) Tateoka	Dhaniharakata	May-Aug.	Alupatna, Mirzapur and Baghamunda.

Pseudoraphis spinescens (R. Br.) Vickery		Aug.-Nov.	Satapada and Chandikhol
Rottboellia cochinchinensis (Lour.) Clayton	Bara swati	Oct.-Nov.	Ghantasila, Rambha on the rocky face of Chilika.
*Saccharaum benghalense*Retz.	Kainsha	Oct.- Jan.	Gaurangapatna and Gopakuda
Saccharum spontaneum L.	Kasatandi, Tandi	Aug-Feb.	Near Khalikot Ghati, Sabulia and Upulialapur.
Sacciolepis indica (L.) Chase		Aug.-Nov	Kanakasankha and Belapada
Sacciolepis interrupta (Willd.) Stapf.		July-Feb.	Badakuda
Setaria pumila (Poir.) Roem. & Schult.	Sialalanguda	May-Feb.	Nairi, Kalijugeswara and Ghantasila.
Setaria verticillata (L.) P.Beauv.	Bileilanguda	Sept-Nov.	Nimuna, Sabulia, Upulialapur and Madhurja.
Spinifex littoreus (Burm.f.) Merr.	Sipalaghasa	Sept-Feb.	Odialapur, Gurubahi, Chandikhol and Belapada.
Sporobolus coromandelianus (Retz.) Kunth		Nov.-Jan.	Gopakuda and Samolo
Sporobolus indicus var. *diander*(Retz.) Jovet & Guedes	Kakrachada	June-Feb.	Keshpur, Hunjana, Janhikuda and Gurubahi.
Trachys muricatus (L.) Pers		Sept.- Nov.	Gheekhol, Baulabandha, Belapada and Keshpur.
Urochloa panicoides P. Beauv.		July-Jan.	Belapada, Chhatragadamasani and Sorana.
Vetiveria zizanioides (L.) Nash.	Bena	Aug.- Jan.	Kalupada, Nairi, Palur and Alanda.
Zoysia matrella (L.) Merr.		Mar- Apr	Barunakuda, Arakhakuda and Pathara

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Addition of two species of *Riccia* (Mich.) L. (*R. bifurca* Hoffm. and *R. subbifurca* Warsnst. ex Croz) to bryoflora of India

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ABSTRACT

Two species of *Riccia* (Mich.) L. viz., *R. bifurca* Hoffm., collected from the hill tops of Yerraipalli Konda and *R. subbifurca* Warsnst. ex Croz., collected from Poolakunta and Duggem Hillocks, Anantapuramu district, Andhra Pradesh are being reported as new distributional records to India.

1. Introduction

The genus *Riccia* (Mich.) L. (Ricciaceae; Marchantiales) was established by Micheli in 1729 Nova Plantarum and validated later by Linnaeus in 1753. *Riccia* is commonly distributed thalloid liverwort throughout the world. Genus *Riccia* is distinct in forming rosette habit, comprise mostly terrestrial forms and show very simple and primitive morphological and anatomical characters. *Riccia* comprises 250 species worldwide (Daniel *et al.*, 2014 & Soderstrom *et al.*, 2016). In India *Riccia* is represented by 38 species (Singh, 2014, Cargill *et al.*, 2019 & Asthana & Srivastava, 2020). In Andhra Pradesh, 12 species (Sandhya Rani *et al.*, 2014, Sreenath & Ravi Prasad Rao, 2019, Asthana & Srivastava, 2020 and Sreenath & Ravi Prasad Rao, 2020), have been reported.

As a part of our explorations for bryophytes in Andhra Pradesh during 2016-2020, we could collect some curious thalloid liverwort specimens which after critical investigation were found to belong to *Riccia bifurca* Hoffm. and *Riccia subbifurca* Warsnst. ex Croz., the former collected from hill tops of Yerraipalli Konda, and the latter collected from Poolakunta and Durgam hills, both fall in Ananthapuramu district, Andhra Pradesh. Perusal of literature cited above, revealed that both the species are new distributional records to India.

2. Materials and methods

Extensive field explorations were conducted during 2016-2020. All the bryophyte specimens were collected by using sharp edged knife and were scraped by using manually bent and sharpened flat spoon. The collected specimens were placed in zip lock polythene cover with labeled field number. Field observations were recorded in the field notes and live photographs were taken using DSLR-Camera (Nikon D3300). Collected materials were brought to the laboratory, made it air dried at room temperature and preserved in brown paper packets (12 × 18 cm) with detailed label (10 × 17cm). Critical examination of the specimens was done by using temporary slides and plant parts were separated by using micro forceps (Varin) VR-15 curved, VR-11 straight with fine sharp edges. Slides were observed under light microscope (Olympus CH20i), light stereo microscope (Olympus SZ61) and micro measurements were taken by

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using ocular micro meter (ERMA) 19 mm, 100 segments in 1 cm. Photographs were taken by using Moto g3 turbo and Samsung one equipped with 13 MP camera with 4x wide digital zoom. Different dimensions were measured and identification of the specimens by using standard floras. Descriptions, habitat and ecology, voucher specimens' information, field photographs are provided for the species. Voucher specimens are deposited in Sri Krishnadevaraya University Herbarium (SKU), Ananthapuramu. Abbreviated names used for the collectors are: AS (Ananthaneni Sreenath) and BR (Boyina Ravi Prasad Rao).

