Research & Activity Report

2012-18

Regional Plant Resource Centre | Bhubaneswar

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CONTENTS

Shri Bijayshree Routray
Minister
Forest & Environment Department
Govt. of Odisha

MESSAGE

I am pleased to learn that RPRC, a reputed center for fundamental and applied scientific research, has been implementing various research projects while achieving its goal in the field of plant taxonomy and conservation, biotechnology, biochemistry, microbiology, horticulture, medicinal and aromatic plants. Apart from intensive research on plant biodiversity assessment, microbial applications, wild edible fruits, mushrooms, mangroves, orchids and phyto-chemicals of selected medicinal plants, few other aspects like bio-fuel production, viral indexing of economically important crops including tissue culture of banana are noteworthy as important thrust and frontier areas of plant sciences. It has consistently maintained and added to its rich collections of rare and endangered plants, orchids, bamboos, palms, cacti and succulents, mangroves, medicinal & aromatic plants, for developing a repository of bio-resources for research and crop improvement. I wish that the outcomes of the work carried out in RPRC would find its way to benefit all stakeholders of Odisha.

I am hopeful that the Research & Activity Report (2012-18) published by the center would be useful for students, teachers, researchers and conservationists. I appreciate the effort of the staff of the center in this regard and convey them my best wishes.

(Bijayshree Routray)

Shri Suresh Chandra Mahapatra
Additional Chief Secretary
Forest & Environment Department
Govt. of Odisha

MESSAGE

The Regional Plant Resource Centre, a Research & Development organization, under the Forest and Environment Department in Odisha has been implementing several innovative research projects for bio prospecting indigenous macro and microflora for wider use through fundamental and applied research. The centre has strengthened and augumented its research and development programmes for inventorising, conserving, propagating, and documenting the rich biological wealth of the region. Production of quality planting materials on commercial scale, germplasm conservation and re-introduction of rare and endangered plants including mangroves & orchids are some of the significant activities of the organization.

I am happy to learn that RPRC has also successfully completed several research projects funded by different Departments of Government of India and Odisha. I hope the Institute would continue to endeavor in finding solutions to meet recent challenges in conserving the biological diversity of the State.

I express my appreciation for bringing out this research & activity report (2012-18) which would be a positive source of information to and disseminate the findings of various research activities being undertaken by the Institute.

(Suresh Chandra Mahapatra)

FROM CHIEF EXECUTIVE'S DESK

Mrs. Rebecca Nayar, IFS
PCCF & Chief Executive

I am pleased to bring out this Research & Activity Report for the period 2012-18 to address various research and development activities undertaken at RPRC during last six years. The report presents implementation of our research programmes which are prioritized to address issues pertaining to conservation and bio-resource utilisation relevant to the eastern ghats in general and Odisha state in particular. In continuation to our effort to establish germplasm banks of various plant groups for conservation and scientific enquiry, the center initiated and maintained advance line of research focusing the prioritized areas such as germplasm conservation and re-introduction of RET and other important special group of plants including mangroves and orchids,biodiversity mapping of eastern ghats, screening of wild edible fruits, mushroom and medicinal plants for active bio-molecules, nutraceauticals, antioxidants, microbial interactions on mangroves and orchids, viarl indexing of crop plants, biofuel and micro-propagation of plantation crops and endangered plants.

Scientists were allotted various research projects with financial support from state Forest & Environment Department under state plan budget after rigorous evaluation by the recently formed Research Advisory Committee (RAC) headed by the PCCF in the Government. The centre has implemented several such research projects covering various thrust areas of research relevant to the sate as per recommendation of RAC.

The centre has conducted regular in-house seminar on various research topics to provide a common platform to the institutional & invited scientists and research scholars to share and exchange the outcomes of their research activities.

The center has been nurturing academic intellect by guiding PhD and MSc students. A six month Project training progarmme for MSc (Biotech) students from various organizations is being organized to provide hands on training to fulfill the requirement of their MSc degree. During last 6 years 24 scholars who worked at the Centre have been registered for Ph. D., 4 submitted their thesis and 13 awarded Ph.D degree. Around 100 students have successfully worked for M.Sc. (Biotech.) short-term projects. During last 6 years, the scientists of this institute have published some 236 research papers in scientific journals of national and international repute.

The scientists, research fellows and supporting staff of RPRC made sustained effort and contributed to growth of the institute, and I extend my sincere thanks to them for their endeavour. Financial support received from various agencies of Govt. of India and Odisha is gratefully acknowledged. We are grateful to Additional Chief Seceretary, Forest and Environment Department, Government of Odisha for providing the research grant under state plan budget and support provided by Director, (Environment) is thankfully acknowledged.

Rebecca Nayar

Rebecca Nayar

INTRODUCTION

Regional Plant Resource Centre (RPRC), popularly called 'Ekamrakanan', was established in 1985 at Bhubaneswar, the capital city of Odisha over an area of 487 acre and can be approached from the land mark CRPF square on NH-5 and is about 1.5 Km. towards northern side of CRPF square. RPRC is an autonomous R & D organization under the Forest and Environment Department, Govt. of Odisha. The centre undertakes scientific research and applied activities to conserve, propagate and document plant resources of the region. Commercial production of horticultural plants, germplasm conservation of rare and endangered, medicinal plants and mangroves are some significant activities of the organization. The center is recognised as a Research and Development organisation by the State Government and Government of India to undertake research leading to Ph.D. degree by Utkal University, Berhampur University, Sambalpur University, Odisha University of Agriculture and Technology, Punjab Rao Krishi Vidyapith, Akola, Maharastra, Pt. Ravi Shankar Shukla University, Raipur, Chhattisgarh, Indian Institute of Technology, Kharagpur, West Bengal and Osmania University, Hyderabad, Andhra Pradesh. During the last 33 years of its existence, the Regional Plant Resource Centre has established itself as a leading research institute of the country and a major centre for conservation of biological diversity of plants. The Botanic Garden raised and maintained by the institute with its panoramic views attract visitors from far and wide. The RPRC Campus has a beautiful lake of about 40 acres and a very rich and diverse flora of more than 2000 species both natural and introduced. Due to conducive conditions, RPRC campus also supports rich faunal diversity (36 species of mammals, 148 species of birds, 38 reptile species, 15 species of amphibians, 15 fish species, 104 species of butterflies, 58 species of arachnids and 41 odonate species have been recorded so far). During recent years, the centre has gained a distinctive position among the leading research institutions in plant sciences and a major centre for conservation of plant diversity of Eastern India.

During recent years under this report period, 24 scholars who worked at the Centre have been registered for Ph. D., 4 submitted their thesis and 13 awarded Ph.D degree. Around 100 students have successfully worked for M.Sc. (Biotech.) short-term projects. The scientists of this institute have published some 236 research papers in scientific journals of national and international repute. The Centre has successfully completed 90 research projects funded by different Departments of Government of India and Odisha and 28 projects are being implemented. The center had earned the honour to act as Lead center for Similipal Biosphere Reserve, and Lead Botanical Garden of Ministry of Environment and Forests. The research activities of RPRC are guided by the recommendations of the Scientific Advisory Committee (SAC) and Research Advisory Committee (RAC).

MANDATE

- The center has a mandate of promoting plant conservation, research and to augment plant resources for sustainable development in the following areas;
- Germplasm collection of selected plant groups (living collections) for long term conservation and research.
- Survey, evaluation, propagation and conservation of medicinal, aromatic, oil-yielding and other economic plants including rare/ endangered species.
- Genetic manipulation of plants through cell, tissue and organ culture, somatic embryogenesis, transformation techniques and other biotechnological approaches.
- Studies on production, conversion and utilization of biomass especially of fuel-wood species.
- Provide necessary expertise and assistance in landscaping, garden lay out, green belt development, plant identification and impart training on plant propagation and nursery technologies.
- Dissemination of information through publication of scientific and popular articles.
- Co-operate and collaborate with other national and international institutions to promote the cause of conservation of biological diversity of plants and exchange of seed and plant materials.

EXECUTIVE SUMMARY

Summary of the achievement made in the field of Research and Development in RPRC during 2012-2018 are highlighted below:

Plant Diversity Assessment, Conservation and Monitoring

Floristic studies, quantitative and qualitative assessment of plant resources of Eastern Ghats in general and Odisha state, in particular, have been undertaken with special reference to biodiversity-rich habitats like Similipal Biosphere Reserve, Chilika lagoon, Bhitarkanika National Park, Mahendragiri, Barbara-Dhuanali forests etc. Qualitative ecological studies conducted in different forest types, along disturbance gradients, altitudes etc. have yielded useful and interesting results. Species and habitat diversity of canes (*Calamus spp.*), orchids, aquatic plants, sea grasses, mangroves, endangered plant species and fungi including mushrooms of Odisha have been studied and documented. Systematics of different plant groups of Odisha such as legumes, grasses, Solanaceae, *Macrotyloma*, *Spermacoce*, *Calamus* has been studied. A web-based application software for plant biodiversity mapping in Odisha (BIOMASS) has been developed for use by the researchers.

In order to determine the threat category and initiate appropriate species-specific conservation actions, population inventories, phyto-sociological studies, Ecological Niche Modeling (ENM), standardization of methods of propagation and reintroduction of a number of threatened plant species occurring in Eastern Ghat regions of India have been successfully undertaken by RPRC. A total of 3081 individuals of *L. comberi*, 6914 of *C. sphaerica* and 1640 individuals of *H. gaitii* were enumerated from Odisha and Andhra Pradesh.

Methods of large-scale propagation of *Lasiococca comberi* from seeds, rooting of stem cuttings and air-layering have been thoroughly standardized and the factors responsible for poor seed germination has been investigated. More than 5000 plants of the species have been raised in the nursery for reintroduction to natural habitats. In case of *Hypericum gaitii*, the techniques of propagation by rooting of apical stem cuttings with application of root promoting substances have been worked out. Seed propagation of *Cycas sphaerica* has been achieved and more than 2500 plants have been raised through standardization seed germination methods. In addition, the technique of propagation of *C. sphaerica* by inducing rooting in bulbils has also been found successful. More than 2,500 plants of L. comberi, C. sphaerica, C. ceylanica and H. gaitii have been reintroduced to Tamana RF of Khurda Forest Division, Mandasaru of Phulbani Forest Division and Similipal Biosphere Reserve and observations of survival and growth performance of the plants are being recorded at regular intervals.

Bioprospecting- the process of discovery and commercialization of new products from biological resources, was attempted in a number of threatened plants of Eastern Ghats including Odisha as they are represented by small populations and numbers and are poorly studied in respect of their utilitarian values and commercial potential. The bioprospecting of these threatened plant species will add to the conservation value of the species, promote cultivation on commercial basis and in turn bring the species out of threatened category.

In order to collect first-hand information of diversity, occurrence, pattern of distribution, phenology, ecology, regeneration potential and use value of all tree species occurring in different forest types of Odisha (470 species) and develop easily workable identification keys based on macro-morphological characters for easy identification of species and to prepare a pictorial guide of trees of Odisha, this project has been taken up by RPRC. The compilation/ preparation of species-wise fliers in respect of 250 species has been completed and it is proposed to bring out the Pictorial Guide to Forest

Trees of Odisha (Part-I) containing information on 250 tree species belonging to 163 genera and 58 families in the first phase. *Siersia paniculata* (Anacardiaceae) has been reported as an additional tree species for flora of Odisha.

Multi-seasonal surveys were conducted in different forest blocks dominated by tribal people in Rayagada, Nabarangpur, Koraput, Kalahandi, Gajapati, Ganjam, Mayurbhanj, Keonjhar, Kandhamal Districts of Odisha, Chattishgarh, Sundarban (West Bengal) for collection of plants and field data in respect of wild edible fruits, leafy vegetables, rhizomes, tubers, flowers and other plant parts used by them as food items.

In order to make an exhaustive floristic inventory and quantitative assessment of plant resources (flowering plants) and fill up the existing gap on research involving flowering plants of Chilika lagoon and its adjoining regions, a project was undertaken under the Integrated Coastal Zone Management Project. *Cassipourea ceylanica, Dimorphocalys glabellus, Uvaria hamiltonii, Mucuna monosperma, Capparis roxburghii, Psoralea corylifolia, Macrotyloma ciliatum, Gyrocarpus americanus, Aponogeton undulatus* etc. have been identified as endangered species needing conservation action.

For study of the diversity, distribution and abundance of aquatic plants of lake water, 30 sampling points were identified in the macrophyte dominated zones and data on seasonal changes in occurrence and density of aquatic plants, water and sediment quality parameters were recorded in three prominent seasons for four years. Special attention was given to distribution of seagrass meadows and their diversity in relation to substratum characteristics, water quality parameters and hydrology. Six seagrass species namely, *Cymodocea serrulata*, *Halodule uninervis, Halodule pinifolia, Halophila ovalis, Halophila ovata* and *Halophila beccarii* were identified and studied.

Symplocos racemosa (Roxb.) is a critically endangered medicinal tree found in the Eastern Ghats of Odisha. Presently scientific data gathered on distribution, population biology along with reproductive capacity. The protocol of *in situ* conservation, regeneration of plants through air-layering is successfully achieved.

Taxonomical revision work of the genus of *Solanum* L. in Eastern Ghats of India has been undertaken. The genus *Solanum* L. is one of the most economically important genera of plants and includes the cultivated potato, tomato, and aubergine. With ca. 1,500 species, it is also one of the largest and most taxonomically challenging genera of plants.

Studies on molecular characterization and assessment of genetic variability in *Shorea robusta* Gaertn. tree populations in Odisha has been initiated to evaluate diversity within and among different natural *S. robusta* tree populations exists in tropical moist deciduous forest regions in Odisha, India using ISSRs.

Microbial Diversity and Applications

Studies on Mushroom diversity and characterization have been undertaken. Under this programme, information of different wild edible mushrooms from different forest division of Odisha was gathered and Nutritional composition and biological properties of 9 commonly consumed wild edible mushrooms by tribals of Odisha, India was analysed in order to assess these specimen as potential source of nutrients and medicine. Few amino acids like Aspartic acid, Glutamic acid, Asparagine, Glutamine, Glycine ,Threonine, Arginine, Leucine, Lysine and Proline were found abundantly in some mushroom species studied.

Five different forest divisions (39 sites) were surveyed and mushrooms belonging to Amanita (6 species), Russula (8 species) and Termitomyces (5 species) were collected , described morphologically and analysed for their nutritional and biochemical properties in the laboratory.

A survey for collection of mushrooms from Bhubaneswar and its suburb areawas carried out to supplement more information on fungal diversity of Odisha. Survey of incidence of mushroom in urban and suburban area of Bhubaneswar exhibited the occurrence of 71 species of mushrooms belonging to 34 genera. As mushrooms are also indicators of green and moist environment, interpretation on environment protection and /or greenery up gradations through plantations and garden development.

A study was carried out on isolation, identification and characterization of endophytic fungi from different rare orchids of Odisha. Total 160 fungi isolated from

different Orchids grow in Odisha, and morphologically characterized and identified.

Endophytes are promising source for application in biotechnology, as they can promote plant growth by several mechanisms. The total fungal endophytes obtained from different orchids were screened for plant growth hormone i.e. Indole acetic acid production by plate test method. Out of 160 fungal isolates, only 53 fungal isolates showed positive result for Indole acetic acid production.

Mycorrhizal diversity and its assiciation with threatened Orchid need to studies for conservation and reintroduction activity. To this effect, an experiment was planned to determine the effect of fungal isolates in seed germination and establishement of *Eria meghasaniensis* and *Pomatocalpa decipiens*. Efforts were made towards isolation of fungi from *Eria meghasaniensi,* an endemic *species* credited to Odisha.

Screening of native endophytic microbes against *Meloidogyne icognita* , a nematode causing huge damage to banana plantation and products in north eastern and other part of India has been initiated. A survey has been carried out in Assam and 123 samples (root/fruit/leaf) from 45 plants samples belonging to 17 types of banana cultivars grown in 7 different districts were collected for further research analysis.

Bioprospecting of phosphate solubilising fungi and their application for improving the growth of some RET medicinal plants has been studied with *Gloriosa superba*, *Xylocarpus granatum*, *Piper longum*, *Operculina turpenthum*. The present study emphasizes on the application of efficient P solubiling strains as biofertiliser in order to enhance the productivity of *P. longum* which is one of the endangered species of Odisha state. The fungal strains tested under pot culture conditions proved their efficacy in growth improvement of growth of *P. longum*. Plants of *P. longum* responded well to fungal inoculation and their average height is higher than uninoculated control. Besides, plant hight and biomass, fungal inoculations also improved the number of fruits per plants and shortened their developmental period for fruiting and ripening. Hence, application of useful Phosphate solubilising fungi may prove as an efficient alternative in sustaining the growth and development of RET plants.

Biomineralization through formulation of bioagent by using native plant growth promoting microbes and evaluation of their usefulness for agriculture productivity has been studied with Chilli and brinjal . Impact of fungal inoculations as compared to uninoculated control was exhibited on plant growth and development during pot culture experiments. However, the suitability of *Aspergillus sp. 6, Aspergillus sp. 5 and Aspergillus sp. 3* was observed to be an effective inoculant for influencing the fruits and its total weight of chilli. Similarly, *Myceloid fungus and sterile mycelia, Aspergillus sp. 8 and 9* were observed to be an effective inoculants for brinjal crops.

Exmeriment on development of nursery technology through novel bioinoculant for better growth and development of some important plantation tree species of Odisha like *Gmelina arborea, Pongamia pinnata, Saraca asoca, Terminalia arjuna, T. bellerica, Dalbergia sissoo, Dalbergia latifolia* , *Madhuca latifolia* was carried out under nursery conditions.

An attempt has been made to record fungal diversity of the unexplored mangrove ecosystem of Subarnarekha of Odisha. Survey, collection , isolation and characterization of fungi from Subernarekha mangroves ecosystem has given a good information on fungal diversity. Overall, 55 no of various samples for the winter season and 141 no. of samples for summer season were collected for the isolation of fungi.

Studies on development of time cut back and low cost technology for biodegradation of green wastes used in Vermicomposting have been carried out using some cellulose degrading microbes. Studies conducted on screening of cellulolytic fungi and its evaluation for the primary decomposting as well as vermicomposting exhibited very promising results and confirm the cellulolytic potential of one of the fungal strains fruitful in this endeavor.