3. Results

Riccia bifurca Hoffm., Deutschl. Fl. 2: 95. 1975; *Riccia arvensis* Aust. 1870, Proc. Acad. Nat. Sci. Philadelphia 21: 232; *R. pusilla* Warnst. 1895, Verb. Bot Vereins Prov. Brandenburg 37: 50; *R. minutissima* Steph. 1898, Spec. Hep.1: 30; *R. subcrispula* Warnst.1902, Kryptog. Fl. Mark Brandenburg 1: 76; Ozenoglu et al., 2019, Turk. J. Bot. 43: 253–261.

Plants terrestrial, thalloid, medium sized, habit more or less complete rosettes, up to 1.8 cm in diameter, thallus light green, brown at margins, yellowish-orange at base; irregularly branched, bifurcate, branching segments 1.2 – 1.7 × 6 – 9 mm, oblong, rounded at apex, median groove lobes narrow at apex, flat in mid lobes spreading about ¼ of the branch width; lateral edges rounded-subacute. Upper surface shows papillate like air pores. Ventral scales whitish or tinged with purple-orange colors. Rhizoids few, smooth and tuberculate; 5 – 7 times as road as high; epidermal cells 40 – 42 × 45 - 48 µm wide, contains orange-brown idioblsat cells in sides of thalli, sometimes these cells spread to dorsal sides of the thalli. Monoeciousarchegonial necks 300 – 450 µm long; sporangium common; spores dark yellowish brown, rounded, 65 - 75µm, winged, wing up to 7 µm wide, smooth or sometimes rough.

Habitat and ecology: Terricolous in moist soils on hill tops, associated with *Oropetium roxburghianum* (Poaceae).

Specimens examined: ATP Dt., Top hill of Yerraipalli Konda, 21 September 2018, 55108, SKU, AS& PA.

Distribution: **World**: Afghanistan, Albania, Algeria, Armenia, Austria, Azores, Baleares, Belgium, Canary Islands, Czech Republic, Corsica, Crete, Croatia, Denmark, England, Estonia, Europe, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Iran, Ireland, Latvia, Lebanon, Lithuania, Luxembourg, Macedonia, Madeira, Morocco, Norway, Poland, Portugal, Romania, Russia, Sardinia, Sicilia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and Southwest Asia and **India**: new distributional records to India from Andhra Pradesh.

Riccia subbifurca Warsnst. ex Croz. Rav. Bryol. Lichen. 30: 62.1903; *Riccia baumgartneri* Schiffn. 1904, Österr. Bot. Z. 54, 3: 88; Ozenoglu *et al.*, 2019, Turk. J. Bot. 43: 253 – 261.

Plants terrestrial, thallus formcomplete rosettes or crowed; thalli 2 – 4 times furcately branching, branching segments 0.5 – 1.5 × 3 -7 mm, thalli bluish green to green, sometimes tinged with purple on dorsal and lateral sides, pale brown to base, becoming whitish with age, branching segments oblong, rounded apically, lobes wider at apex, median groove narrow, widening to about ¼ of branch width, fairly deep and distinct at apex; lateral edges rounded; margin glabrous or with cilia, cilia on margins lobes from apex to base, few, 120 – 270 µm long, papillate in upper ½ of the segments. Ventral scales hyaline or with pale purplish spots. Rhizoids numerous and smooth.Thalli 2 – 3 times as broad as high in cross section; epidermal cells rounded, in groove rounded or pyriform. Monoecious.Antheridial and archegonia necks reddish-purple and not exceeding above the thallus. Spores brown, ovoid to rounded, 80 – 100 µm, winged, wing 6 – 9 µm wide, margin smooth.

Habitat and ecology: Terricolous, on field bunds, mostly monodominant, sometimes associated with *Cyperus rotundus* (Cyperaceae).

Specimens examined: ATP Dt.,Poolakunta, 03 October 2019, 57004, SKU, AS; Durgam hills, 17 October 2019, 57100, SKU, AS& SMN.

Distribution: World: Albania, Algeria, Austria, Azores, Belgium, Canary Islands, Corsica, Crete, Croatia, England, Europe, France, Germany, the Netherlands, Hungary, Iran, Ireland, Italy, Israel, Luxembourg, Macedonia, Madeira, Montenegro, Morocco, Portugal, Slovakia, Spain, Syria, Sweden, Switzerland, Turkey, United Arab Emirates, Southwest Asia and **India:** new distributional records to India from Andhra Pradesh.