Recently, screening for bio control agents against fungal pathogens causing Panama wilt and Anthracnose diseases on banana varieties cultivated in Odisha has been initiated. Total 104 fungal isolates obtained from 7 sites /six banana var. After purification and characterization, 40 different types of fungi obtained including three species of Fusarium. Indigenous fungi microfungi as well as endophytic fungi isolated from

different habitat and plants were evaluated for their antifungal activity against *Fusarium* and *Colletotrichum* isolated from different banana cultivars Screening of 100 nos. different fungi for their bioactivity against these pathogens have been completed. Preliminary screening for the biocontrol agent showed good antifungal activity in 15 different fungi .

To study bioprospecting of mangrove fungi for Bioactive and Phosphate solubilising potential, elaborative work was done withfungal strain BC 98 against seven no. of Fusarium sp. The fungus was having wide spectrum bioactivity as it was inhibitory to the all seven fungal pathogen belonging to Fusarium sp. proving usefulness of this fungal strain towards development of plant protection agent as far as the fusarial diseases are concerned. However, a detailed studies are required to confirm the bioactive potential of this fungal strain against other group of pathogens , so that it can be utilized as wide spectrum biocontrol agent .

Propagation, Conservation and Re-introduction of RET & other important Plants

In order to conserve salt-sensitive landward back mangroves, a holistic approach has been undertaken. This research activity involved optimization of rooting through vegetative propagation in juvenile stem micro-cuttings of *Exceocaria agallocha*, mass propagation & hardening of rooted saplings of *Heritiera fomes, H. littoralis, Cerbera mangha,.Excoecaria agallocha;* biomolecular changes during hardening of the saplings exposed to salt stress ; re-introduction of hardened saplings of *Excoecaria agallocha, Heritiera fomes, H. littoralis, Cerbera mangha* in the wild habitat and finally post re-introduction evaluation of the introduced plants for their sustainable growth & development.

A total 3000 *Excoecaria agallocha* plants were raised through stem cutting method in the nursery. Propagated plants were subjected to hardening against different concentration of NaCl-salt stress (e.g.,50mM.100mM,150mM and 200mM) in order to acclimatized for re-introduction in the native. For re-introduction trial, 2000 hardened plants were planted during Aug,2013 in an experimental plot in Khadibil area under Balasore Wild Life Division allotted by Forest Division.

Another experimental trial has been started with *Heritiera littoralis* for their re-introduction potential in Bhitarkanika using vegetatively propagated plants hardened with various level of sodium chloride salinity (100mM, 200mM, 300mM, 400mM and 500mM). A total 99 nos of *Heritiera littoralis* saplings were reintroduced in three different sites (Mahisamara, Suajore and Dangmal) of Bhitarkanika National Park during March-October, 2017. As per data recorded during 2017-18, more than 70% re-introduced plants were survived as of now.

A new approach for scaling up of vegetative propagation through *in vivo* shoot multiplication in hypocotyls of Rhizophoraceae mangroves has been initiated. This study primarilly aimed at induction of *in vivo* multiple shoots in hypocotyl of Rhizophoraceae species like *Bruguiera parviflora, Kandelia candel* and *Rhizophora apiculata* and their biomolecular evaluation.

In vivo multiple shoot regeneration from hypocotyls of Rhizophoraceae mangroves was influenced by salinity and proline leading to expression of species-specific differential antioxidant enzyme activities. The specific enzymes viz. peroxidase, catalase and superoxide dismutase may be used as indicator to depict pathway of shoot organogenesis in *B. parviflora*, *K. candel* and *R. apiculata*.

A study was initiated for cloning and functional validation of salinity tolerant genes from mangrove plants of Odisha with *Rhizophora apiculata* using TRIzol method of total RNA from both control and salt stressed leaf samples represent driver and tester, respectively.

In order to conserve & restore viable populations of inportant Orchids of Odisha, population analysis has been initiated with extremely rare orchids *Eria meghasaniensis, Dendrobium regium, Cymbidium bicolor* .Tissue culture techniques are being used for mass propagation of these orchids. Protocols have been standardised for 37numbers of wild orchids of Odisha. Many of these like *Dendrobium regium*, *Cymbidium bicolor*,*Tainia hookeriana, Phaius tankervilleae* etc. Seedlings of *Dendrobium regium*, *Cymbidium bicolor* and *Tainia hookeriana* successfully introduced into different natural habitats

Studies have been taken up to produce quality planting materials of ornamental orchids. Effect of different

growth regulators on the induction and multiplication of shoots were thoroughly studied. Under these works, mass propagation protocols have been standardized for 34 number of orchids and planting materials of 13 numbers of orchids are available for sale. For the production of quality planting materials for *Dendrobium* Soniaorchids, ISSR molecular markers have been developed and being used for the identification of somaclonal variations.

Ex situ conservation work on two endangered species *Cordia macleodii* & *Blepharispermum subsessile* has been undertaken. A study was carried out to standardize protocol for direct & indirect regeneration and mass propagation of *Blepharispermum subsessile* DC. A method for high frequency shoot bud regeneration from cotyledon of *B. subsessile* DC is reported for the first time. It has been successfully standardized and described for adventitious buds and also high frequency multiple shoot induction.

Studies on Medicinal Plants and Wild Edible Fruits

Biological screening of medicinal plants for cytotoxic, antioxidant, antifilarial, antifungal and anticancer activities has been performed with *Clerodendron viscosum,C. indicum, Combretum roxburghii, Combretum densiflorum, Combretum albidum, Terminalia bellerica*, *T. chebula* and *T. catappa*.

Bioassay guided isolation of active principles from selected medicinal plants viz. *Combretum roxburghii* , *Rauvolfia tetraphylla* was done with leaf extracts to evaluate antioxidant and antifilarial activities.

Comparative analysis of wild and cultivated varieties of medicinal plants was performed to evaluate medicinal properties. Variation in the cultivated and wild varieties was not very significant, irrespective of the habitat, medicinal potential of the two remain similar in most of the cases. Slight variation was obtained in the flavonoids content of hexane extracts of both.

Studies on molecular screening of wild *Saraca asoca* (Roxb.) from natural population of Similipal Biosphere Reserves, Champagarh Protected Forest, Tamana Reserve forest, Kapilash Reserve forest and Puri & Bhubaneswar to screen the elite clones through morphological, molecular and phytochemical markers were undertaken. Nine efficient primers were screened and amplified 104 polymorphic bands which exhibited 94.51% polymorphism. Plantation of about 300 rooted air layering plantlets according to populations (Champagarh, Similipal, Bhubaneswar) and hormonal combinations for the purpose of mass propagation has been established. Quantitative and qualitative assessment of total flavonoid, a secondary metabolite from the methanolic extracted bark samples of *Saraca asoca* collected from different natural forest reserves of Odisha (Kapilash RF - 16 bark samples, Similipal RF - 25 bark samples, Champagarh RF - 25 bark samples and Tamana RF - 25 bark samples) were completed.

This research study included production of QPM of *Piper longum* through vegetative propagation; quantitative estimation of protein content in leaf cuttings of *Piper longum* and vine node cuttings of *Operculina turpethum* to justify the QPM produced.

In order to achieve QPM of *Piper longum,* mass multiplication of *P. longum* was carried out through vegetative propagation procedure using different types of micro cuttings viz. vine node cuttings with single node and two types of leaf cuttings (Apical and Petiolar).

Studies on mass multiplication of *Embelia tsjeriam-cottam,* through vegetative propagation for production of quality planting materials (QPM) as well as ex-situ conservation; assessment of quantity and quality of embelin present in both wild and cultivated plants were condected. As regard to mass propagation and QPM production of *E. tsjeriam-cottam,* stump cuttings/ wildings can be used for mass multiplication of this vulnerable plant. Around 100 nos of vegetatively propagated QPM raised and maintained in the nursery. Ex-situ conservation has been initiated by planting the propagated QPM in the field of nursery premises.

In connection with evaluation of Embelin content, the present study revealed that embelin was also present in leaf and stem bark parts apart from seeds of *E. tsjeriam-cottam*. This finding is also corroborative with the reports of various workers (Swamy *et al.,* 2007; Raghu *et al.,* 2011). While **t**he seed parts showed highest yield of embelin content (4.88% dry wt.), the stem bark possessed 1.14% dry wt. of embelin followed by leaf (0.96% dry wt.). Hence both the leaf and stem bark parts can also be used as alternative/substitute to the seeds for getting embelin.

Recently a research study has been aimed to evaluate and ensure *Ardisia solanacea* and *Aegiceras corniculatum* as suitable substitutes for RET listed medicinal plants *Embelia ribes* & *E. tsjeriam-cottam* pertaining to adequate occurrence of major active phytochemical 'embelin'& other related compounds in leaves & fruits.

Phytochemical analysis and biological screening of *Homalium nepalense, Homalium tomentosum* and *Homalium zeylanicum* for antioxidant, anti-diabetic, anti-inflammatory and hepatoprotective activities have been performed. Total phenolic and flavonoid contents of the leaves and bark part of three Indian *Homalium* species were estimated; it is established that leaves and bark of *H. nepalense* possess better antioxidant quality than other two *Homalium* species that need further study and clinical tests. Bark of the plant was proved to be more potent than the leaves.The purpose of this study was to evaluate ameliorative effects of *Homalium* species on CCl_4-induced hepatocellular injury in rats. Oxygen-radical absorbance-capacity (ORAC) and cell-based-antioxidant-protection-in-erythrocytes (CAP-e) were performed and found that the ethyl acetate fractions of bark (HNEB) and leaf (HNEL) showed a remarkable degree of antioxidant activities in a dose dependent manner. H. nepalense possesses significant hepatoprotection effect because of its antioxidant constituents.

For the diabetic study the *H. zeylanicum* was subjected for *in-vitro* anti-diabetic studies and was found IC_{50} value of ethyl acetate extract (bark) was 25 µg/ml, which is found to be most active one than other extracts; as compared with the standard drug i.e. Acarbose Protein agglutination of anti-inflammatory study was performed and bark of *H. zeylanicum* was found to more potent anti-inflammatory activity and as compared with the standard drug like Diclofenac All the results indicated its sound pharmacological potential.

Phytochemical screening and toxicity profiling of *Geophila repens* as a potential source for drug against Alzheimer disease were permormed.The results of this study revealed that phenols and flavonoids could be responsible for the antioxidant, anticholinesterase activities of *G. repens*.

Study was condected for phytochemical and biological evaluation of *Hydrolea zeylanica* for anti-diabetic, and anti-inflammatory activites.The above investigation revealed that the ethyl acetate leaf extracts of *H. zeylanica* showed significant antioxidant activity in various *in vitro* methods. The ulcer index measured in different groups showed strong evidence for the antiulcer activity of the leaf extract of *H. zeylanica*.

Anticholinesterase activities of some traditional Indian Spices viz.*Cuminum cyminum, Cinnamomum zeylanicum* or *Cinnamomum verum*, *Trigonella foenum-graecum* , *Syzygium aromaticum*, *Curcuma longa* ,*Glycyrrhiza glabra,Zingiber officinale* .*In vitro* cholinesterase inhibition assay of all above spices have the potential memory enhancing property by modulating the flow of choline for signal transmission in the nervous system. Hence, it is concluded that all spices might be effective and can be optional herbal drugs to cure neurological related diseases.

A study was conducted to evaluate Bioactive Polysaccharides for antitumor and immuno-modulatory activity from wild edible Mushroom *Lentinus fusipes* found in Odisha. Water soluble heteroglycan (PS-II) with an average molecular weight 60 kDa was isolated which exhibited significant in vitro splenocyte and macrophage activations with optimum dose of 20 µg/ml and 80 µg/ml respectively.

Nutrients, antinutrients, antioxidant, essential aminoacids and pectin in wild edible fruits of Odisha have been analysed.Till date, around 85 nos of wild edible fruits were subjected to analysis of their nutritional aspects and many of these fruits were found rich in nutritional, antioxidant and low antinutritional properties The wild edible fruits had been collected from various forest regions of Odisha . Some of the species viz. *Aegle marmelos, Annona squamosa, Antidesma ghaesembila,Artocarpus lacucha,Bridelia retusa, Buchanania lanzan,Calamus gurba,Careya arborea,Carissa spinarum,Citrus medica, Cordia dichotoma, Dillenia pentagyna,Diospyros melanoxylon,Eugenia rothii, Ficus auriculata,Ficus hispida, Limonia acidissima, Madhuca indica, Melastoma malabathricum, Mimusops elengi, Morinda*

tinctoria,Phyllanthus emblica, Streblus asper,Syzigium cumini,Toddalia asiatica, Ziziphus mauritiana showed promising nutraceutical properties.

Studies on Bio-energy Production

In order to produce biofuel such as bioethanol, biodiesel and biohydrogen, the saccharification process has been standardized. The protocols have been standardised for efficient release of glucose molecules from different promising spp. *Gliricidia sepium, Phragmites karka, Agave sisalana, Acacia mangium*. Enzymatic cellulose hydrolysis profiles for the COSLIF-pretreatment process has been initiated.

Horticulture and Floriculture

Mass propagation of different verities of banana through tissue culture has been standardised. Efficient, safer and cost-effective protocols for in vitro production of local Musa species Patakpura and Champa through tissue culture has been developed. Banana plantlets of varieties GajaBantal, Patakpura, Champa, Grand naine in nursery of RPRC. Different varieties like cv. GajaBantala, cv. Robusta, cv. Grand naine, cv. Patkapura and cv. Champa are being produced in aseptic condition inside the laboratory.

Introduction of new Musa spp. cv. Yangambi-Km5 In Odisha and its micro propagation has been initiated. The project actively focused on the introduction of a new variety in Odisha through advance tissue culture technique. Successfully establishment of mother block was done at RPRC through a plantation of Tissue cultured plants of Yangambi variety which was initially collected from Horticulture research station, Kovvur, Andhra Pradesh.Morphological data of plants like height, circumference, no. of leaves were taken.

Efficient & cost-effective protocol has been developed for rapid propagation of GajaBantal banana plantlets (QPM) through application of optimum concentrations of phytohormones for meristem culture *in vitro.*

Genetic fidelity testing for tissue culture raised banana at RPRC by using PCR based molecular tools has been initiated in order to provide genetically uniform, pest, and disease-free planting materials.. Amongst 12 different cultivars studied, four cultivars, namely Martman, Amrutapani, Robusta, and Red Green Banana were found closely related and genetically distant from rest of the 12 cultivars.

Proteomic analysis of banana fruit to identify fruit ripening process related key proteins has been initiated.

HRD & Publications

During this report period, 13 Ph.D have been awarded, 4 submitted, around 25 continuing (registered) under different Universities like Utkal University, North Orissa University, SOA University and Ravenshaw University.

Towards fulfilment of MSc. (Biotechnology) degree, around 100 students from different institutions were provided project training (short term) by the scientists on various topics/subjects relevant to ongoing research activities in the centre complete their project work leading to award of dissertation.

The Scientists of RPRC have published 236 research papers during this report period (2012-18) in national & international journals. Besides publication of a book, scientists have also contributed some 17 nos of book/book chapters/booklets during above period of research activities.

Symplocos racemosa

RESEARCH ACHIEVEMENT

Plant Diversity Assessment, Conservation and Monitoring

Plant biodiversity inventory, assessment and monitoring in Eastern Ghats

(2012-13; State Plan funded)

PI: Dr. Pratap Chandra Panda

Research Fellows: Tirthabrata Sahoo, Sanjay Pattnaik & Ashok Kumar Biswar

Floristic studies, quantitative and qualitative assessment of plant resources of Eastern Ghat in general and Odisha state, in particular, have been undertaken with special reference to biodiversity-rich habitats like Similipal Biosphere Reserve, Chilika lagoon, Bhitarkanika National Park, Mahendragiri, Barbara-Dhuanali forests etc. Qualitative ecological studies conducted in different forest types, along disturbance gradients, altitudes etc. have yielded useful and interesting results. Species and habitat diversity of canes (*Calamus spp.*), orchids, aquatic plants, sea grasses, mangroves, endangered plant species and fungi including mushrooms of Odisha have been studied and documented. Systematics of different plant groups of Odisha such as legumes, grasses, Solanaceae, *Macrotyloma*, *Spermacoce*, *Calamus* has been studied. A web-based application software for plant biodiversity mapping in Odisha (BIOMASS) has been developed for use by the researchers.

Research fellows during plant collection and photography in the field

Population inventory, ecological niche modeling, propagation and reintroduction of threatened plant species of Eastern Ghats of India

(2012-17; Dept of Biotechnology, Govt. of India funded)

PI: Dr. Pratap Chandra Panda

Research Fellow: Pradeep Kumar Kamila

In order to determine the threat category and initiate appropriate species-specific conservation actions, population inventories, phyto-sociological studies, Ecological Niche Modeling (ENM), standardization of methods of propagation and reintroduction of a number of threatened plant species occurring in Eastern Ghat regions of India such as *Lasiococca comberi, Hypericum gaitii, Cycas sphaerica, Cassipourea ceylanica, Alphonsea maderaspatana, Polyalthia simiarum, Uvaria hamiltonii, Dimorphocalyx glabellus, Gnetum ula* have been successfully undertaken by RPRC. A total of 3081 individuals of *L. comberi*, 6914 of *C. sphaerica* and 1640 individuals of *H. gaitii* were enumerated from Odisha and Andhra Pradesh as detailed below.

Species	No. of sample plots	No. of seedlings	No. of saplings	Immature individuals	No. of adults	Cut stumps	Total no. of individuals
Lasiococca comberi	47	2241	249	-	591	-	3081
Cycas sphaerica	301	2816	1283	374	2102	339	6914
Hypericum gaitii	25	-	-	-	-	-	1640

Methods of large-scale propagation of *Lasiococca comberi* from seeds, rooting of stem cuttings and air-layering have been thoroughly standardized and the factors responsible for poor seed germination has been investigated. More than 5000 plants of the species have been raised in the nursery for reintroduction to natural habitats. In case of *Hypericum gaitii*, the techniques of propagation by rooting of apical stem cuttings with application of root promoting substances have been worked out. Seed propagation of *Cycas sphaerica* has been achieved and more than 2500 plants have been raised through standardization seed germination methods. In addition, the technique of propagation of *C. sphaerica* by inducing rooting in bulbils has also been found successful. Rooting could be induced in 2-year old stem cuttings of *Cassipourea ceylanica* and *Dimorphocalyx glabellus* by treating them with 2000 ppm and 2500 ppm of IBA respectively and plantlets so raised could be acclimatized and hardened in large-scale under mist-house conditions. More than 2,500 plants of L. comberi, C. sphaerica, C. ceylanica and H. gaitii have been reintroduced to Tamana RF of Khurda Forest Division, Mandasaru of Phulbani Forest Division and Similipal Biosphere Reserve and observations of survival and growth performance of the plants are being recorded at regular intervals.