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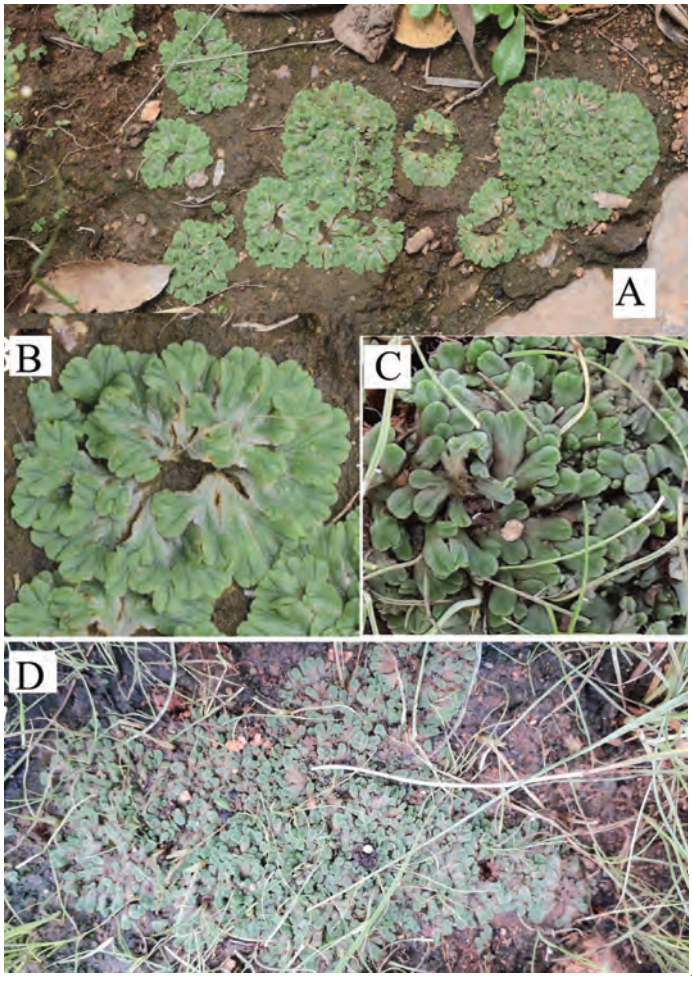

Plate. 1: A, B: *Riccia bifurca* Hoffm. A. Plant natural habit, B. Magnified view of thallus. C, D: *Riccia subbifurca* Warsnst. ex Croz. C. Magnified view of thallus, D. Plant natural Habit.

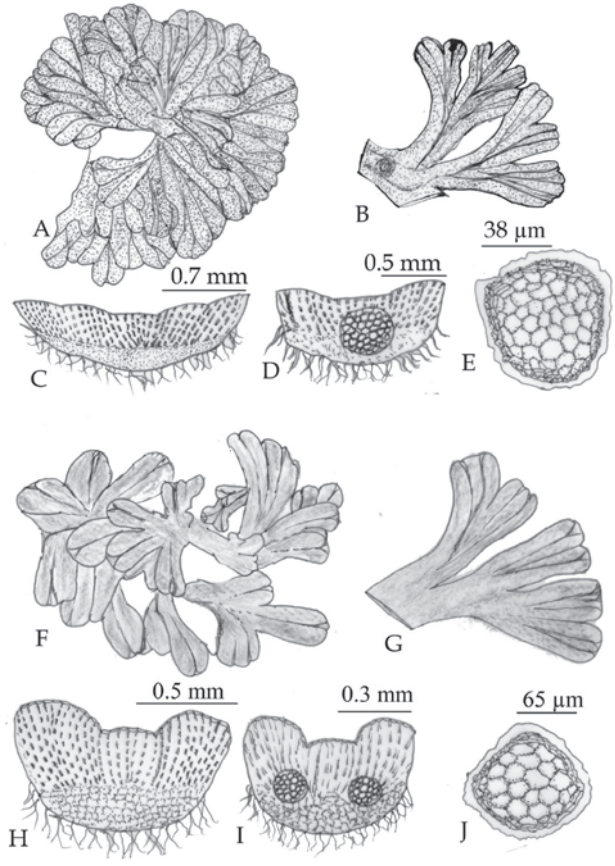

Figure. 1: A-E: *Ricciabifurca* Hoffm. A. Thallus, B. Magnified view of branching portion, C. Cross section of thallus near apex, D. Cross section of thallus through near sporophyte, E. Magnified view of Spore and F-J: *Ricciasubbifurca* Warsnst. ex Croz. F.Thallus, G. Magnified view of branching portion, H. Cross section of thallus near apex, I. Cross section of thallus through near sporophyte, J. Magnified view of spore.

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Wahlenbergia marginata (Thunb.) A. DC. *(Campanulaceae)*, a new distributional record to Andhra Pradesh

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ABSTRACT

The present paper deals with the extended distribution of *Wahlenbergia marginata* (Thunb.) A.DC. to Andhra Pradesh, collected from Srikakulam, district.

While exploring the forests of North Circar districts of Andhra Pradesh during 2017, we could find a curious specimens of *Wahlenbergia* sp. in Seethampeta forests of Srikakulam district, which after critical study was identified as *W. marginata* (Thunb.) A. DC. although the species is known to distribute throughout India, (Krishnamurthy, *et al.*, 2014: Nayar *et. al.*, 2014), till date, there no records for its occurrence in the state of Andhra Pradesh (Pullaiah & Karuptusamy, 2018).

Wahlenbergia Schrad. ex Roth belonging to family Campunalaceae comprises about 260 species; the represenatives of the genus are found in all continents except North America and dominant in Southern Hemisphere (Mabberley, 2017). In India, the genus is represented by 6 species (Haridasan & Mukherjee, 1996).

Present paper deals with the update nomenclature, technical description, phenology, distribution and voucher specimens collected.

Wahlenbergia marginata (Thunb.) A. DC., Monogr. Campan. 143. 1830; Fl. EG 4.4.2011; *Campanula marginata* Thunb; Syst. Veg. (ed. 14) 211.1784 *Wahlenbergia gracilis* (Forst.f.) Schrad.ex A. DC. Monog. Campan. 142. 1830; FBI 3:429.1881; Gamble 2: 738.1921; *Campanula gracilis* G. Forst., Fl. Ins. Austr. 15. 1786.

Perennial herbs with elongate carrot like roots; Stem erect or ascending up to 40 cm long, branched at base, cylindrical to slightly angular, striate, sparsely hirsute; Leaves simple, alternate, mostly on lower part of stem, sessile, Lamina spatulate, oblanceolate, elliptic- linear, 1-6.5 × 0. 2-0.7 cm long, margin sparsely serrate or minutely toothed, entire, sinuate, glabrous or sparsely hirsute, strongly one-nerved; Inflorescence axillary and terminal long pedicillated solitary or binate cymes; pedicel up to 20 cm long; Hypanthium conic, obovoid, glabrous. Calyx lobes0.2-0.4 cm long, triangular or subulate. Corolla blue, broadlycampanulate, 0.3- 1.0 cm long, lobes oblong, obovate; Capsule obconic, subglobose- obovoid, 0.3-0.8 cm long, tri-locular; Seeds ellipsoid or oblong, slightly compressed, 0.3-0.5 mm long, smooth, yellowish brown or dark brown.

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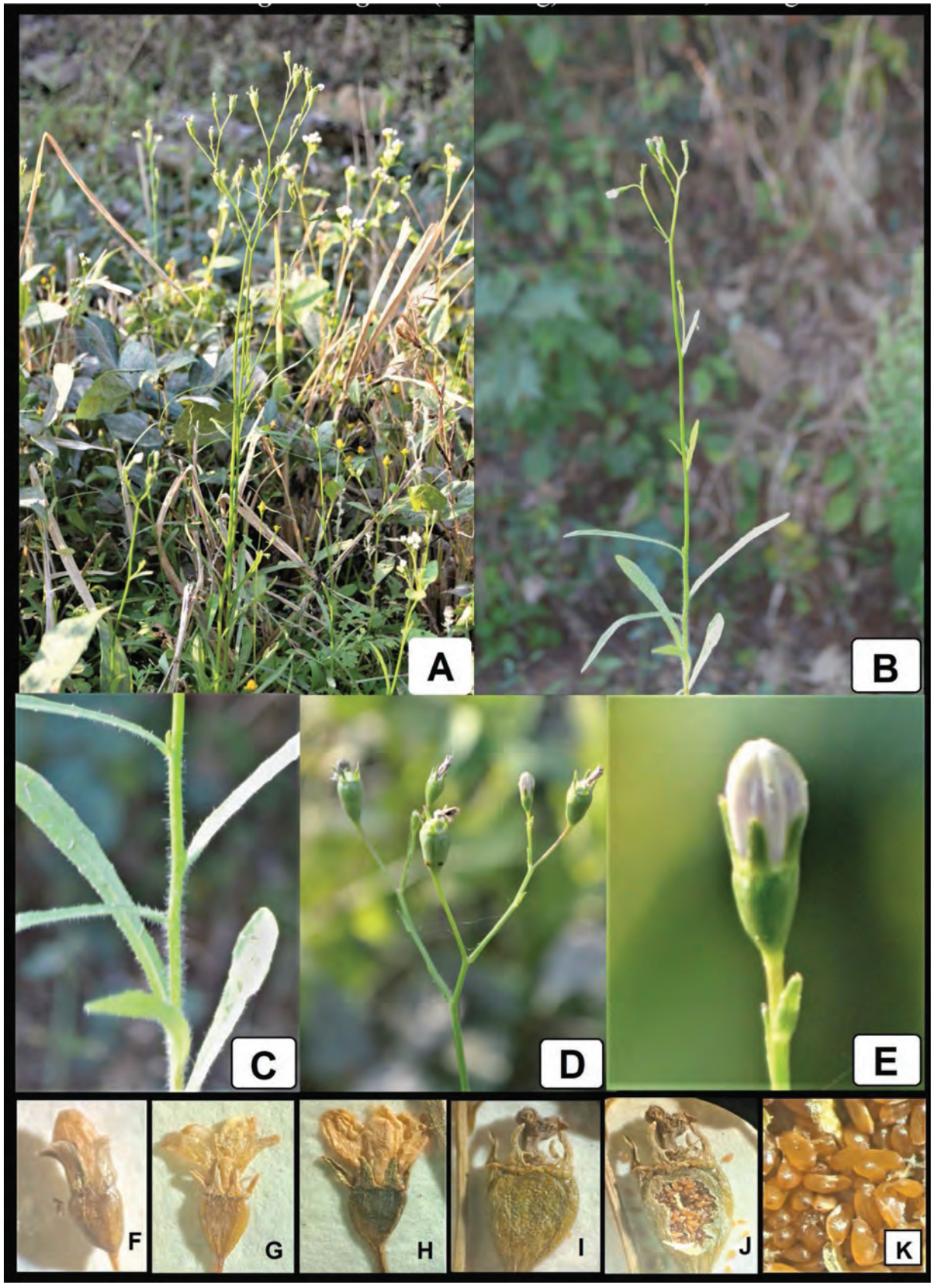
A. Herbarium specimen of Wahlenbergia marginata