Propagation and reintroduction of threatened plants of Eastern Ghats of India

Bioprospecting of threatened plants of Eastern Ghats of India

(2017-19; State Plan funded)

PI: Dr. Pratap Chandra Panda
Research Fellow: Pradeep Kumar Kamila

Bioprospecting- the process of discovery and commercialization of new products from biological resources, was attempted in a number of threatened plants of Eastern Ghats including Odisha as they are represented by small populations and numbers and are poorly studied in respect of their utilitarian values and commercial potential. During the last couple of years, the bioprospecting of three endemic and threatened plant species of Eastern Ghats of India namely, *Lasiococca comberi, Hypericum gaitii* and *Cycas sphaerica* has been undertaken at RPRC. Physico-chemical analysis of seeds of *Lasiococca comberi* revealed that it has high protein (13.78%), crude fiber (22.2%) and carbohydrate (11.54%) contents. The seed oil contains high amount of polyunsaturated fatty acids especially linolenic acid (65.3%) and has great potential for use in food and nutraceutical industries.

The essential oil from tender parts of *Hypericum gaitii* was found to be a rich source of sesquiterpene and monoterpene hydrocarbons with *α*-pinene (69.5%) and *β*-caryophyllene (10.5%) as the predominant constituents besides possessing moderate antioxidant property. The plant is also identified as a new source of pseudohypericin. The endosperm of *Cycas sphaerica* had high contents of carbohydrate, fatty acids, fibre, vitamin B1 and C, essential amino acids such as leucine, threonine and lysine. As many as 40 phytochemicals were isolated from the endosperm, out of which ethyl-α-D-glucopyrinoside, 3-0-methyl-D-glucose and cis-vaccenic acid, palmitic acid, γ-sitosterol were the important compounds.

The bioprospecting of these threatened plant species will add to the conservation value of the species, promote cultivation on commercial basis and in turn bring the species out of threatened category.

Fatty acids	*Lasiococca comberi*	Flax	Perilla	*Dracocephalum kotschyi*
Palmitic acid (16:0)	5.3 ± 0.14	5.3	7.3	4.75
Stearic acid (18:0)	3.1 ± 0.09	3.1	3.3	2.31
Oleic acid (18:1)	13.8 ± 0.18	16.6	20.9	18.11
Linoleic acid (18:2, n-6)	7.1 ± 0.05	16.0	15.4	13.56
Linolenic acid (18:3, n-3)	65.3 ± 0.84	58.0	53.0	61.23
∑ Polyunsaturated fatty acids	72.4	-	-	-

Fatty acid composition of Lasiococca comberi seed oil with high Linolenic acid (%)

Fruits and seeds of *Lasiococca comberi*

Component	Values
Oil (%w/w)	41.53 ± 0.28
Moisture content (%w/w)	7.1 ± 0.10
Protein (%w/w)	13.78 ± 0.18
Crude fiber (%w/w)	22.2 ± 0.14
Ash (%w/w)	3.84 ± 0.03
Carbohydrate (%w/w)	11.54 ± 0.27

Proximate composition of *Lasiococca comberi* seeds

Bo.	RT	Name of the compound	Melecular Formulae	Melecular Weight	Peak Area %
l.	12.35	Ethyl a-d -glucopyranoside	C8Ht606	208	26.30
2.	1 3.28	3-0- Methyl-d -glucose	C7Ht406	194	33.23
3.	14.87	Undecanoic acid, LO-rnethyl-, methyl ester	C13H2602	214	0.32
4.	15.10	Z-8-Methyl-9-tel:radecenoic acid	C15H2802	240	0.41
5.	15.44	n-Hexadecanoic acid	C1[>li3202	256	7.23
6.	17.14	7,10-Hexadecactienoic acid, methyl ester	C17H3002	266	0.20
7.	17.24	9-0ctadece noic acid (Z)-, methyl ester	C19H3602	296	l.L5
8.	17.93	cis-V accenic acid	CJgH3402	282	18.66
9.	18. 19	Octadecanoic acid	C18H3602	284	1.32
10.	19.37	Linoleic acid ethyl ester	C2oH3602	308	0.05
11.	19.72	5,8,1 J , 14-Eicosatetraenoic acid, methy l ester,	C21H3402	3J8	0.08
12.	20.06	cis-13-Eicosenoic acid	C20H3802	310	0.22
13.	21.98	9-0ctadece noic acid (Z)-, 2-bydroxy-1. -	C21H4004	356	0.16

Compounds identified in endosperms of Cycas sphaerica

Study of the diversity, distribution and phenology of forest trees of Odisha and development of a pictorial guide and easy identification key based on macro-morphological characters

(2015-19; State Plan funded)

PI: Dr. Pratap Chandra Panda

Research Fellows: Prabhat Kumar Das, Swadhin Mohanty & Somnath Chatterjee

Though the exact number of tree species occurring in India is not known, the species number may go up to 2,000 which include both flowering plants and gymnosperms. In Odisha, it has been estimated that the total number of wild forest trees and exotics those thoroughly naturalised in forest ecosystems is about 470 species. Though field level information of distribution, phenology, use and silvicultural aspects of commonly used timber and medicinal plants are available, there is scanty information on vast majority of the wild forest trees having limited local use value or no use at present. No doubt, these species contribute enormously to the ecosystem and human welfare and likely to have

unexploited economic potential. In order to collect first-hand information of diversity, occurrence, pattern of distribution, phenology, ecology, regeneration potential and use value of all tree species occurring in different forest types of Odisha (470 species) and develop easily workable identification keys based on macro-morphological characters for easy identification of species and to prepare a pictorial guide of trees of Odisha, this project has been taken up by RPRC.

Under the project, the field level data on occurrence, density, phenology and ecology of 300 species of trees have been collected and compiled. The photographs of tree crown, bark, leaf, flowers, fruits, seeds of about 200 tree species have been collected. The compilation/ preparation of species-wise fliers in respect of 250 species has been completed and it is proposed to bring out the Pictorial Guide to Forest Trees of Odisha (Part-I) containing information on 250 tree species belonging to 163 genera and 58 families in the first phase. *Siersia paniculata* (Anacardiaceae) has been reported as an additional tree species for flora of Odisha.

Commonly in open forests; rocky hills etc. Small tree.

USES

The fleshy, purplish-coloured pulp of the fruit is eaten by forest dwellers. The seeds and roots are used for folk medicine as herbal remedies for stomach ailments and fevers. The leaves used for flexible moulds to bake chapattis in, with their raised veins leaving a beautiful impress on the soft dough, especially in forest fringe village.

The wood is durable and used for making carved combs, turnery articles, light furniture, toys, mathematical instruments, wooden utensils, etc.

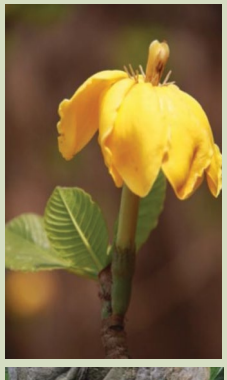
Fruit-eating birds and herbivore animals consume the fruit in large quantity.

Botanical description

Leaves opposite or 3-nate, subsessile, broadly elliltic, orbicular or obovate, upto 37 x 18 cm, obtuse or rounded, secondary nerves strong, reaching nearly to the margin, glandular hairy in the axils beneath,base narrowed, young leaves pubescent beneath; stipules with a broad ovate and cuspidate deciduous limb, the lower part persistent, connate, sometimes becomes detached at the base and remaining as a movable tube, 5-6.2 mm long on the twig.

***Gardenia latifolia* Ait.**
Rubiaceae

Flowers white or yellow, large, solitary 7.5-10 cm diam., usually borne when the leaves are small; peduncles short. Calyx 1.2-2 cm long somewhat mealy and pubescent, somewhat ridged by the decurrent calyx-lobes; calyx-lobes very unequal, subulate, apiculate. Corolla tubes 5-6.2 cm long funnel-shaped above, hairy, lobes 5-9, usually over 7. Anthers partly exserted.



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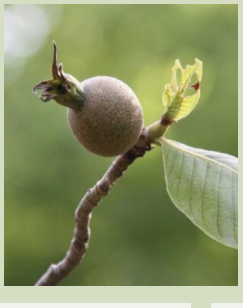


Distribution :

Tropical and Sub-tropical regions of Asia, Africa and Madagascar.

Throughout India,

In Odisha : Bargarh, Sambalpur, Similipal, Kalahandi, Nuapada, Khordha

Flowering time: March-April
Fruiting time: Dec-June

Fruit globose, 3.7-5 cm diam., slightly scabrous.

Bark smooth, pale, shoots stout, buds resinous.

A flier depicting morphological characters, uses, distribution and photographs of different plant parts

Diversity, distribution and ethno-botany of wild edible food plants used by the tribals of Odisha

(2013-14; State Plan funded)

PI: Dr. Pratap Chandra Panda

Research Fellows: Samarendra Narayana Mallick & Tirthabrata Sahoo

Odisha is home to as many as 62 tribal communities including 13 primitive tribal groups. The majority of the tribal population live inside forests or fringe villages and depend heavily on wild forest food and biomass for their livelihood. The wild plants and plant parts gathered from nearby forests in different seasons contribute significantly to the food and nutritional security of the poor tribals especially at the time of food scarcity. They are aware of the edibility of the species, seasonality and the processing methods as an age-old practice. However, with modernization and settled agriculture, the ethno-botanical knowledge is being lost, which need proper study and documentation leading to identification of new sources of food, medicine and neutraceuticals.

Under this programme, multi-seasonal surveys were conducted in different forest blocks dominated by tribal people in Rayagada, Nabarangpur, Koraput, Kalahandi, Gajapati, Ganjam, Mayurbhanj, Keonjhar, Kandhamal Districts of Odisha, Chattishgarh, Sundarban (West Bengal) for collection of plants and field data in respect of wild edible fruits, leafy vegetables, rhizomes, tubers, flowers and other plant parts used by them as food items. Data on mode of use, manner of food preparation, storage etc. have been collected through house-hold data collection and village level meetings/ interactions and questionnaire circulation. The quantity of production, collection, sale and marketing of wild fruits, roots, tubers and leafy vegetables and other NTFPs have been assessed by local market surveys and house-hold and village level data. In Odisha, a total of 121 villages were surveyed besides 10 villages of Sundarban areas, West Bengal and 6 villages of Chhattisgarh state.

A total of 204 species belonging to 80 families were recorded for their use as food plants by tribal and poor people of the studied areas. The fruits of 87 species, leaves of 76 species, tubers and roots of 47 species, seeds of 9 species and flowers of 7 species were observed to be used by the tribal communities.

Marketing and sale of wild food plants in tribal districts of Odisha

Qualitative and quantitative assessment of biological diversity and distribution pattern of macrophytes (angiospermic plants) of Chilika Lagoon and its adjoining regions

(2012-16; CDA-Integrated Costal Zone Management Project)

PI: Dr. Pratap Chandra Panda

Research Fellows: Dr. Pradosh Kumar Acharya, Subrat Kumar Kar, Sri Pramod K. Tripathy & Swadhin Mohanty

In order to make an exhaustive floristic inventory and quantitative assessment of plant resources (flowering plants) and fill up the existing gap on research involving flowering plants of Chilika lagoon and its adjoining regions, a project was undertaken under the Integrated Coastal Zone Management Project.

Through multi-seasonal survey of vegetation and flora of the lake water, islands and shoreline of Chilika lagoon, a total of 748 species of angiospermic plants belonging to 486 genera under 127 families have been collected, identified and preserved as herbarium

specimens. Of these, *Vahlia digyna* and *Cymodocea serrulata* turned out to be new distributional records for the state of Odisha. The changes in the pattern of vegetation and floristic elements have been studied. *Cassipourea ceylanica, Dimorphocalys glabellus, Uvaria hamiltonii, Mucuna monosperma, Capparis roxburghii, Psoralea corylifolia, Macrotyloma ciliatum, Gyrocarpus americanus, Aponogeton undulatus* etc. have been identified as endangered species needing conservation action.

For study of the diversity, distribution and abundance of aquatic plants of lake water, 30 sampling points were identified in the macrophyte dominated zones and data on seasonal changes in occurrence and density of aquatic plants, water and sediment quality parameters were recorded in three prominent seasons for four years. Special attention was given to distribution of seagrass meadows and their diversity in relation to substratum characteristics, water quality parameters and hydrology. Six seagrass species namely, *Cymodocea serrulata*, *Halodule uninervis, Halodule pinifolia, Halophila ovalis, Halophila ovata* and *Halophila beccarii* were identified and studied.

The distribution of 20 submerges and emergent aquatic macrophyte species has been mapped on GIS platform taking into consideration the point distribution data with the help of GIS Unit of CDA, Bhubaneswar. The vegetation of the islands, sand dunes close to sea coast and shoreline areas was surveyed and quantitatively analysed. Several rare and botanically interesting plants like *Gyrocarpus americanus, Cassipourea ceylanica, Capparis roxburghii* have been recorded from the uninhabited islands. The frequency, density, abundance and IVI (Importance Value Index) of individual tree species and diversity parameters like Shannon Index, Simpson Index, Evenness Index etc. were calculated and interpreted.

The yield and productivity of different submerged and emergent aquatic macrophytes as influenced by seasonal fluctuations were assessed by estimating density per unit area, fresh and dry biomass yield

Different ecological habitats of Chilika lake and its environ (a-island, b-sand dune c- salt marsh d-Shoreline e- *Phragmites karka* formations in Northern sector f- *Schoenoplectus littoralis* along muddy shore, *g-Eichhornia crassipes* in Northern sector, h- Seagrass meadow in outer channel.

Some rare, endangered and threatened plants of Chilika and its adjoining regions

and chlorophyll contents. Irrespective of seasons, exceptionally high biomass yield was observed in *Phragmites karka, Eichhornia crassipes*, *Potamogeton pectinatus*, *Halophila ovalis* and *Halophila ovate*. Maximum biomass yield was recorded for emergent macrophytes in post-monsoon months.

Study on distribution, phytogeography and reproductive biology of *Symplocos racemosa* Roxb. in Odisha

(2013-15; State Plan funded)

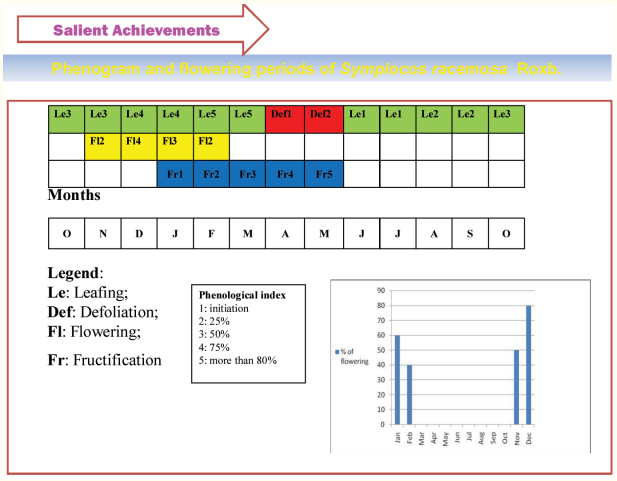
PI: Dr. C. Kalidass

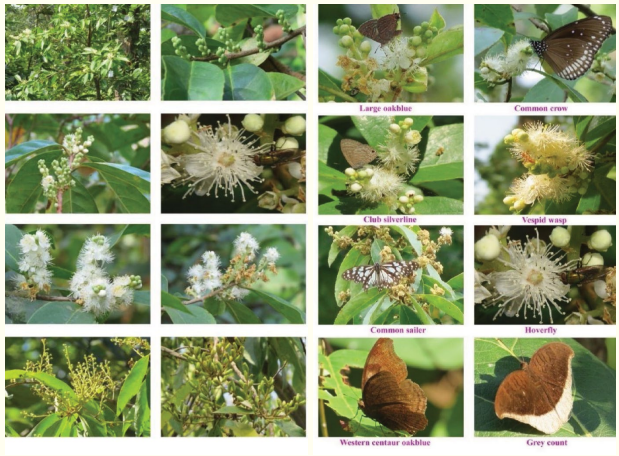
Research Fellows: Ramesh kumar and Manas Ku. Panda

Indian subcontinent is known to be a grand repository of medicinal plants. Due to varied topographic, climatic and edaphic conditions India harbours a vast array of vegetable wealth which provides raw materials for pharmaceuticals, phytochemicals, flavouring and cosmetic industries. In recent time, a workshop on "*Conservation assessment & management prioritisation for medicinal plants of Odisha*" was organised by Regional Plant Resource Centre, Forest Department, Government of Odisha and FRLHT, Bangalore at Bhubaneswar. After rigorous exercise made by the experts it was revealed that as many as 41 medicinal plants are enlisted as threatened categories such as Critically Endangered, Endangered, Vulnerable, Near Threatened etc. Out of which *Symplocos racemosa* Roxb. (Odia name: Lodha) has been assessed as Critically Endangered (CE). Some of the identified threats for survival of the taxon are loss of habitat, harvest for medicine and trade of parts including bark, fruits and flowers. CAMP workshop strongly recommends for research and future management including reproductive biology and regeneration capacity i.e. seed germination, vegetative and tissue culture propagation of the taxon.

Symplocos racemosa (Roxb.) is originally distributed in the Similipal Biosphere Reserve, as well as the other parts of the Eastern Ghats, in the Sambalpur, Takkapa, Rebna reserve forest. It is an indigenous plant of North-east India. Its flowering season is around November to January. They are bright greenish-white in colour, turning brown before wilting. Inflorescence is terminal and axillary racemes. The actinomorphic flowers show a forenoon (9.00 h – 17.00 h) pattern of anthesis after which pollen anthesis takes place (10.00 h – 18.00 h). The highest percentage fruit (52.18±7.26%) was obtained in cross pollination compared to bagged flowers, which showed less fruit set and successful cross pollination of the flowers require a large number of insects (Hoverfly, Vespid wasp, Grey count, Fly, Mottled emigrant, Large oakblue, etc.) visitations. Among these *Polistes sp* is most common. Flowers favour cross pollination due to a delayed stigma receptivity. Mature seeds were harvested.