B. *Wahlenbergia marginata* A. Natural habit with other flora, B. Single habit, C. Stem and leaf texture, D. Inflorescence, E. Flower, F-J. Flower maturation stages, K. Seeds

Phenology: **Fl. & Fr.:** Feb.-May.

Habitat and Abundance: Rare, in wastelands and agricultural fields.

Distribution: World; India (throughout), Bangladesh, China South-Central, China South-East, Japan, Java, Kazanretto, Korea, Laos, Lesser Sunda Is., Maluku, Myanmar, Nansei-shoto, Nepal, New Guinea, Ogasawara-shoto, Philippines, Sri Lanka, Sulawesi, Taiwan, Thailand, Vietnam.

Specimen examined: 53110 (SKU), 08-02-2017, Sirikonda outskirts (Palasa- Seethampeta), Srikakulam district, Andhra Pradesh, India, coll. BR & PA.

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Lygodium flexuosum (L.) Sw. (Lygodiaceae): A new record for Eastern Ghats of Tamil Nadu, India

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ABSTRACT

The climbing fern *Lygodium flexuosum* (L.) Sw. is reported for the first time from the Eastern Ghats of Tamil Nadu. A brief description, photograph and pertinent notes are furnished for easy identification.

The climbing fern genus *Lygodium* was established by Swartz (1801) and it can easily be noted in the field by its scandent, long, vine-like leaves and finger-like fertile marginal lobes (Mueller, 1982; Singh & Panigrahi, 1984). It comprises about 29 species (POWO 2020), mostly distributed in the tropics, subtropics, and in eastern USA (Duek, 1978). In India, so far nine species have been reported (Fraser-Jenkins *et al.*, 2016), among them Eastern Ghats is represented by three species: *Lygodium altum* (C.B.Clarke) Alderw., *L. flexuosum* (L.) Sw. and *L. microphyllum* (Cav.) R.Br. (Mandal *et al.*, 2020). Studies by Pemberton & Ferriter (1998), Lott *et al.* (2003) and Volin *et al.* (2004) proved that several species of *Lygodium* are problematic invasive species in many countries.

In Tamil Nadu, the Eastern Ghats start from the Jawadi Hills and extend up to the Alagar Hills (Ramachandran *et al.*, 2016). The Jawadi, Elagiri, Shevaroy, Chitteri, Kalrayan, Bodamalai, Kolli, Pachaimalai, Semmalai, Aiyalur, Karandamalai, Sirumalai, and Alagarmalai are the major hills, covering an area of 6024 km2 (Jayakumar *et al*., 2009). During 2013, the first author has collected *Lygodium flexuosum* from the riparian fringes of Karandamali, Eastern Ghats, Tamil Nadu. Thereafter the images were sent to Fraser-Jenkins and he confirmed our identification. Recently, we came across an article entitled 'A census of pteridophytes of Eastern Ghats, India' by Mandal *et al.* (2020) in which the species was reported only from the Eastern Ghats of Odisha and Andhra Pradesh but not from the Tamil Nadu. Hence we scrutinized the literature with reference to distribution of this fern and we found that the species shows wider distribution range in India (Fraser-Jenkins 2008; Fraser-Jenkins *et al.*, 2016) and in Tamil Nadu it is hitherto reported only from the hill ranges of Western Ghats (Manickam & Irudayaraj, 1992, 2003; Benniamin & Sundari, 2020). Furthermore it was not reported from any of the hill ranges in Eastern Ghats of Tamil Nadu (Subramanyam *et al.*, 1960; Dwarakan & Ansari 1998; Karuppusamy *et al.*, 2001; Manickam *et al.*, 2004; Moorthy *et al.*, 2012; Sundari *et al.*, 2012; Kumaraguru *et al.*, 2015; Kavitha *et al.*, 2017; Sureshkumar *et al.*, 2020). Hence it is being reported here as a new distributional record for Lygodiaceae of Eastern Ghats of Tamil Nadu.