The protocol of *in situ* conservation, regeneration of plants through air-layering is successfully achieved by Taxonomy & Conservation division, RPRC, Bhubaneswar. In e*x situ* conservation methods, the root segments used as explants showed high number of shoots when treated with IBA 300 ppm and IBA 400 ppm. The protocols of *ex vitro* regeneration of plants from root segments, for the





Floral Biology of Lodha

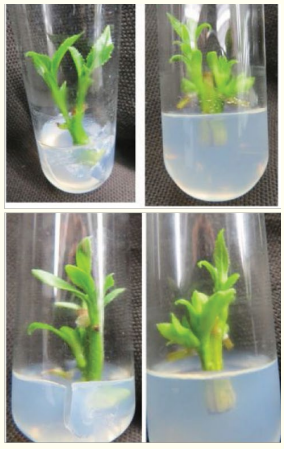
Pollinators of Lodha

adventitious shoots were developed, after 6-7 months complete plantlets were obtained. Auxins enhance root regeneration in vegetative propagation of stem cutting materials have tried for *ex situ* condition. But still no significance results were obtained for all type of plant materials like with leaves pruned to 1/3 of their area, with leaves totally removed and with leaves intact.

Shoot tips and nodal explants of *Symplocos racemosa* Roxb. were cultured on various concentrations of MS media with plant growth regulators (BA, Kinetin, IBA, IAA, NAA and GA_3). Moreover, shoot tips did not show any response for the shoot initiation. Nodal explants showed shoot initiation and elongation in various concentrations of plant growth regulators. After shoot elongation, that *in vitro* shoots are inoculated to rooting media. It showed basal callus formation; but no roots *in vitro* condition. Leaf and intermodal explants are inoculated on MS media with various concentrations of 2,4-D (0.5 -2.5 mg/l). The high percentage of green coloured friable, brown coloured friable and compact callus were observed in different concentration of 2,4-D from the intermodal explants.

These studies investigated the influence of various concentration of Indole butyric acid (IBA) hormone on root and shoot development in the root segments, stem cutting and also air-lerying of *Symplocos racemosa* Roxb. Air-layering is a reliable and easy means of propagation, especially in plant species which are difficult to root on stem cuttings. Many researchers reported that application of root promoting substance during the air-layering helps to get profuse roots within a short time. In this experiment rooting took long time. Moreover, the present investigation was taken up to find out the most efficient concentrations of IBA hormone which enhance rooting of layering and improve the rooting characters. The second experiment has investigated the influence of different concentration of indole butryic acid (IBA) hormone on root and shoots development in root segment of *Symplocos racemosa*. The longest shoots per sprouted root segment were produced from 400 ppm of IBA treatment in the targeted endangered medicinal plant. The high sprouting and rooting percentage of the *Symplocos racemosa* root segments was obtained from root segments treated with 700 & 500 ppm of IBA concentration. From this study it was concluded that IBA concentration gave the greatest number and longest roots and shoots per root segment. In the third experiment, for rooting, of stem cuttings were treated

Adventitious roots by Air-layering



Micropropagation of Lodha

Different stage of multiple shoot from the root segments of *Symplocos racemosa* Roxb.

with different concentration of IBA hormone and propagated in the garden soil under misting house in RPRC. None of the stem cuttings showed rooting on sprouting after 30 days, in all the IBA concentration tested. Due to lack of time *in vitro* studies were not conducted. For the *in vitro* studies was identified as difficult for propagation in very short time.

Table . Population biology of *Symplocos racemosa* Roxb. in different populations

S.No	Species name	D	AB	PF	BA	RD	RF	RBA	IVI
1	*Shorea robusta*	9.08	9.08	100.00	359.31	25.23	9.79	49.82	84.81
2	*Symplocos racemosa*	12.92	12.92	100.00	208.92	35.87	9.76	28.97	74.60
3	*Lagerstroemia parviflora*	1.66	2.50	66.67	36.30	4.62	6.50	5.03	16.17
4	*Diospyros melanoxylon*	2.41	2.64	91.67	38.93	6.71	8.94	5.40	21.05
5	*Diospyros montana*	3.66	6.29	58.33	57.80	10.18	5.69	8.01	23.89
6	*Terminalia chebula*	0.58	1.40	41.67	13.69	1.62	4.07	1.90	7.58
7	*Terminalia belerica*	0.17	1.00	16.67	1.99	0.46	1.63	0.28	2.36
8	*Syzygium cumini*	0.25	1.00	25.00	4.29	0.69	2.44	0.60	3.73

Total Basal Area = 721.258

Dominance Index = 0.5827

Diversity index; Simpson index = 0.4173; Shannon Index = 3.147

A systematic study of the genus *Solanum* L. (Solanaceae) in Eastern Ghats of India

(2015-18; State Plan funded)

PI: Dr. C. Kalidass

Research Fellows: P. Murugan and Rupalin Jena

The genus *Solanum* L. is one of the most economically important genera of plants and includes the cultivated potato, tomato, and aubergine. With ca. 1,500 species, it is also one of the largest and most taxonomically challenging genera of plants. *Solanum* in Eastern Ghats of India, it's represents a significant gap in the local floristic knowledge. High levels of morphological variability make identification difficult and the common occurrence and weedy habit of many species has discouraged plant collectors and taxonomists who have frequently dismissed these plants as "uninteresting weeds". No complete taxonomic treatment is available since H.H.Haines (1925). No up to date taxonomic reference material is readily available except short popular treatments by Saxena & Brahmam (1995). *Solanum* in Eastern Ghats of India has suffered from widespread and cumulative confusion throughout its taxonomic history and the majority of herbarium determinations are out of date.

Solanum L. is a large and diverse genus of flowering plants, which include three food crops of the highest economic importance, the brinjal, potato and the tomato. It's medicinal importance species includes *S. torvum* Sw., *S. trilobatum* L., *S. americanum* Mill., *S. viarum* Dunal and *S. virginianum* L. and also contains the nightshades and horse nettles, as well as numerous plants cultivated for their ornamental flowers and fruit. In the present study of taxonomical revision of the genus of *Solanum* L. in Eastern Ghats of India, following 13 species were collected from various climatic regions of Eastern Ghats, Odisha only through survey. The specimens were collected, and given 163 field number and 326 Acc. Numbers before depositing them to the herbarium of RPRC. Herbarium specimens were consulted from Regional Research Libarary (RRL), IMMT, Bhubaneswar and Madras Herbarium (MH), Botanical Survey of India, Coimbatore. A new species of *Solanum* L. was record from Eastern Ghats of Odisha i.e., *Solanum diphyllum* L., extended distribution from Eastern Ghats of Odisha for *Solanum sisymbriifolium* Lam. and one new varieties i.e., *Solanum americanum* Mill. var. *odishensis* P. Murugan, C. Kalidass and P.C. Panda was identified.

Morphological evaluation of *Solanum* species demonstrated that characters related to habit, branches, leaf, flower, fruit and seed were significantly different between species. Similarity values of all 13 OTUs ranged from -0.2 to 0.66. *Solanuum torvum* showed maximum similarity value of 0.66 with *Solanum viarum* and *Solanum sisymbriifolium* minimum similarity value

(-0.02) was observed. For future continuation, Southern central, Southern and Southern most areas will be surveyed for the genus *Solanum* L. in Eastern Ghats of India. To consulate the herbarium specimens will be necessary of the CAL (Central National Herbarium, Kolkata) for the future duly completed.

In the taxonomical revision of the genus of *Solanum* L. in Eastern Ghats of India, in total five field tours were conducted at different parts of Eastern Ghats, which consists of 25 days exploration, survey and specimens collection. There were been two famous herbarium consultation at Madras Herbarium (MH), BSI, Coimbatore and Central National Herbarium (CAL), BSI, Howrah. We collected 20 species and 2 varieties including three cultivated species. Completed secondary level descriptions of *Solanum torvum* Sw., *Solanum melongena* L. var. *insanum* (L.) Prain, *Solanum sisymbriifolium* Lamk., *Solanum trilobatum* L., *Solanum viarum* Dunal and *Solanum virginianum* L. Completed preliminary description of *Solanum pubescens* Willd., *Solanum asperolantum* Ruiz & Pav., *Solanum elaegnifolium* Cav., *Solanum pseudocapsicum* L. and *Solanum seaforthianum* Andrews, as well as photo plates was completed. Live germplasms were collected and planted in RPRC garden. In total 14 species were planted here for the purpose of future studies. We conducted our last field tour in Nayagarh District, Khandapada forest range and collected some interesting specimens of the genus *Solanum* L., which on critical study were identified as *Solanum villosum* Mill., this species still not reported in Odisha, also Eastern Ghats. Manuscript preparation on this is going on.

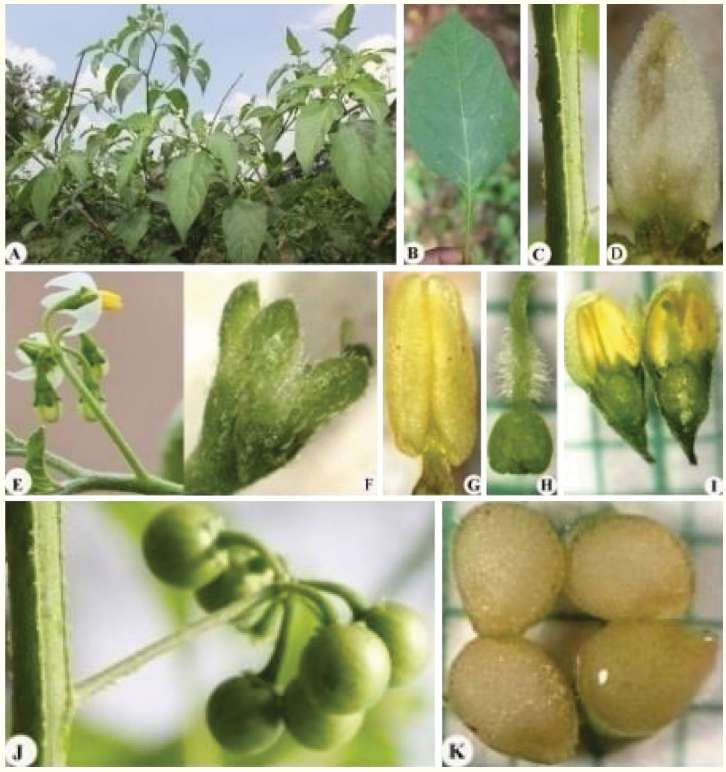
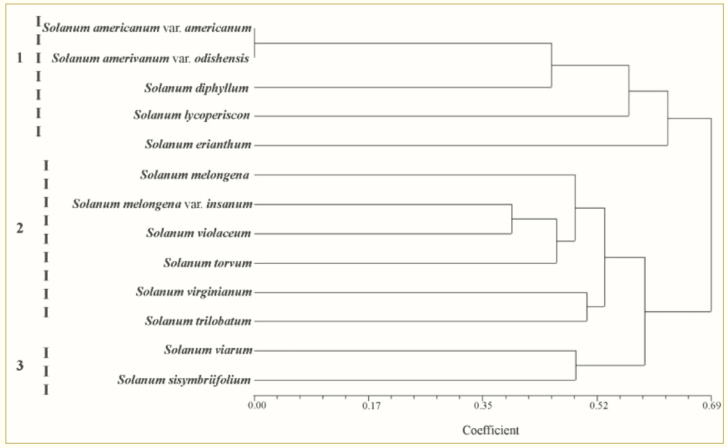


Plate 2. Solanum Americanum Mill,var, odisnehsis P. Murugan, C. Kallidass & P.C. Panda var. nov. (Solanaceae): **A.** habit, **B.** leaf, **C.** branches, **D.** Petal, E. inflorescence, **F.** calyx, **G.** stamen, **H.** pistil, **I.** I.s of flower bud, **J.** fruits branches, **K.** seeds



Dendrogram obtained from neighbour joining (NJ) method showing the relationship of *Solanum* taxa employed in the study.

Solanum seaforthianum Andrews,

Solanum villosum Mill.

Solanum elaegnifolium Cav.,

The herbarium sheets were handed over to our RPRC herbarium. The details as follows:-

- Field Book Number 18001 to 18091, 176 sheets (six specimens single sheet)
- Field Book Number 10501 to 10550, 96 sheets (four specimens single sheet)
- Field Book Number 10576 to 10600, 50 sheets
- Total 322 herbarium sheets have been submitted and approximately 160 herbarium sheets are under process.

There were new records of *Solanum diphyllum* L., extended distribution of *Solanum sisymbriifolium* Lam., new varieties like *Solanum americanum* Mill. var. *odishense* Kalidass and P. Murugan from Eastern Ghats.

Molecular characterization and assessment of genetic variability in *Shorea robusta* Gaertn. tree populations in Odisha

(2014-18; State Plan funded)

PI: Dr. Giridara Kumar Surabhi

Research Fellows:
Subhankar Mohanty; Rajesh Kumar Meher;
Hrudananda Sahu; Nirakar S. N. Pradhan.

Trees are major components of forests/ wild and essential for maintaining health of several ecosystems. Sal (*Shorea robusta* Gaertn.) is a tropical tree species belonging to the Dipterocarpaceae which consists of three sub-families, 17 genera and 511 spp.. It is a hermaphrodite species which attains a height up to 30-35m and trunk (girth) diameter of up to 2.0-2.5m. In wetter areas, it is evergreen; in drier areas, it is dry-deciduous, shedding most of the leaves in between February to April, leafing out again in April and May. Other Shorea species are insect-pollinated and wind is the exclusive pollen vector in *S. robusta*. Though the plants produce flowers and fruits luxuriantly in the plains and foothills, its overall natural regeneration is very poor. Further, it exhibits large scale mortality or die-back at the seedling stage due to drought. Past records provide evidence of larger distribution of *S. robusta* forests in the northern and eastern parts of India, and their eventual clearance for expanding agriculture, human settlement etc. During the past decades, there was massive deforestation to use the wood as railway sleepers, ship-building and other load bearing purposes etc., resulting in the decreasing of natural populations in the wild. In addition, Sal forests yield non-timber forest products, including fodder, seed for oil, tannin and gum from bark and leaves for plate making, hence it is one of the economically important forest tree species. Genetic diversity and natural distribution pattern are very important for the introduction and conservation of forest plant species in general and *S. robusta* in particular. Therefore, this pioneering investigation aimed at determining the genetic variability assessment within and among different natural *S. robusta* tree populations exists in tropical moist deciduous forest regions in Odisha, India using ISSRs.

ISSR primer polymorphism

Sampling (consisting 100-adult trees) was carried out in a sal dominated natural moist deciduous forest regions exist within Odisha state, India (Table 1). Out of 20-ISSR primers screened, 16-ISSR primers produced clear, scorable and reproducible DNA alleles classes. The 16-ISSR markers amplified a total of 118 alleles and the total number of scored alleles varied from 5 to 12 for different primers, with a mean of 7.37 alleles per primer (Table 2), of which 74 were polymorphic with an average of 4.625 polymorphic alleles per primer. ISSR primer $(GA)_8$YG yielded the highest number of alleles (12) and primers $(CA)_8$RG and $(CT)_8$G yielded lowest number of alleles (5) with average allele size between 200-3500bp. The percentage of polymorphism for individual primers ranged from 40% [$(CA)_8$RG] to 83.33%[$(AC)_8$C] (Table 2). The ISSR fingerprinting profile obtained by using the primer 5'-AGGGCTGGAGGAGGGC-3' in ATH population are depicted as Figure-2 panel-B.

Genetic variation within and among population

The percentage of polymorphic loci recorded highest for the KJR (86.54%) and lowest for the ATH (70.51%) populations, with an average value of 79.32% (Table 5).

The effective number of alleles (Ae) showed variation in the rage of 1.359 (KHD) to 1.404 (KJR and TMN) with a mean of 1.386, and recorded 1.710 at species level. Nei's gene diversity (He) values ranged from 0.219 (KHD) to 0.251 (TMN) with an average of 0.251 and at species level recorded 0.394. Shannon's information index (Io) observed highest in TMN (0.389) and lowest in ATH (0.333) population with an average value of 0.360, and at species level recorded 0.573. Further, among the four populations studied, ATH showed lowest level of variability and KJR (0.382), TMN (0.389) exhibited highest variability, respectively. The gene flow (Nm) estimated using ISSRs was low (0.3649) per generation (Table-5). Analysis of molecular variance (AMOVA) showed highly significant (*P<0.001*) genetic variability among populations and revealed a higher proportion of genetic variability within populations (54.06%) compared to among population genetic variability (45.94%) (Table-3).

Genetic relationship between populations

The pair wise genetic identity value among the populations ranged from 0.6915 between KHD and KJR to 0.7517 between KHD and ATH, with a mean of 0.7216 (Table-4). Further, genetic distance was higher for TMN and KJR populations (0.3520) and lowest for KJR and KHD populations (0.0649) (Table-4). The similarity matrix representing Jaccard's similarity coefficient was used for clustering four-populations, adopting UPGMA algorithms similarity matrix. The clustering of different populations based on Jaccard's coefficients presented in Figure-1 panel-C, and which grouped the populations into two major clusters. Cluster-I represents the KJR sal population alone. Cluster-II again divided into two sub-clusters; these are sub-cluster-a and sub-cluster-b. Sub cluster-a represents the TMN population alone and the sub-cluster-b represents the ATH and KHD populations, respectively (Figure 2 Panel C). The KJR population is genetically the most distant from all others, followed by TMN. The clustering pattern under study revealed considerable genetic variability within populations. The grouping of sal populations through principal coordinate analysis (PCA) also resulted in similar trends as observed through three-dimensional Principal Co-ordinate Analysis (Figure-2 panel D).

Fig.1: Collection of leaf samples from tropical moist deciduous sal populations for DNA fingerprinting - Kalahandi South Forest Division.

The present study reports genetic variability assessment in different populations of tropical moist deciduous forest tree species, sal for the first time in India. The tested ISSR primers were allowed the discovery of reasonably high level of polymorphism (average 63%) and are a reflection of presence of a wide range of genetic variation among the individuals examined.

The analysis of molecular variance (AMOVA) in the current study revealed a significantly (<0.001) high variance (54.06%) within the populations compared to variance that exists among the populations (45.94%)

Table 1. Description of *S. robusta* samples collected from different locations in Odisha, India.

Population	Population code	Type of forest	Av. annual rainfall (mm)	GPS reading			Number of samples
				Latitude	Longitude	Altitude/ elevation	
Kadukaman, Kalahandi South Forest Division	KHD	Reserve forest	1378.20	19° 36'.065'N	083° 08.726' E	753m	25
Athamalik, Hatidara Forest Division	ATH	Reserve forest	1421.00	20° 44.182' N	084° 40.589' E	343m	25
Benmunda and Bandhori, Keonjhar Forest Division	KJR	Reserve forest	1534.50	21° 13'.325' N	085° 30.518' E	220 m	25
Tamna and Rajin, Khurda Forest Division	TMN	Reserve forest	1449.10	19° 53'.349' N	084° 59.769' E	520 m	25

Table 2. List of ISSR primers, total number of amplified fragments, number of mono- and polymorphic fragments, and percentage of polymorphism generated in the *S. robusta*.