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Lygodium flexuosum (L.) Sw. in J. Bot. (Schrader) 1800(2): 106. 1801; Manickam & Irudayaraj, Pterid. Fl. West. Ghats, S. India: 238. 1992; Manickam & Irudayaraj, Pterid. Fl. Nilgiris: 77. 2003; Fraser-Jenk. *et al*., Annot. Checkl. Ind. Pterid. 1: 107. 2016. *Ophioglossum flexuosum* L., Sp. Pl. 1063. 1753. *Lygodium semibipinnatum* R. Br. Prod. Fl. Nov, Holl.: 162. 1810. *Lygodium pinnatifidum* Sw. in Schrad. J. Bot. 1801(2): 303. 1803. *Lygodium serrulatum* Bl., Enum. Pl. Jav. 254. 1828. (Fig.1)

Rhizome creeping covered by dark brown, multi cellular, uniseriate hairs. Stipe up to 50 cm long, glabrous adaxially flat, abaxially round. Young fronds palmate, oblong, lanceolate, about 2-4 m tall and 35 cm wide tripinnate, primary pinnae alternate about 10 cm apart with about 3 mm long, common stalk forked once, each forked branch bears three pairs of simple or forked pinnules; pinnules up to 7 x 1 cm, oblong, lanceolate, veins simple or forked, forked twice or thrice, free, reaching the margin, pinnae light green, texture coriaceous. Sporangia arranged in finger-like spike along the margin of the pinnules. Sporangia 0.3 mm in size, horizontal with terminal annulus, short stalked up to eight pairs, arranged in two alternate rows. Spores trilete, 25 x 30 m in size, exine verrucate.

Specimens examined: INDIA. Tamil Nadu, Dindigul District, Karandamalai, Peria aruvi valley, 430 m, *R.Kottaimuthu 20102*; same place, 25 December 2019, *R.Kottaimuthu 21309* (Alagappa University Herbarium!).

Global Distribution: India (Andaman Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Haryana, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh & West Bengal), Africa, Australia, Bangladesh, China, Japan, Malaysian Islands, Pacific Islands, Philippines Sri Lanka, Taiwan, Thailand and Vietnam.

Distribution in Eastern Ghats: Gandhamardan Hills (Mishra *et al.*, 2001), Rampa Hills (Singh & Panigrahi, 1984), Nallamalai (Ellis, 1990) and Karandamalai (present report).

Medicinal Uses: With the help of literature survey, we found that *L. flexuosum* is one of the potential medicinal ferns widely used by the indigenous people of India for various primary healthcares. The whole plant is used as expectorant; rhizome boiled with mustard oil and locally applied to carbuncles and in rheumatism, sprains, scabies, wounds and ulcers (Dixit, 1959; Singh & Viswanathan, 1996). Rhizome is also used as abortifacient and as appetizer. It is also used in the treatment of abdominal pain, cholera and jaundice (Girach & Aminuddin 1989; Ramesh *et al*., 2003), fever, female infertility and gonorrhea (Rout *et al.*, 2009).

Fig.1. A twig of *Lygodium flexuosum* (L.) Sw.

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A new distributional record of *Actinopteris radiata* (Sw.) Link. (Pteridaceae) from Eastern India; a threatened taxon

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ABSTRACT

Family Actinopteridaceae Pichi-Sermoli (1970) has been merged into family Pteridaceae Ching. by Kramer & Green (1990) and Smith *et al.* (2006). *Actinopteris radiata* (Sw.) Link., a tiny clumped fern with miniature fan-palm shaped leaves was reported from south, central and west India but never from eastern India. Present collection extends the geographical territory of the taxon. This medicinally useful species has been extensively collected hence has become threatened. The taxonomic and distributional aspect has been discussed in this paper.

1. Introduction

Prior to the merger of allied families like Adiantaceae, Parkeriaceae, Hemionitidaceae, Actinopteridaceae etc. in to *Pteridaceae* by Kramer & Green (1990) and Smith *et al*. (2006), genus *Actinopteris* Link. was the sole genus in the monogeneric family Actinopteridaceae Pichi-Sermoli. The nomenclatural history of *Actinopteris* depicts how it ping-ponged between various families under different generic identity. However, all these families subsequently rested in the broader circumscription of family Pteridaceae. This species thrives in lower to lower-mid altitude of hot dry areas among sheltered rocks, below the boulders preferring the calcareous substrate. This taxon was reported from south, west and central part of India but never reported from eastern part of the country. The distributional record in adjoining countries like Nepal, Myanmar, Sri Lanka, Afghanistan strongly suggests that the taxon might be growing in hot and dry areas of the eastern India. Ghosh et al. (2004) did include the taxon in their book "The Pteridophytic Flora of Eastern India" but mentioned that the species is not reported from eastern India and suggested to search for the species from this geographical region.

This species was described under as many as six genera namely *Actinopteris*, *Asplenium*, *Aerostichum*, *Acropteris*, *Blechnum* and *Pteris*. There are plenty of mentions of this plant in Ayurveda, Siddha and folk medicines. The topical use of the paste of the whole plant is beneficial in scabies and control of pigmentation. Besides, the whole plant is used to control diabetes and the roots are advised for conception. The chemical composition of the plants are mainly steroids, triterpenoids and flavonoids Manonmani *et al.* (2013). Large scale collection of the species has pushed the taxon into threatened category.

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During the floristic survey to document the wild edible plants of Keonjhar district, Odisha the authors came across this tiny species growing in Barasuan forest area, Telkoi, Keonjhar. The specimen was collected, identified and preserved in the Department of Botany, North Odisha University, Baripada. The identity was confirmed in CAL. The published literature like Beddome (1883-1892), Saxena & Brahmam (1994-96), Panigrahi (1998), Ghosh et al. (2004) and Fraser Jenkins (2015) were consulted to verify the identity and distribution of the species.

2. Taxonomic Treatment

Until the treatment put forth by Green (1990) and Smith et al. (2006) this taxon was treated as to belong to a monogeneric family i.e. Actinopteridaceae. There are 5 species in the world out of which two are reported from Indian subcontinent. *Actinopteris radiata* and *A. semiflabellata* were very closely resembling species whereas the latter is yet to be reported from India. Eyeing the close resemblances of these taxa it is pertinent to provide the diagnostic key for the easy identification of the species.

Key to the Species

1. Scales of the stipe and rhizome are one kind, lamina broad with a median notch and flabellate……*A. radiata*
2. Scales dimorphic, lamina narrower and cuneate, often divided into two halves, without median notch…… *A. semiflabellata*

Actinopteris radiata (Sw.) Link. Fil. Sp. 80, 1841, Hook Ic. Pl. 10.t. 975, f. 2-3, 1854; Hook, Sp. Fil. 3: 276, 1860; Hook. etBak. Syn. Fil. 246, 1867; Bedd. Ferns South Ind. t. 124, 1865; Pichi-Sermoli, Webbia 17(1): 8, 11.f.1a.f. 1962 et in Webbia 17(2): 318-321, f.1. 1963.

Typus: Koenings.n.

Fertility: July –Sept.

Asplenium radiatum Sw. Schard. J.Bot. 1800(2): 50. 1801

Acrostichum dichotomum Forskk. Pl. Aeg. Arab 184. 1775 non Linn. 1753.

Actinopteris dichotoma Kuhn. Bot. Zeit. 29: 504.1871.

Acrostichum radiatum Koening ex Poir. Enc.Bot. Suppl.1:P128.1810.

Acropteris radiata Link. Hor. Berol. 2:56.1833.

*Blechum radiatum*Presl. Tent. Pterid. 103.1836.

*Pteris radiata*Boj/ Hort. Maur. 399.1837.

Actinopteris australis var. *radiata* C.Chr. Dansk. Bot. Ark. 7:125.1932.

Pteris dichotoma Kuhn. Fil. Deck. 18.1867; Fil.Afr.79. 1868.

Very small plant, ca. 8-15cm. tall with fan-palm shaped circular leaves. Rhizome creeping, short, scaly; scales withshining black stripes at the centre and light narrow edges. Fronds with thin scaly stipe. Fertile fronds 10-17 cm long, stipe longer than the lamina. Lamina flabellate, divided into two symmetrical segments with prominent median deep notch up to the base of lamina, lamina branched with 5-6 times dichotomy; first dichotomies are almost equal in length and the second ones unequal, segments of the blade 32-38, narrow, linear with apices divided in to 2-4 acute points. Lamina base and upper stipe covered with pluricellular minute hairs above and abundance of persistent scales beneath, scales falcate to tortuous, ovate-lanceolate, lobes irregular, sometimes dentate at base, tapering apex end in a long hair, fertile apices with almost equal twin pointed teeth. Sori elongated on either side of the midrib, indusiate. (Fig.-1a &b)

Note

Very much similar to *A. semiflabellata* Pichi-Sermoli. but distinct due to its broader, flabellate lamina. Fertile segment is almost with twin apices whereas *A. semiflabellata* tending to end in a single point. Fertile fronds are shorter than the sterile ones than in *A. semiflabellata*. During the winter (dry season) the lamina hangs down and turns grey but revives during rain.