S.No.	Primer sequence (5'-3')	Length of amplified alleles (bp)	T_m	Total no. of alleles	No. of monomorphic alleles	No. of polymorphic alleles	Polymorphism (%)
1	CACACACACACACACARG	200-1300	52.7°C	5	3	2	40
2	TGGACACACACACACAC	300-1600	47.4°C	8	4	4	50
3	ACACACACACACACACC	450-1500	54.8°C	6	1	5	83.33
4	CACACACACACACACAG	300-1700	53.3°C	9	4	5	55.55
5	GAGAGAGAGAGAGAGAYT	350-1500	52.1°C	6	2	4	66.66
6	GAGAGAGAGAGAGAGAYG	250-1600	52.9°C	12	5	7	58.33
7	AGAGAGAGAGAGAGAGYT	400-2000	50.0°C	9	3	6	66.66
8	AGGGCTGGAGGAGGGC	400-2500	49.8°C	9	3	6	66.66
9	AGAGAGAGAGAGAGAGC	200-3500	52.8°C	6	2	4	66.66
10	GAGGGTGGAGGATCT	450-2400	49.1°C	8	3	5	62.50
11	CTCTCTCTCTCTCTCTG	300-1600	46.8°C	5	1	4	80
12	AGAGAGAGAGAGAGAGT	450-1400	52.4°C	6	2	4	66.66
13	ACGGTGTGTGTGTGTGT	450-1550	54.5°C	9	2	7	77.77
14	GAAGAAGAAGAAGAAGAA	350-1500	43.2°C	7	3	4	57.14
15	ACAGACAGACAGACAG	400-1550	47.4°C	6	2	4	66.66
16	CAGCGACAAG	450-3000	33.5°C	7	4	3	42.85
	Total			118	44	74	1007.43
	Average per primer			7.375	2.75	4.625	62.96

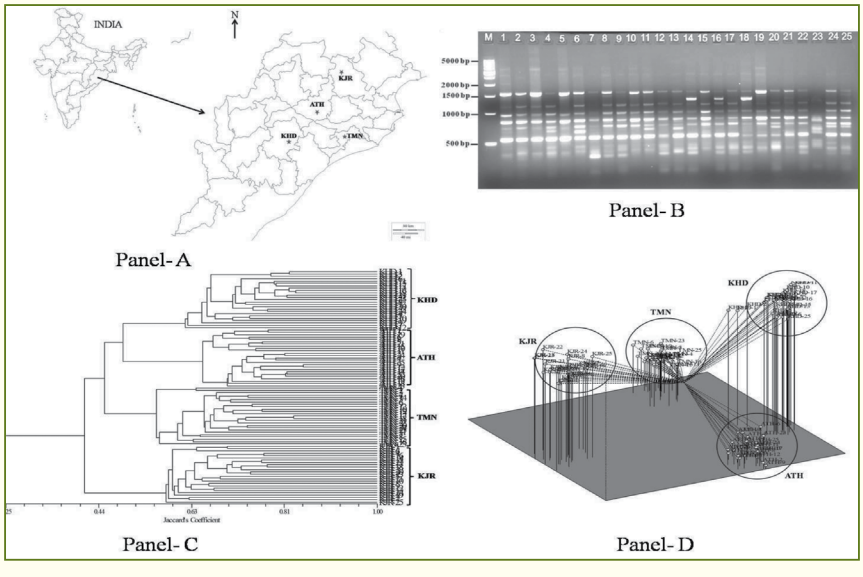


Fig. 2. Panel A: Map of India showing the sampled populations of *S. robusta*. KHD, Kalahandi; ATH, Athamalik; KJR, Keonjhar and TMN, Tamna populations. **Panel B:** ISSR fingerprinting profile of 25-individuals of *S. robusta* using primer- 5'-AGGGCTGGAGGAGGGC-3' and 'M' is a molecular size marker (500bp). **Panel C:** UPGMA-based dendrogram representing genetic relationships among four-populations of *S. robusta* based on Jaccard's similarity coefficients. **Panel D:** 3D plot shows distribution of 100- *S. robusta* tree individuals from four different populations by principal coordinate analysis.

and our results are in agreement with the trend observed in perennials and long-lived tree species. The gene flow (Nm) pertains to gene movement across intra- and inter-population levels and Nm largely shows impact on genetic differentiation in populations. The low level of gene flow and high level of inter population differentiation in the present study could be a reflection of limited seed and pollen dispersal and inbreeding nature of *S. robusta* populations. Further, *S. robusta* being a long-lived tree species has maintained a high genetic diversity. The genetic differentiation among the populations could be the result of an adaptation to environmental gradients. In particular, *S. robusta* is distributed across different eco-geographic conditions with respect to soil composition, altitude etc. which could drive the acquisition of total adaptation. Both UPGMA-phenogram as well as PCA displayed similar grouping of populations. The PCA results corresponded well with the grouping of populations based on cluster analysis. The dendrogram (Jaccard's similarity coefficient) showed

Table 3. Analysis of molecular variance (AMOVA) for 100-individuals in four populations of *S. robusta.*

Source of variation	d.f.	SSD	MSD	Est. Var.	TV (%)	*p*-value
Among population	3	1267.28	422.42	16.13	45.94	<0.001
Within population	196	1822.96	18.98	18.98	54.06	<0.001
Total	199	3090.24	441.40	35.11		

df, degree of freedom; SSD, sum of squared deviation; MSD, mean sum of squared deviation; Est. var., estimated variance; TV %, total variance percentage*p*-value, probability value.

Table 5. Genetic variability within populations of *S. robusta* detected by ISSR analysis.

Population	A_O	A_e	H_o	I_o	P (%)	Nm
KHD	1.750 (0.43)	1.359 (0.35)	0.219 (0.18)	0.339 (0.25)	75.00	-
ATH	1.705 (0.45)	1.380 (0.38)	0.220 (0.19)	0.333 (0.27)	70.51	-
KJR	1.865 (0.34)	1.404 (0.34)	0.246 (0.17)	0.382 (0.23)	86.54	-
TMN	1.852 (0.35)	1.404 (0.32)	0.251 (0.16)	0.389 (0.22)	85.26	-
Mean	1.793	1.386	0.234	0.360	79.32	-
At species level SD	1.980 0.13	1.710 0.28	0.394 0.12	0.573 0.15	98.08	0.3649

A_O-observed number of alleles, A_e-the effective number of alleles, H_o-Nei's gene diversity, I_o-Shannons's information index, P-percentage polymorphism, Nm-Gene flow.

Table 4. Nei's unbiased measures of genetic identity (above diagonal) and genetic distance (below diagonal) between the populations of *S. robusta* by ISSR.

Populations	KHD	ATH	KJR	TMN
KHD	***	0.7517	0.6915	0.7442
ATH	0.2855	***	0.7232	0.7243
KJR	0.0649	0.3241	***	0.7033
TMN	0.2954	0.3226	0.3520	***

highest genetic similarity between populations KHD, ATH and TMN compared to KJR population. The higher genetic similarity indicates that higher probability of origin of all these populations from the same ancestral source, eventually distributed to different locations and also geographically close locations. However, it is true that the higher genetic diversity of the *S. robusta* populations in Odisha, India is largely due to a bigger population size and distribution. In conclusion, the molecular analysis based on an amplification signal using ISSR markers is sufficiently informative and powerful to authentically elucidate genetic variability in *S. robusta*. The present pioneering report using ISSR markers is proved their effectiveness in quantifying genetic variability within and among populations of *S. robusta*. Keonjhar *S. robusta* population harbor highest genetic diversity thereby deserving higher priority for *in situ* conservation. Overall high genetic diversity, limited gene flow and genetic differentiation indicates the need for implementing *in situ* and *ex situ* conservation of studied *S. robusta* populations.

Microbial Diversity and Applications

Extraction of secondary metabolites from some mushrooms of odisha and evaluation of their bioactivity as antimicrobial and anticancer agent

(2012-14; State Plan funded)

PI: Dr. Nibha Gupta

Research Fellows: Ashutosh Rajoriya, SushriShant Tripathy

The diversity of mushroom flora in forests and agroforests of the region is yet to be comprehensively investigated, notwithstanding the fact that in tribal dominated districts of Sundergarh, Koraput, Kandhamal, Mayurbhanj, and Keonjhar mushrooms are consumed in many villages during June-September. In view, a survey has been planned to record data on occurrence of different types of mushrooms in Odisha. It was aimed to collect ethno-botanical information of wild edible mushrooms from the different forest divisions of Odisha and collection of the same in ample amount for the various biochemical and nutritional analysis . Ethanobotanical information of different wild edible mushrooms from different forest division of Odisha was gathered and mushroom fruit bodies were collected in ample amount. 29 different types of mushrooms have been found being used by the native tribals as food. Total *phenols* are the major naturally occurring antioxidant components found in methanolic extract from wild edible mushrooms. The total phenolics content had wide variation across species. In the studied species, it varied from 0.90± 0.01 to 4.55±0.37 mg GAE/g of dry extract. The nine wild edible mushroom species could be categorized into low, moderate and high phenolics species on the basis of the total phenolics component. In general the β- carotene and lycopene are found in rudimentary concentration in mushrooms. The content of β- carotene differed considerably between the studied edible mushroom species. Estimation of the *alkaloids* in the analysed sample revealed that highest amount of alkaloid in *R lepida* followed by *V. volvaceae*.

The present study aimed to inform on the nutritional and biochemical constituents of eleven wild edible mushrooms of Odisha, The outcome of this study may encourage standardization of cultivation protocol of wild edible mushrooms in order to utilize their nutritive as well as antioxidant potential and develop it as food and health care supplements.

Nutritional composition and biological properties of 9 commonly consumed wild edible mushrooms by tribals of Odisha, India was analysed in order to assess these specimen as potential source of nutrients and medicine. The protein content of the studied mushrooms varied widely ranging from 0.93 to 20.53 mg/g. *T. eurrhizus* and *Lentinus tuberigium* were rich in protein and showed higher amount of protein. Amongst sampled specimens the ash content ranged from 3.63 to7.36 % and *T. eurrhizus* exhibited relatively higher ash content. The carbohydrate content ranged between 19.16 and 38.77. Comparatively, *Russula sp* had high amount of reducing sugar (21.18 ± 2.80 mg/gm)than other edible mushrooms studied. All mushrooms exhibited presence of the crude fiber differing between 1.92 – 4.34 %. Amongst the edible ones *T. eurrhizus* was observed to have very high Iron content . *V. volvaceae* contained very high amount of phosphorus (0.87%) and Zn (133.33 ppm). A varying level of magnesium was noted in wild varieties (0.03-12.02%). The range for sodium was wide differing between 0.03-0.17%, A total of 20 amino acids have been analyzed from the dry mushrooms samples. The concentration of free amino acid ranged from 3.31±0.09 to 13.38±0.63 % in dry weight basis. Few amino acids as Aspartic acid, Glutamic acid, Asparagine, Glutamine, Glycine ,Threonine, Arginine, Leucine, Lysine and Proline were found abundantly in some mushroom species studied.

Inventory and study of wild edible and poisonous mushrooms of forest ecosystem of Odisha

(2013-16; MoEF& CC,GoI funded)

PI: Dr. Nibha Gupta

Research Fellows: Ashutosh Rajoriya, Smita Behera

Five different forest divisions (39 sites) were surveyed and mushrooms belonging to Amanita (6 species), Russula (8 species) and Termitomyces (5 species) were collected , described morphologically and tentatively identified. The distribution pattern of indigenous wild mushrooms was also anlysed in terms of % occurrence. Among 19 species belonging to Amanita, Russula and Termitomyces, five species namely, Amanita caesarea, A. loosii, Russula brevipes, R. nigricans , R. lepida, Termitomyces eurrhizus, T. microcarpus, T. heimi , T. clypeatus and T. medius were found as edible and used as food by local forest tribal community. Among them, five mushrooms viz., Russula brevipes, R. nigricans , R. lepida, Termitomyces eurrhizus, T. microcarpus, T. heimi were collected in bulk amount from the forest local market and analysed for their nutritional and biochemical properties in the laboratory.

Nutritional and Biochemcial analysis : Wild edible mushrooms are rich in trace minerals, and have high water, protein, fibre, carbohydrate contents and low fat/energy levels making them an excellent food for use in low caloric diets . Mushrooms also appear to be a good source of vitamins, such as vitamin B, vitamin C and vitamin E. Mushrooms are deficient in vitamin D, however they are found to be a rich source of ergosterol, the precursor of vitamin . Mushrooms have become attractive as a source of antioxidant nutraceuticals, as established in different *in-vitro* assays. The studies on mushrooms of Odisha have still not been well investigated. All above fact stimulated to carry

Different mushrooms of wild *Amanita, Russula* and *Termitomyces* found in Odisha forests

out a range of biochemical analysis pertaining to the nutritive and medicinal potential of some wild edible mushrooms of Odisha.

The analysis of nutrients included determination of proteins, carbohydrates, reducing sugars, non reducing sugars, fiber, ash and cholesterol content. The macronutrient profile in these species revealed that the wild edible mushrooms are rich sources of protein and carbohydrates, and had low amounts of cholesterol. Unsaturated fatty acids (UFA) and, in particular oleic and α-linoleic acids, were predominant in all the mushrooms. The levels of beneficial elements in the edible varieties were higher than those of the toxic elements.. In the present amino acid profiling all these amino acids were present in the requisite amount for the healthy human diet. A very elevated level of Vitamin-A or retinol and riboflavin was found in *V. volvaceae*, Antioxidant analysis of nine wild edible mushroom fruit bodies were carried out *in-vitro* conditions which revealed a range of antioxidant components giving quite prompt response to widely accepted antioxidant assay by scientific communities. The analysed mushroom especially *Lentinus fusipes* and *Lentinus tuberregium* was found to possess good amount of phytochemicals such as phenolics, flavonoids and carotenoids.

As the extinction of wild macro fungi species have started tremendously, still it has not been brought into consideration of conservation. Developing the culture for cultivation of some of these wild edible mushrooms as well as popularizing the pharmacological potential and food value of these wild edible mushrooms can create a good market for the tribal people as source of seasonal income in large scale mushroom all over the state. Antioxidant components are also present in enormous amount in the mushroom and its mycelium. Flavonoids, tannin, β-carotene, phenolics provides good antioxidative properties in the mushrooms. Attempts were made towards the culture development of some wild edible mushrooms and it has been evident that different medium composition, pH, temperature, inoculums size and incubation period affects the biomass development. From the study it was concluded that extreme pH and temperature doesn't support growth and carbon, nitrogen, phosphorus and other micronutrient exert great effect on the biomass development of the mushroom mycelium. Screening of extracellular enzymatic activities of the seven mushroom mycelia was taken into consideration for which most popular and palatable mushroom from Odisha . Studies in this relevance showed varying enzymatic activities, a good L-asparaginase activity was recorded in *R. nigricans* and *R. brevipes*. Mushroom mycelia of *R. nigricans* showed an appreciable amount of cellulase activity along with phosphate solublization potentialities; best lipase activity was recorded in mycelial culture of *R. brevipes*. Almost all the studied mushroom mycelia showed positive test for the IAA production and a poor protease activity was seen in *R. brevipes* where all other species showed no proteolytic activity.

Diversity of mushrooms from urban environment of Bhubaneswar and its suburban areas

(2016-17; State Plan funded)

PI: Dr. Nibha Gupta

Research Fellows: Jiban Jyoti Panda

Macro fungi known as mushrooms are conspicuous by their vast range of colors, shapes and sizes. Exploration of urban fungal biodiversity has not figured as a priority scientific project in the Odisha. Several reports on wild mushrooms from different forests of Odisha have been reported. Studies on occurrence of mushrooms in urban area is still lacking though several green , moist microhabitats in the form of public gardens, semi protected campus like RPRC, Utkal university, Nandan Kanan , Medicinal garden and city road side plantations of Bhubaneswar may be the good habitat for the mushroom growth and development. Hence, a survey for the collection of mushrooms from Bhubaneswar and its suburb area is required which can supplement more information on fungal diversity of Odisha. Survey of incidence of mushroom in urban and suburban area of Bhubaneswar exhibited the occurrence of 71 species of mushrooms belonging to 34 genera (Amanita, Clavaria, Coltricia, Coniphora, Conocybe, Cacryopinax, Daldinia, Entoloma, Fomitopsis, Ganoderma, Grifola, Hygrocybe,

Field photographs of mushrooms growing in different habitat/host plants in Bhuabaneswar environment

Lentinus, Lycoperdon, Macrolepiota, Phallus , Phellinus, Pisolithus, Suillus , Termitomyces, Trametes , Tricholoma). this investigation, occurrence of species like *Ganoderma ucidum, Trametes versicolor, Clavaria vermicularis, Schizophyllum commune, Macrolepiota procera* frequently occurred. As mushrooms are also indicators of green and moist environment, interpretation on environment protection and /or greenery up gradations through plantations and garden development may be suggested.

Twelve different wild and non-edible mushrooms namely-Amanita australis, Amanita vaginata,Conocybe apala, Dacryopinax spathularia, Entoloma incanum, Hirneola auricular, Hygrocybe russocoriace, Leucocoprinus cretatus, Marasmieus anomalus, Marasmieus haematocephalus, Marasmius plicetus and Pluteus lutescens were evaluated for bioactive properties against 4 bacteria and one fungus. Antimicrobial activity was determined by well diffusion method on nutrient agar and sabouraud dextrose agar medium by using methanolic extracts of above mushrooms. Most of mushrooms species showed antibacterial activity against PPB-1 (gram –ve) bacteria. Amanita australis, Conocybe apala and Leucocoprinus cretatus also showed activity against bacteria PPB5 (gram -ve). Most of the mushrooms species studied in the present work exhibited growth inhibition against gram -ve bacteria where as only Amanita vaginata, Conocybe apala, Leucocoprinus cretatus and Marasmieus haematocephalus were found to be active against MLB-6 (gram +ve) bacteria. No growth inhibition was observed in fungus i.e., Colletotrichum and bacteria PPB-9 (gram -ve) along with no activity was found from the methanolic extracts of Hygrocybe russocoriace against all test organisms. This preliminary screening has opened a line of approach for the mass scale extraction of bioactive compounds which is responsible for the inhibition activity against bacteria.

Research Publications

Taxonomic and functional characterization of fungal flora associated with Orchids

(2012-14; State Plan funded)

PI: Dr. Nibha Gupta

Research Fellows: Sonali Satpathy, Hruda Ranjan Sahoo

Mycorrhizal fungi are particularly important for members of the orchid family as the seeds of orchid are minute and contain very few stored food reserves, so fungal colonization is essential for the growth and development following germination . All orchids require appropriate fungus for germination. In reference to the context , a study was carried out on isolation, identification and characterization of endophytic fungi from different rare orchids of Odisha . Total 160 fungi isolated from different Orchids grow in Odisha, and morphologically characterized and identified .Efforts made towards isolation of fungi from different Orchids from wild as well as nursery grown has rewarded with collection of 110 no. of fungi. Since, characterization and identification of fungi is difficult and time taking task, we could be able to identify only 41 isolates up to genus level. Variation in occurrence of fungi may be dependent upon the host, environmental factors as well as local plant community. Further elaborative studies are required to reach any conclusion regarding the specific mycorrhizal association and its credibility towards endemism of this Orchid in Odisha.

Endophytes are a promising source for application in biotechnology, as they can promote plant growth by several mechanisms. These include: plant hormone synthesis, siderophore production, phosphate solubilisation and nitrogen fixation .There are several

reports on the capacity of endophytic organisms to synthesize phytohormones. Numerous endophytes are actively involved in the synthesis of auxins in pure cultures and plant. IAA producing organisms are believed to increase root growth and root length, resulting in greater root surface area which enables the plant to access more nutrients from soil Therefore, screening of the endophytes for their invitro potential of auxin production could provide a reliable base for selection of effective plant growth promoting microbes. Among 160 fungal isolates obtained from different orchids, the highly occurred species was *Paecilomyces sp.* followed by *Aspergillus sp.,* Sterile mycelium and *Penicillium sp.* Some other species found were *Fusarium sp., Mucor sp., Alternaria sp., Cladosporium sp., Curvularia sp.* and *Trichoderma sp.* But about 16 fungal isolates obtained from various orchids remained unidentified. The total fungal endophytes obtained from different orchids were screened for plant growth hormone i.e. Indole acetic acid production by plate test method. Out of 160 fungal isolates, only 53 fungal isolates showed positive result for Indole acetic acid production . Those fungal isolates which showed positive result for Indole acetic acid production in plate test method were subjected for biochemical estimation of Indole acetic acid production. From 53 fungal isolates, about 15 fungal species showed IAA production in range of 20-30 µg/ml, 14 fungal species in range of 10-20 µg/ml and 14 fungal species in the range of 1-10 µg/ml . But one of the fungal isolate showed very good result in IAA production and some isolates showed IAA production in the range of 60 µg/ml and 30-50 µg/ml.

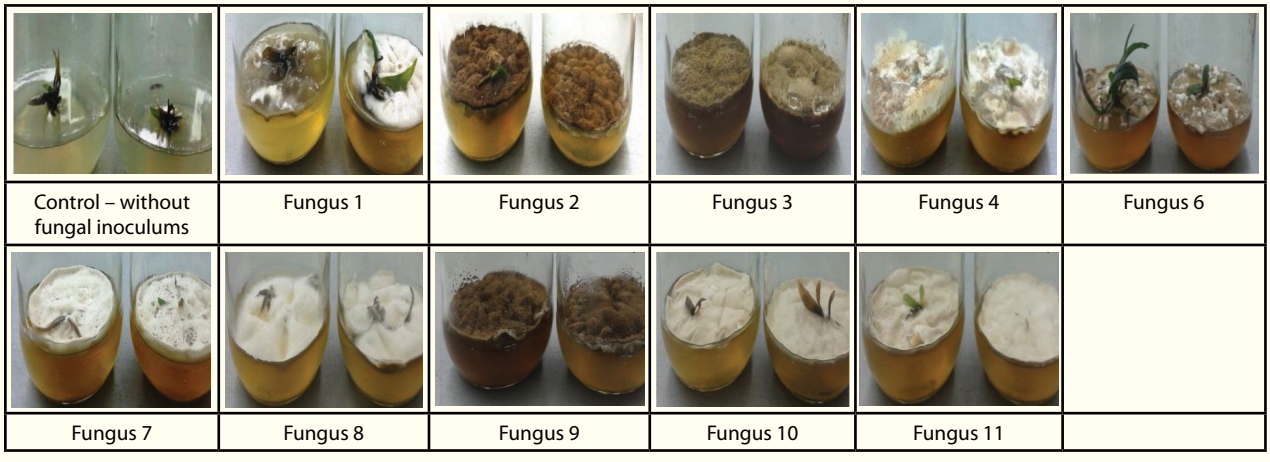
Studies on fungal associations of two RET Orchids (Eria meghasaniensis and Pomatocalpa decipiens) of Odisha and its evaluation for growth, development and establishment

(2014-15; State Plan funded)

PI: Dr. Nibha Gupta

Research Fellows: Sonali Sandeepta Senapati, Kshyama Pradhan

Orchid seed germination can be initiated and seedling development accelerated in vitro if certain fungi can establish peltons in the developing protocorms. It is very important to note that orchid mycorrhiza associations of terrestrial orchids has been worked out very well as comparision of tropical epiphytic orchids. Hence, nderstanding of mycorrhizal diversity in threatened orchid is verymuch essential for conservation and reintroduction activity. In view, an experiment was planned to determine the effect of fungal isolates in seed germination and establishement of *Eria meghasaniensis* and *Pomatocalpa decipiens*. Efforts made towards isolation of fungi from *Eria meghasaniensis* has rewarded with collection of 110 no. of fungi. Since, characterization and identification of fungi is difficult and time taking task, we could be able to identify only 41 isolates upto genus level. Variation in occurrence of fungi may be dependent upon the host, environmental factors as well as local plant community. Further



Determination of the effect of fungal isolates in seed germination and establishment of *Pomatocalpa decipiens*

elaborative studies are required to reach any conclusion regarding the specific mycorrhizal association and its credibility towards endemism of this Orchid in Odisha. Experiments carried out towards screening of fungi to establish its role in growth and development of *Pomatocalpa decipiens* in tissue culture conditions as well nursery conditions did not exhibit any promising results. However, inoculation of fungi no6 in tissue culture raised seedling helped a little in plant growth. More experimentations with different fungal strains alongwith the other environmental factors (physical and chemical) are needed to establish facts regarding the requirement of mycorrhizal association for growth and development of *Pomatocalpa decipiens in laboratory and field conditions.*

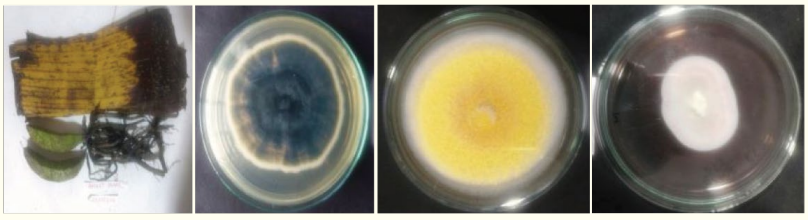
Harnessing the potential of endopytes against root knot nematode *Meloidogyne icognita* in banana

(2017-18; DBT, GoI funded)

PI: Dr. Nibha Gupta

Research Fellows: Jiban Jyoti Panda

Main objective of the project is to screen native endophytic microbes against Meloidogyne icognita , a nematode causing huge damage to banana plantation and products in north eastern and other part of India. A survey has been carried out in Assam and 123 samples (root/fruit/leaf) from 45 plants samples belonging to 17 types of banana cultivars grown in 7 different districts were collected. Plant samples were surface sterilized and treated for isolation of Endophytic fungi and bacteria. Presently, More than 100 isolates of endphytic fungi and 10 bacteria were isolated and pure cultures are maintained in laboratory. Morphological and molecular identification and characterization is the next target of the project.



Bioprospecting of phosphate solubilising fungi and their application for improving the growth of some RET medicinal plants

(2012-15; DST (INSPIRE), GoI funded)

PI: Dr. Nibha Gupta

Research Fellows: Hruda Ranjan Sahoo (INSPIRE Fellow)

Filamentous fungi which have the ability to solubilise inorganic insoluble phosphates can be used because of their potential to produce and release organic acid in their environment. Therefore, inoculation of phosphate solubilising microbes is a reliable technique to increase phosphate solubilisation in soil. Moreover, optimization of potential of phosphate solubilising fungi for increased tolerance to high salt, high pH, and high temperature can be done to improve ubiquitous growth of certain medicinal plants which are highly significant. A wide spectrum screening of 160 fungi was takend upt for the phosphate solubilization potential by using Pikovskaya's medium containing Tricalcium phosphate as P source in triplicates and incubated at 28°C for 5-7 days. The positive fungal strains were screened further biochemically under submerged culture conditions. Fungal isolate no. F 31 and F 20 exhibited 34.9% and 33.2% solubilization , respectively. Both the fungi showed the solubilization potential of rock phosphate upto 30 % in liquid culture conditions.

Only 61 isolates (38.13%) showed phosphate solubilisation activity which was carried out in plate culture conditions. 61 isolates were further screened biochemically using TCP (Tricalcium phosphate) as phosphate source in triplicates. In broth medium, the phosphate solubilisation activity is also determined from the decrease in pH of the medium which ranged from 4.1-8.8. The percentage of solubilisation of

phosphate ranged from 1-35% (in case of culture filtrate) and percentage of immobilisation of phosphate ranged from 4-42 % (in case of mycelium). From the obtained results, 2 isolates showed highest percentage of solubilisation of phosphate (isolate 31 and 20 respectively). Finally, 2 isolates were selected for further study in presence of rock phosphate in broth medium which showed phosphate solubilization potential greater than 30% in liquid conditions. These isolates when screened biochemically using rock phosphate as phosphate source in triplicates in Czapek dox medium showed percentage of solubilisation of phosphate 21.4% and 7.6% (isolate 20 and 31 respectively). The strain modification of the best isolate (isolate 20) was taken up in order to determine its efficacy in presence of different medium components mostly carbon sources in the medium. The optimization of carbon requirement towards solubilization efficiency was also experimented and both the fungi preferred fructose as major carbon source to be added into the growth medium.

Plant growth and development are associated with access to minerals and phytohormones. Some microbes ave the capacity to solubilize phosphate and produce phytohormones which are considered functional features of plant growth promotion. The present wok is intended to reveal that the range of endophtic fungi that colonized the different parts of selected traditional medicinal plants and isolation and identification of possible microbial inhabitants of medicinal plant tissues having P solubilization activity. In the present study, specific isolation of endophytic fungi from different medicinal plants *Gloriosa superba*, *Xylocarpus granatum*, *Piper longum*, *Operculina turpenthum* was done and pure cultures were screened for the phosphate solubilization potential . Maximum phosphate solubillization potential i.e. 27% was exhibited by Aspergillus sp. isolated from *Gloriosa superba*.

Micrbes paly an important role in plant growth promotion, health and enhanced productivity. Endophytic microbes associated with plant also promote its growth and increases productivity due to the capacity of solubilising P mostly Ca and Fe Phosphates. The present study emphasizes on the application of efficient P solubiling strains as biofertiliser in order to enhance the productivity of *P. longum* which is one of the endangered species of Odisha state. The fungal strains tested under pot culture conditions proved their efficacy in growth improvement of growth of P. longum. Plants of *P. longum* responded well to fungal inoculation and their average height is higher than uninoculated control. Besides, plant hight and biomass, fungal inoculations also improved the number of fruits per plants and shortened their developmental period for fruiting and ripening. Hence, application of useful Phosphate solubilising fungi may prove as an efficient alternative in sustaining the growth and development of RET plants.

Formulation of bioagent by using native plant growth promoting microbes and evaluation of their usefulness for agriculture productivity

(2014-15; State Plan funded)

PI: Dr. Nibha Gupta

Research Fellows: Madhuchhanda Sahoo, Matreyee Babu

Microorganisms are useful for biomineralization of bound minerals making nutrients available to their host and /or its surroundings. Most of the tropical soils are phosphate fixing hence free form of phosphate is not readily available to the plants. Application of Mineral solubilizers in such type of problematic soils could be an effective method to achieve higher growth and productivity of plants of economic importance. Many soil fungi, predominantly of the genera *Aspergillus* and *Penicillium*, have been shown to possess the ability to solubilize sparingly soluble phosphates *in vitro* by secreting inorganic or organic acids. Growth promotion and increased uptake of P by crop plants inoculated with P-solubilizing fungi have also been reported by many investigators. The main Objective of the project was to screen the fungal inoculants (endowed with phosphate solubilising potential) for better growth and development of some important agriculture crops. The test plants considered were Chilli and brinjal due their short span of growth and developmental stages. During the project tenure, pure cultures of pre-tested (for phosphate solubilising potential) fungal cultures were analysed for their morphology, identification and extracellular beneficial activity in laboratory conditions. Simultaneously, the

fungi present in soil (to be used for the pot experiment) were also analysed for their various morphological characteristics and extracellular activity. In next phase , pot experiment was set by growing test plants under control and inoculated conditions (16 fungi used). Observations were recorded for the periodical growth and development of test plants. Data were analysed for the impact of fungal inoculations on final product. Impact of fungal inoculations as compared to uninoculated control was exhibited on plant growth and development during pot culture experiments. However, the suitability of *Aspergillus sp. 6, Aspergillus sp. 5 and Aspergillus sp. 3* is observed to be an effective inoculant for influencing the fruits and its total weight of chilli. Similarly, *Myceloid fungus and sterile mycelia, Aspergillus sp. 8 and 9* are observed to be an effective inoculants for brinjal crops. Further experimentation on combination of other factors like soil types, supplementation of fertilizers, seasonal variation and varietal hosts is required to reach the final conclusions. However, results obtained during short period of project are certainly promising and will be exploited further for the development of microbial consortium for other plants of economic importance and useful for the state.

Topic: Designing of nursery technology through novel bioinoculant for better growth and development of some important plantation tree species of Odisha (2015-16)

Microorganisms are useful for biomineralization of bound minerals making nutrients available to their host and /or its surroundings. Most of the tropical soils are phosphate fixing hence free form of phosphate is not readily available to the plants. Application of Mineral solubilizers to the seedlings helps in their establishment in such type of problematic soils. The process of inoculating microbes to the soil in a forest nursery could be an effective method to achieve higher growth and establishment of tree species on aforestation sites. Use of these beneficial microbes as bioinoculants /biofertilizers would reduce the cost of chemical fertilizers involved In plantation programes. This could be helpful in large scale production of quality planting material as well as promotion of some tree species having problem for germinability, establishment and healthy seedling growth. In view , an experiment on development of bioinoculants for some forest tree species *(Gmelina arborea, Pongamia pinnata, Saraca asoca, Terminalia arjuna, T. bellerica, Dalbergia sissoo, Dalbergia latifolia*) was carried out under nursery conditions. Data recorded on various growth parameters exhibited the usefulness of fungal inoculations on growth improvement under nursery conditions. Such fungal supplementation was also shown usefulness in establishment of plants transplantation stage. The finding of the study reveals microbial treatments of seedling can significantly influence and the potential of inoculants in afforestation technique in problematic soil. The plants of *forest tree species* grown under different treatment along with control untreated plants exhibited good growth in terms of plant height, biomass and plant parts with significant variations. Screening and selection of microbial inoculants for the development of biofertilizer is needed as all microbial strains performing better in laboratory conditions may or may not perform good in field conditions. Their performances also depend upon host specificity. It is not necessary that all microbial applications effects the growth performances of the particular host plants. Hence, the preliminary study carried out on some selected fungi with few tree species has opened

Impact of fungal inoculations on chilli grown under pot culture experiment

avenue towards more detailed experiments for the development of microbial consortium for the growth and development of plants having problems of seed germination , establishment during transplantation and growth under adverse conditions. However, our fungal strains F 12 , F3 and F5 that has shown cumulative effect with all plants tested could be the better alternative for development of biofertilizer for transplantation tree species. To reach some effective conclusion, more experimentations on the impact of dual and triple inoculation based on Rhizobium, PGPR, Arbuscular mycorrhizal fungi is required.

Impact of microbial applications on growth and development of *Madhuca latifolia* (Mahua) and Pongamia pinnata (Karanja) under nursery conditions

(2016-17; State Plan funded)

PI: Dr. Nibha Gupta

Research Fellows: Swagatika Mishra , Swatishree Pani

Pogamia pinnata is inedible oil yielding plant and useful as alternative biofuel energy. The plants do have less seed germinability and slow growth as well . Germination, growth and establishment of this species is also one of the major constraints behind its propagation and conservation. *Madhuca latifolia* (Mahua) is widely known as 'Butter nut tree' and economically important as its flower are used as a food , seeds are rich in edible fats , fruits are used as vegetable and widely consumed by the tribes. As for the better potential, good quality of mahua tree should be cultivated through various biotechnological approaches. The application of biofertilizers in agriculture sector is well recognized worldwide through comprehensive studies on agriculture crops but very little information on their effects on forestry species especially *M. latifolia* is available in literature. Application of microbial consortium involving phosphate solubilising microbes, nitrogen fixing rhizobia , P-uptaker arbuscular mycorrhizal fungi under different soil compositions (soil types, organic manure, chemical fertilisers) will be useful for the development of nursery technology for this tree species. In view, an experiment was planned to determine the impact of microbial inoculations on growth and development of *Pongamia pinnata* and *Madhuca latifolia* under different soil compositions. Experiments on microbial application (indigenously isolated) on Pongamia pinnata has been successfully implemented. Data recorded on various growth parameters exhibited the usefulness of microbial application on growth enhancement of plants under nursery conditions. Experiment on Mahula has already been set in nursery conditions by using indegeous rhizospheric microbes and final data awaited.

Standardization of nursery technology by application of PGPF (Plant growth promoting fungi) under different soil compositions and its impact on quality of Piper longum: A RET medicinal plant of Odisha

(2016-18; NMPB, GoI funded)

PI: Dr. Nibha Gupta

Research Fellows: Manas Ranjan Panigrahi, Soumya Ranjan Nayak, Rahul Behera

Piper longum is having several medicinal properties due to the dry spikes of female types which is economically important. India is a major producer, consumer and exporter of Piper longum (long pepper). The plant due to its immense economic importance has high demand and therefore is overexploited from the wild by indiscriminate fruit collection. The disappearance of the plant from its natural habitat can be prevented by promoting their cultivation on large scale. The problems associated with cultivation are mortality under field conditions, poor growth and yield. The low productivity of piper species is non-availability of healthy planting material and crop losses due to biotic and abiotic stresses As a result the plant has been included in the list of 32 prioritized medicinal plants by National Medicinal Plant Board (NMPB). RET medicinal plants belonging to Rare, Endangered and Threatened plants are valuable for their medicinal property but some of them are deficient in phosphorus uptake which hinders their growth. Filamentous fungi have the ability to solubilise inorganic insoluble phosphates such as ferric phosphate, tricalcium phosphate, aluminium phosphate can be used because of their potential to produce and release organic acid into the environment. Therefore, inoculation of phosphate solubilising microbes is a reliable technique to increase phosphate solubilisation in soil. Hence, utilization of phosphate solubilising fungi as biofertiliser have gigantic potential for making use of fixed P present in soil in crop production.