Local Name

Mayursikha & Morpankh (Hindi), Chudala & Mayursikha (Sanskrit), Nanmukappullu (Malayalam), Mayilatumsikhai (Tamil) and Mayoorashikhi (Kannada).

Ecology

This species grows in plain to lower-mid altitude (up to 1000ft.) of hot dry areas among sheltered rocks, below the boulders preferring the calcareous substrate.

Specimen Examined

N.C. Nair 8386(CAL), B.C. Vyas 8953(CAL), G. King 14268(CAL), J. Ghatak 460(CAL) and A.K.Biswal NOU-1573

Conservation Assessment

Although Chandra *et al.* (2008) did not include *Actinopteris radiata* in rare and threatened category, but the over harvesting of the species for medicinal use has been the main reason for the shrinkage of the population.

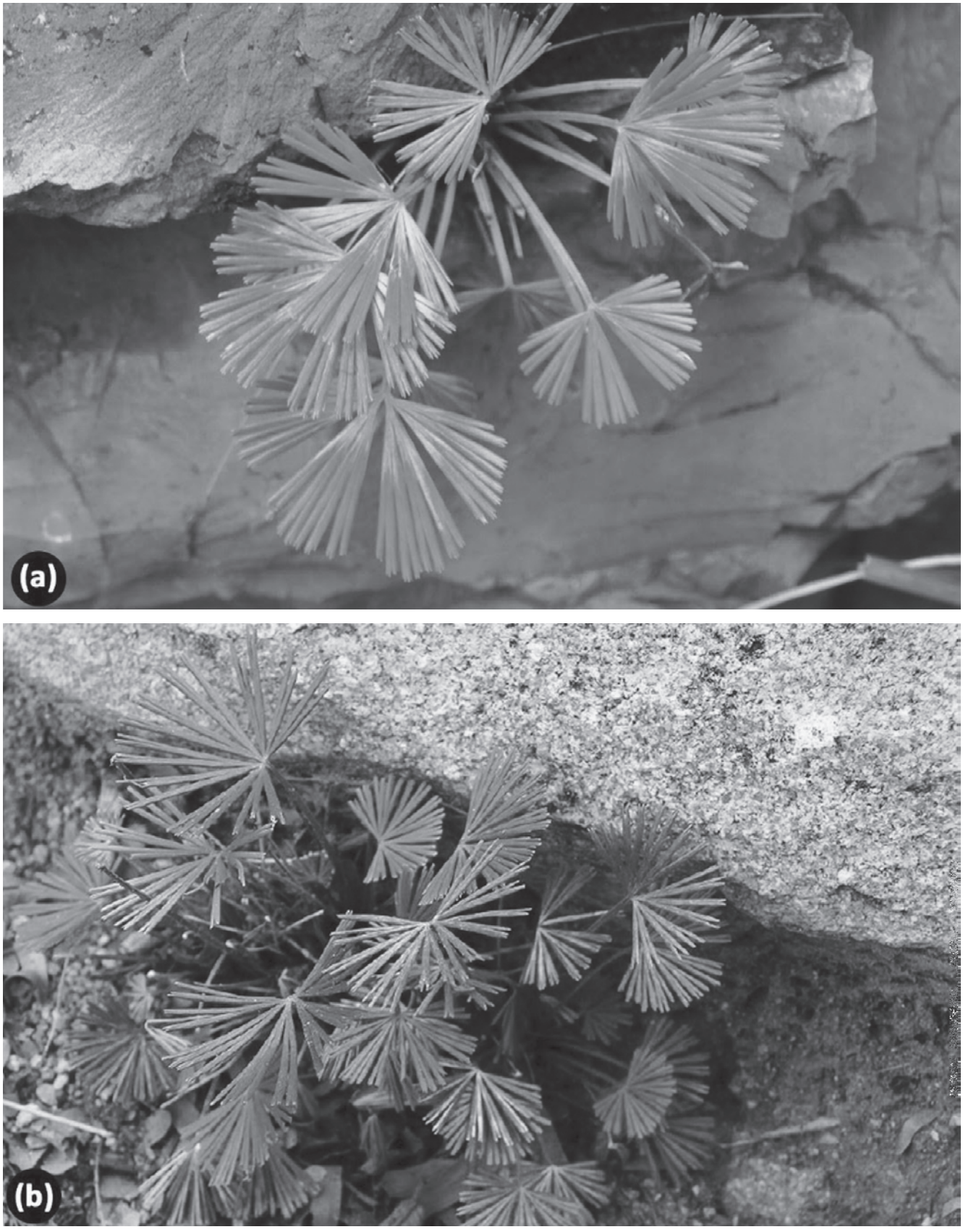

Fig. 1. Actinopteris radiate (Sw) Link
(a) Habit, (b) Fertile

The statement of Ghosh *et al.* (2004) indicates the rarity of the taxon and its occurrence in eastern India. The present collection by the author also notes that the population was meagre at the site of collection and very much location specific. *In situ* conservation is the choice of action to conserve the taxon.

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