Rhizospheric and phyllospheric fungal flora of Piper longum (three ecotypes) were isolated, purified, and evaluated under pot culture conditions for plant growth promoting activity. Data on various growth parameters has already been recorded and fungal inoculants AR3 and AR6 were found to be best in enhancing growth of Piper longum . Second set of Experiment on combination of above fungal inoculants with plant growth hormone producing fungi has also been set. Results are awaited.

Development of fruits of Piper longum grown under different fungal treatments
(Comparison of treated plants with untreated uninoculated control plants of Piper longum)

Dual inoculation of Phosphate solubilising fungi and IAA producing fungi exhibited good response towards plant growth development and improvement. The combination of AS2+AS-3, AS1+BS-3 and AS-1+BL-5 observed with good potential of enhancing growth of Piper longum under inoculated conditions. Fruit yield was found more in plants grown during rainy season in comparison to the plants grown in winter season. The ultimate target to enhance the productivity in the form of fruits is important and it has been achieved during various fungal treatments. Surprisingly, the soil treated with fertilizer or salt improved the fruit production during winter season as compared to rainy but not good as compared to the fungal treatment alone and/ or in dual inoculation. It is clearly evident that the *Piper longum* grow well during rainy season and its quality upgraded due to fungal inoculations. However, the supplementation of fertilizer along with fungal treatment exhibited good option for *Piper longum* growers to get fruits during winter season also.

Fungal diversity in Subarnarekha mangrove ecosystem of Odisha

(2014-16; OBB, GoO funded)

PI: Dr. Nibha Gupta

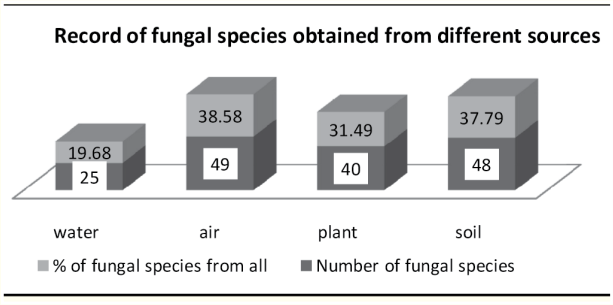
Research Fellows: Kiran Mohapatra, Ms. Sonali Sandeepta Sentapati , Soumyashree Nayak

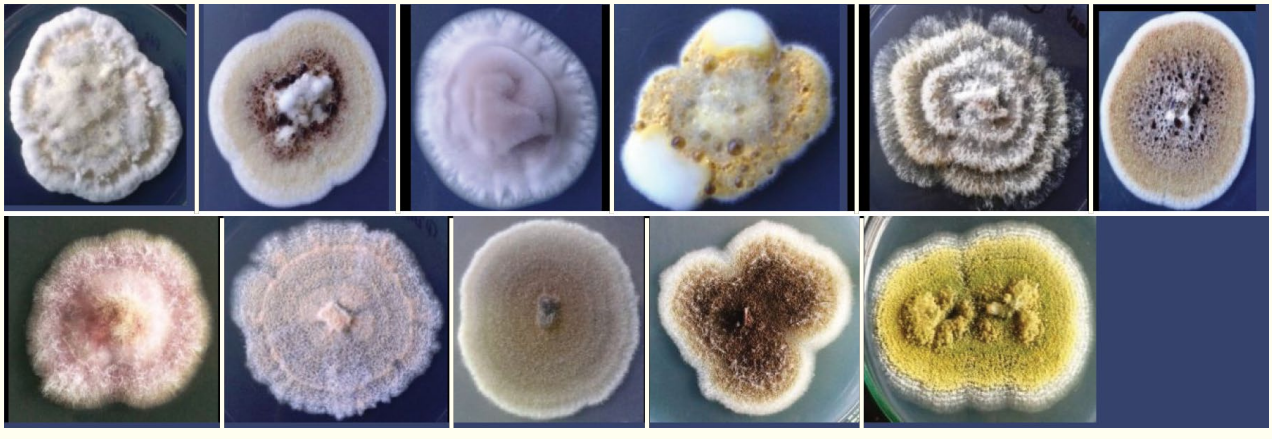
It is evident that mangrove habitats are biologically rich and provide a unique ecological niche for microbial diversity. Mangrove wet lands of Odisha covers Devi mouth, Mahanadi delta, Bhitarkanika, Dhamara mouth, Budhabalanga mouth and Subernarekha mouth. A considerable amount of work has been done on microbial diversity of Bhitarkanika mangrove ecosystem of Odisha.. No systematic record was available on the fungal flora of Subarnarekha mangrove ecosystem of Odisha. Hence, an attempt may be put forward to record fungal diversity of the unexplored mangrove ecosystem of Subarnarekha mouth. Soil, water, plant samples were collected from 15 different sites of Subarnarekha mangrove area during winter season. The environmental air from different sites were also be trapped on the culture plates containing different nutrient media for the growth and isolation of fungi. Simultaneously, 47 no. of plant samples belonging to 14 mangrove species were collected from 10 different sites of mangrove area. Fungi were isolated by direct inoculation and incubation methods. The fungal isolates were identified (at the Genus level) and characterized based on their morphological characters and microscopic analysis by using taxonomic guides and standard procedures. Air sample entrapped from the mangrove environment was treated for the isolation of fungi. Total number of fungal colonies grown on the different media plates were calculated as % incidence. The maximum number of fungal colonies were isolated on PDA media as compared to SDA and site no.1 and 14. Impact of vegetation on the air fungal flora could not be observed. Total 50 fungi have been isolated and their site wise occurrence has been described. All fungal isolates were grown in different media for morphological characterization and data recorded. Similarly, fungi have been isolated from different sources like water, plants and soils collected from this mangrove area and characterized for their morphology. Data related to fungal distribution in different sites as well morphological features have been described. Slide culture technique used for the identification of these fungal isolates confirm the presence of *Alternaria* sp., *Articullospora* sp., *Aspergillus* sp., *Cladosporium* sp., *Eupenicillium* sp., *Thallospora* sp., *Penicillium* sp., *Curvularia* sp., *Fusarium* sp., *Phomopsis* sp., *Paecilomyces* sp., *Pestalotiopsis* sp., non sporulating dematiaceous fungi and sterile mycelium. These fungi are tentatively identified and further work is under progress

A considerable amount of work has been done on microbial diversity of Bhitarkanika mangrove ecosystem of Odisha. Studies pertaining to the occurrence and distribution of fungi and bacteria, salt tolerance behaviour, Arbuscular mycorrhizal association of mangroves and occurrence of *Streptomyces* are documented and reported in various report. Very scanty reports on microbial diversity of other mangroves area of Odisha are available. Most of the reports are based on the studies on bacterial diversity. No systematic record was available on the fungal flora of Subarnarekha mangrove ecosystem of Odisha. Hence, an attempt may be put forward to record fungal diversity of the unexplored mangrove ecosystem of Subarnarekha mouth. In view, samples of plants and soils were analysed for the occurrence of fungi Plants belonging to mangrove and non mangrove or mangrove associates

were treated for isolation of fungi present in leaf , rhizosphere root, pneumatophores and flower, fruits buds etc. Among 59 samples tested for the purpose and total 40 different fungi were isolated , purified, characterized and identified . Fungi belonging to *Alternaria , Aspergillus, Cladosporium, Colleltotrichum , Curvularia,* Dematiceous form *, Humicol, Paecilomyces, Penicillium, Pestalotiopsis sp.* found in Subernarekha area have been present in the plant system (Table -4). Almost all samples tested were associated with minimum one fungi and maximum 4-5 types except few which did not exhibit the incidence of fungi. Most occurred fungi was *P. variculosum* which was present in 11 number of samples tested. *Penicillum commune* (33.33) and *Penicillium purpureogenum* (10), *Aspergillus tamari*, *Aspergillus sp. 1* was mostly occurred fungi indifferent water sample collected from the mangrove area. 28 % fungi were myceloid types from water of this area. Only fungi belonging 5 genera among 19 genera were present in the water samples . 48 no. of species were present in soils. Maximum number of fungi were belonging to *Penicillium* sp. followed by *Aspergillus* and *Fusarium* . Other gernea *Alternaria* , *Humicola*, *Khuskia* , *Paecilomyces*, *Eupenicillium* wee also present in different soil samples . *Aspergillus flavipes* , *Aspergillus* 3 , Myceloid -26 , *Penicillium variculosum* , *P. Chrysogenum*, *P. implicatum* were observed more frequently in different sites. However, myceloid 26, *Penicillium variculosum* were found to be present in maximum sites in the soil.

Mangrove ecosystems of different countries were earlier analyzed and reviewed for various aspects of microbial population. It is evident that mangrove habitats are biologically rich and provide a unique ecological niche for microbial diversity. Mangrove wet lands of Odisha covers Devi mouth, Mahanadi delta, Bhitarkanika, Dhamara mouth, Budhabalanga mouth and Subernarekha mouth. A considerable amount of work has been done on microbial diversity of Bhitarkanika mangrove ecosystem of Odisha. No systematic record was available on the fungal flora of Subarnarekha mangrove ecosystem of Odisha. Hence, an attempt may be put forward to record fungal diversity of the unexplored mangrove ecosystem of Subarnarekha mouth. Survey, collection , isolation and characterization of fungi from Subernarekha mangroves ecosystem has given a good information on fungal diversity. Overall, 55 no of various samples for the winter season and 141 no. of samples for summer season were collected for the isolation of fungi. Different microbiological methods as well as media used for general and selective isolation exhibited many no. of colony forming units (isolates) of fungi reside in the given sample .Maximum number of fungal isolate were obtained from the air trapped in different media plates of different sites in both the season i. e. 32.88 and 38.84 % of the total no. of isolates in winter and summer season, respectively. Plant and soil were having more or less similar no. of isolates in summer season where as during winter season the soil samples were having more no. of fungal colony forming unit as compared to plants and other system. However, water collected from different sites of river and creeks





Micro fungi isolated from Subernarekha mangrove ecosystem of Odisha

contained comparatively less no. of fungal isolates. In all, 126 types of fungi were found in different samples of soil, water, plants and air collected from different sites. Most frequently occurred fungi were Aspergillus, Alternaria, cladosporium, Curvularia, Colletotrichum, Fusarium, Penicillium, Dematiceous fungi , and many myceloid fungi . Mangrove ecosystem of Subernarekha has been explored primarily and first time in Odisha. The above study on mangrove fungi provides unique opportunities for mycologists to explore more non culturable fungal diversity and exploit their ecological, medicinal and industrial potential.

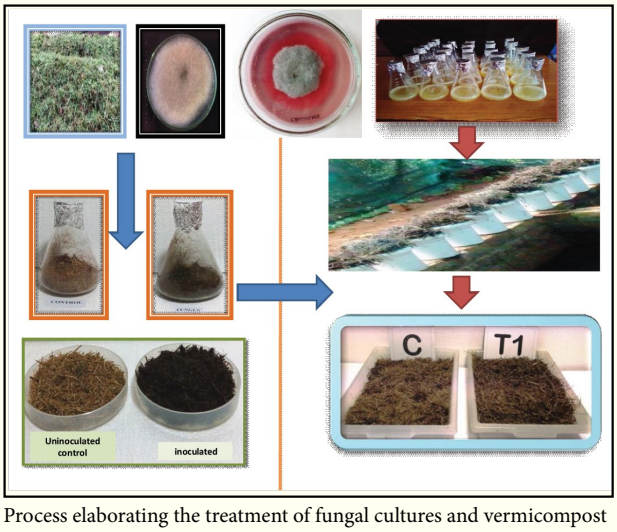
Development of time cutback and low cost technology for biodegradation of green wastes used in Vermicomposting

(2015-16; State Plan funded)

PI: Dr. Nibha Gupta

Research Fellows: Swagatika Mishra, Swatishree Pani

The green wastes from garden, local plantations and household droppings are very difficult to manage as it needs huge energy in form of manpower and other functional machinery. Since, such type of mechanical management of green waste is time consuming too, an alternative is needed so that live energy may not be wasted and put into another gainful use. In this context, vermi composting is an eco-friendly technology of using earthworms as versatile natural bio-reactor for rapid conversion of any organic wastes under value added manure. Vermicompost, or castings, is worm manure and are considered as best soil amendment available (Anastasi et al., 2005). It is fact that by establishing vermicompost units we can recycle the wastes from our own resources and create an effective fertiliser in the process. The raw material is first primarily decomposed by using cow dung slurry and requires 60 to 90 days prior to be utilized for vermicomposting. The time taking process of primary decomposition of raw leaf litter underlines the need to explore the potentials of cellulolytic microbes for the transformation of green wastes into useful primary product for vermicomposting. The microbial decomposition of waste materials will take less time. In view to this, present project has been proposed to cut short the duration required for the vermicomposting of green waste by using some cellulose degrading microbes. Studies conducted on screening of cellulolytic fungi and its evaluation for the primary decomposting as well as vermicomposting exhibited very promising results and confirm the cellulolytic potential of one of the fungal strains fruitful in this endeavor. Studies conducted on screening of cellulolytic fungi and its evalutaiton for the primary decomposting as well as vermicomposting exhibited very promising results and confirm the cellulolytic potential of one of the fungal strains fruitful in this endeavor. Findings on the biodegradaton of green wastes through fungal activity and subsequent vermicomposting through *Eudrilus eugenae* a night crawler earthwarm proved to better option towards time cut back of the long process usually required for the vermicomposting in normal way. Not only the time saving, this experiments with selected fungi and its role in preparation of decomposed material required for the better and early vermicomposting come out with the good quality of compost as pot experiment on experimental vermicompost exhibited growth promoting properties better than the normal vermicompost. Seven different types of vegetable had been taken into consideration to test the growth promoting potential of prepared vermicompst and compared with the normal vermicompost usually prepared with the cow dung decomposting and further vermicomposting by earthwarms. It was found that the experimental vermicompst was proved to be better than the normal one as the seeds of vegetable germinated early in case of ladies finger , beans and trigonella



Process elaborating the treatment of fungal cultures and vermicompost development

and coriander. Not only the plant development, it was observed the positive effect of experimental vermicompost on leaf number, no. no. of fruits in case of ladies finger and beans. The plants of coriander and trigonella produced more biomass as compared to the normal vermicompost. More experimentation at laboratory and field scale is required to reach any conclusion pertaining to the exploitable potential of the fungi in mass scale.

Study on fungi associated with mushroom fruit bodies and its exploration for L asparaginase production

(2012-13; State Plan funded)

PI: Dr. Nibha Gupta

Research Fellows: Sunita Pattnaik

L asparaginase enzymes are known as antitumor agent and known to degrade L asparagine into L aspartic acid and ammonia in a hydrolytic reaction causing a rapid depletion in serum aspargine, an exogenous supply of which is required for growth of certain tumors . Asparaginases are found in diverse sources in nature, including bacteria, yeasts, molds, plants and vertebrates. It has been observed that eucaryotic microorganisms like yeast and filamentous fungi have a potential for asparaginase production. The *Mucor sp.* was grown in Glucose –Asparagine medium(pH-5.5 at 30˚C for 12 days.) both in static and shaking condition. However, the organism produced a high enzyme activity in static condition(141.17 i,u/mg of Protein).Filtration was done in three different Sephadox gel (G-100, G-75, G-50) and showed more enzyme activity in Sephadox gel G-100 comparing to other Sephadox gel. The pH Optimization of the enzyme was studied in different pH values ranging from 4.5-8.5 and showed maximum enzyme activity at pH 8.0. The enzyme thermally stable up to 45˚C. It preferred Arginine substituting L-Asparagine and also in combination as their substrate. The enzyme activity increased in presence of NaCl (0.5% to 5%) showed maximum activity in 4% NaCl. The activity of enzyme remains live for 30days but its activity decreased according to the days. The Fungal strain *Mucor sp.* showed maximum crude enzyme activity i,e 141.17 i,u/mg of protein in static condition, achieved a protein a single band of 66kDa, thermally stable up to 45˚C, pH 8.0. It used Arginine and Phenylalanine as substrate

Screening for bio control agents against fungal pathogens causing Panama wilt and Anthracnose diseases on banana varieties cultivated in Odisha

(2016-17; State Plan funded)

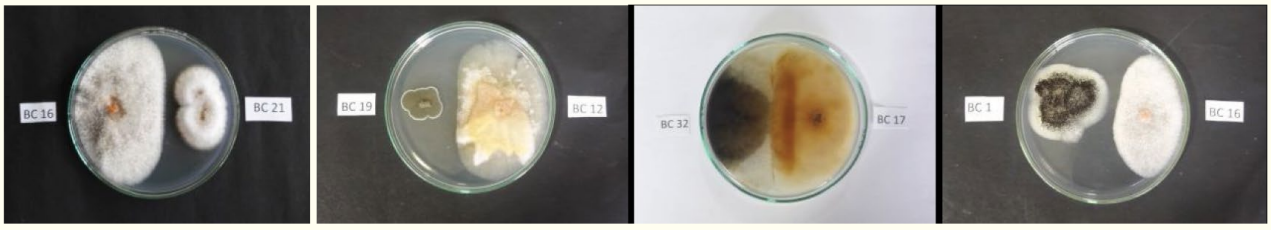
PI: Dr. Nibha Gupta

Research Fellows: Niharika Mohanty

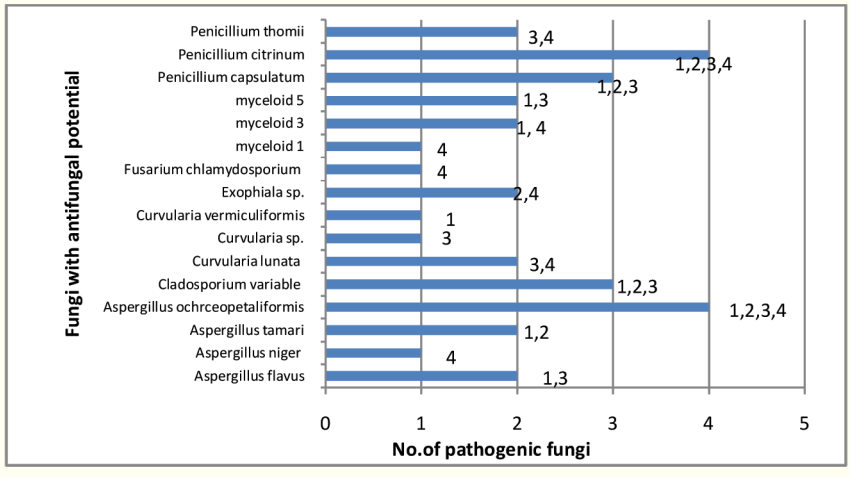
Banana (*Musa* sp.) is the second most important fruit crop in India next to mango. Its year round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favourite fruit among all classes of people. It has also good export potential. The banana crop is vulnerable to a number of diseases in various parts of the world, including the black Sigtoka, Xanthomonas wilt, Bunchy top , and fusarium wilt but fusarium's soil borne nature makes it especially challenging. FAO has already warned India Fusarium wilt which has recently spread from Asia to other parts of the world. Popularly known as tropical race 4 (TR4) or Panama disease, is posing a serious threat to production and export of the popular fruit, with serious repercussions for the banana value chain and livelihoods. To this context , present project proposal on studies on exploration of antagonistic endophytes and exploitation of their potential as biocide towards fungal diseases stands very important. In view, six different types of banana cultivars were evaluated for fungal diversity at phyllosphere level in healthy and diseased plants collected from different parts of Odisha. Total 104 fungal isolates obtained from 7 sites /six banana var. After purification and characterization, 40 different types of fungi obtained including three species of Fusarium. Indigenous fungi microfungi as well as endophytic fungi isolated from different habitat

and plants were evaluated for their antifungal activity against *Fusarium* and *Colletotrichum* isolated from

different banana cultivars Screening of 100 nos. different fungi for their bioactivity against these pathogens have been completed. Preliminary screening for the biocontrol agent showed good antifungal activity in 15 different fungi .



Antifungal properties of biocontrol fungal agent against Fusarium sp.



Antifungal potential fo fungi against banana fungal pathogens

along with L-aspargine.From the above observations carried out clearly indicate that *Mucor sp.*has the ability to produce significant amount of L asparaginase enzyme than other fungal strain.

Optimization of submerged culture requirements for the production of mycelial growth and exopolysaccharide by some selected Fungi

(2016-18; S&T Dept.GoO funded)

PI: Dr. Nibha Gupta

Research Fellows: Smita Behera

At present, a considerable number of fungi including higher basidiomycetes, lower filamentous fungi, and yeasts from different ecological niches were known for their ability to synthesize EPSs in laboratory culture systems. However, many still remain uninvestigated or under explored. Though , Odisha is endowed with occurrence of several fungi, emphasis has not yet been given for evaluation of fungi for exopolysacchride production which is reportedly found novel source of secondary metabolites. Hence, it is thought to undertake product oriented research exclusively on optimization of culture requirement for the enhanced production of exopolysaccharide by some selected fungi. Optimization of the requirement of pH, Temp, nutrient media , carbon and nitrogen sources has been experimented in submerged culture conditions in order to enhance the exopolysaccharide production by fungal strains. The fungal isolate RN preferred xylose, pH 6, 30c, 10 days incubation in dark and static conditions. However, the application of enhancer and precursor of metabolism especially tween and phosphate source did not confirmed as effective factor for the enhanced production of exopolysacchride . Experiments with the nutritional consortium of the different components may improve the exopolysaccharide production by this fungal strain.

Microbial exopolysaccharide are of great value now days.

As plant and seaweed source of exopolysaccharides are extracted in a laborious way hence microbial alternatives have been searched and used. Submerged culture technique had promising effect towards the ease of recovery of the polysaccharides dissolved in the medium. Polysaccharides from fungal source have been proved to be effective in different fields**.** The objective of this study was to optimize submerged culture condition of a new fungal isolate to improve and enhance the production of mycelia biomass and exopolysaccharide. The present study investigates the optimization of process parameters for enhanced production of EPS by OFAT (One factor at a time method). The influence of initial pH value, incubation period and temperature, mode of culture (static/shake), culture vessel, carbon and nitrogen, ionic salts, enhancers, surfactants were investigated. OFAT method revealed glucose and xylose as carbon source, peptone and yeast extract as nitrogen source, pH 6 with 7 days incubation statically and dark in 250ml Erlenmeyer flask as an good conditions and component for maximum EPS production. Commercial formulated SD medium exhibited good EPS production than the laboratory composed SD media. K_2HPO4, Olive oil, tryptophan were screened as suitable enhancer and elicitor for EPS production. The mycelial biomass could be observed in each and every experimental setup with significant differences due to the cultural and nutritional factors. After optimization of culture medium and environmental conditions in batch cultures, a new medium composition was formulated and evaluated for EPS production aided with Olive oil and Tween 80 in different combination along with control. Optimized media developed in the present study was a combination of the individually screened nutrient component, estimated the maximum EPS (1002.3 ± 189.72 mg/l) which was later expelled to 1468.1 mg/l after the addition of olive oil which was much higher and reported first time from this fungus. Mass scale production of crude EPS was done using optimized medium followed by purification by Sepharose 6B and Sephadex coloumn. Partially purified EPS was collected from the coloumn and precipitated. HPTLC was performed to analyze its monosaccharide composition having 7 standards (maltose, fructose, xylose, galactose, glucose, raffinose and sorbose) and one sample in three different form (Partially purified EPS, Crude EPS, Dialyzed EPS sample of PLB fungal culture) having mobile phase Butanol: Pyridine in 5:1 ratio. HPTLC data reveals presence of maltose, fructose xylose, glucose, raffinose and sorbose in the all the three

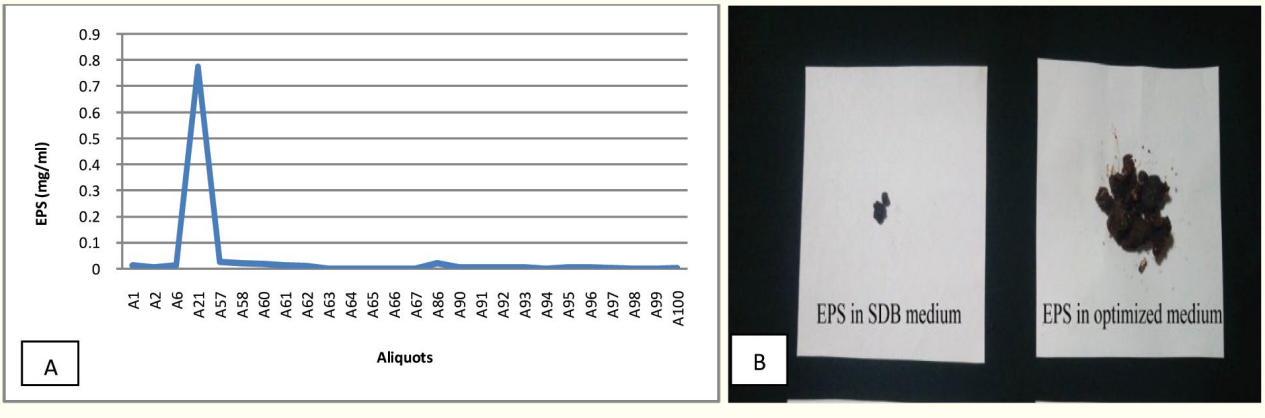


Fig. A : Gel permeation chromatogram of the polysaccharide, isolated from novel fungal strain, B : purified polysaccharide

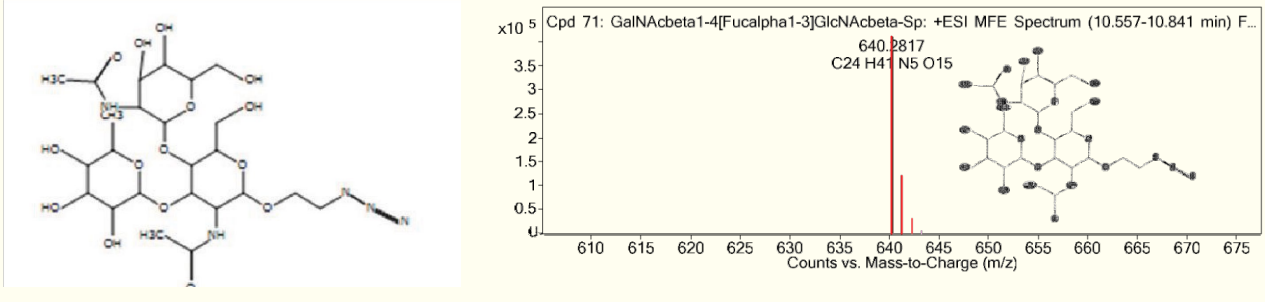


Fig. Structure of tentatively identified Glycan

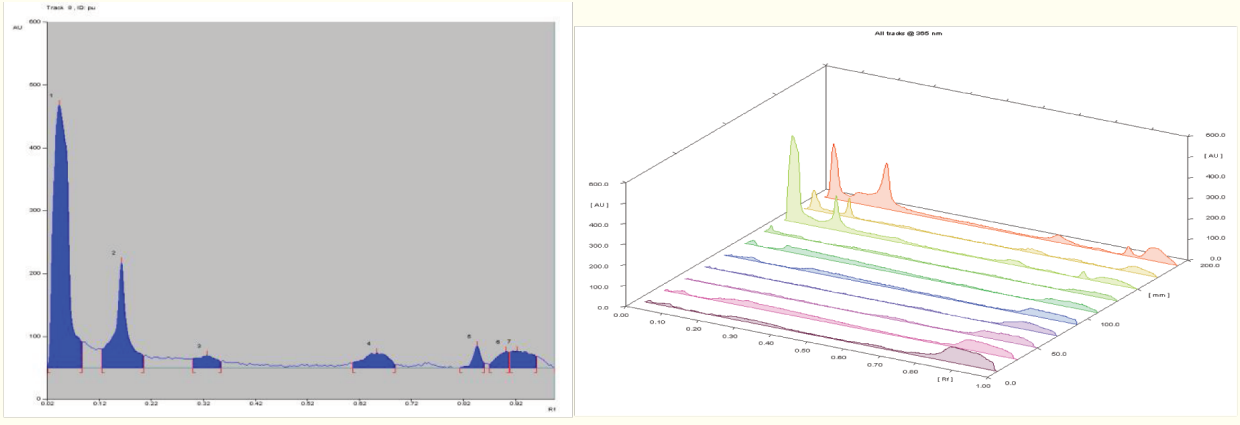


Fig. HPTLC chromatogram of acid hydrolysed exopolysaccharide at 254 nm showing different peaks of sugar constituents in standard (maltose, fructose, xylose, galactose, glucose, raffinose and sorbose) and polysaccharide (partially purified, crude, dialyzed and)

form of same EPS sample of PLB fungal culture. Data were recorded at 365 nm. Conformation was done by comparing retention factor of standards with sample. LCMS analysis confirmed the presence of a water soluble glyacan named as GalNAcbeta1-4[Fucalpha1-3] GlcNAcbeta-Sp with elemental composition C24 H41 N5 O15 having apparent Mass 6.39 x10 ^{2} kDa.

OFAT method was also used to optimized nutritional medium for the EPS production by second novel fungal strain M-18. The influence of initial pH value, incubation period and temperature were taken into consideration in static condition. Output confirms 9 days of incubation period, pH 6.0 and temperature 25ºC best for the growth and exopolysaccharide yield. Malt extract broth medium used as basal medium and supplementation of xylose, glucose, tryptophan, olive oil, Tween 80, vitamin C, K_2HPO_4 and $CaCl_2$ was done at different ratio. Finally an optimized medium formulated includes: malt extract medium (basal medium), xylose, glucose, tryptophan, olive oil, Tween, vitamin C, K_2HPO_4, $CaCl_2$, pH 6.0, incubation period of 9 days at temperature 25 ºC giving yield of 4829.33 ± 954.21mg/l of exopolysccharide. Extracted crude EPS are further partially purified using sepharose 6B and sephadex G-75 coloumn and each aliquot were estimated by Phenol Sulphuric acid medthod.

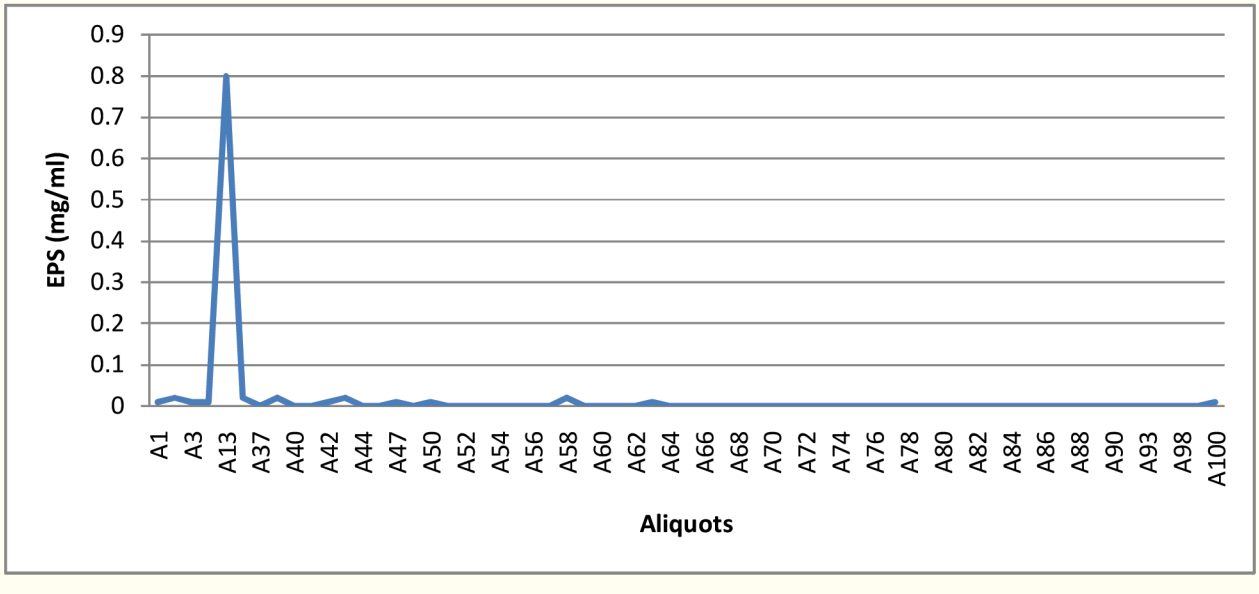


Fig. Gel permeation chromatogram of the polysaccharide, isolated from novel fungal strain M-18

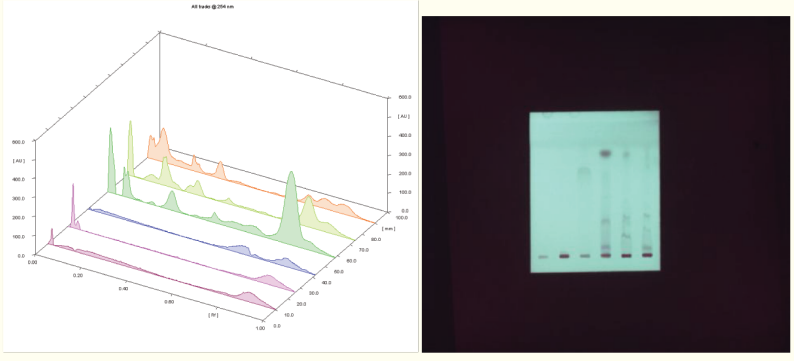
Bioprospecting of mangrove fungi for Bioactive and Phosphate solubilising potential

(2017-18; State Plan funded)

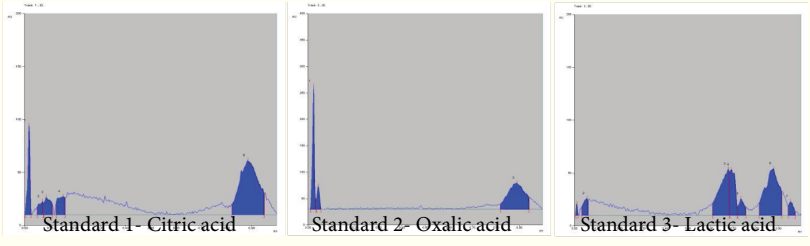
PI: Dr. Nibha Gupta

Research Fellows: Swagatika Mishra , Swatishree Pani

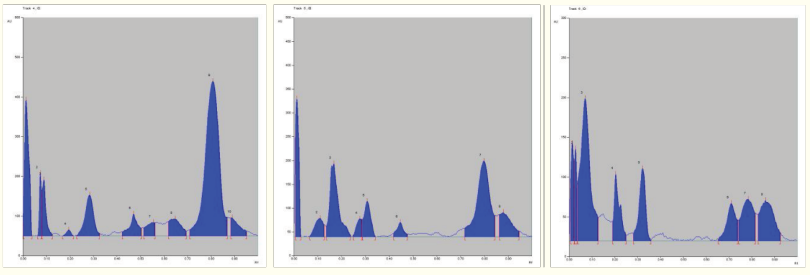
It is evident that mangrove habitats are biologically rich and provide a unique ecological niche for microbial diversity. Several fungi and bacteria are reported for their occurrence and beneficial activity in mangrove ecosystem. Phosphorus solubilizing microbes play role in phosphorus nutrition by enhancing its availability to plants through release from inorganic and organic soil P pools by solubilization and mineralization. Principal mechanism in soil for mineral phosphate solubilization is lowering of soil pH by microbial production of organic acids and mineralization of organic P by acid phosphatases. Use of phosphorus solubilizing microbes as inoculants increases P uptake. Hence, Phosphate solublising fungi from unexplored sources are very important in order to get new and /or microbial strains having more potential . Data recorded on screening of more than 100 mangrove fungi and three best fungal strains having potential of P solubilization under submerged culture conditions were selected. C: N screening and their combinational ratio was selected for the enhanced P solubilising activity in terms of solubilised P content and decrease in pH due to organic acid production. HPTLC was performed to detect the presence of Organic acid in culture filtrate and compared with the standard organic acids. The production of Citric acid, Lactic acid and oxalic acid by fungal strain F 11 and FP 12 where as the fungal strain FC 22 exhibited the production of lactic acid only. It is noted that these fungal strains has good potential of organic acid production , thereby able to solubilise the P content show pos



HPTLC chromatogram of organic acid (culture filtrate extract) at 254 nm showing different peaks of metabolic constituents in standard A- std 1(Citric acid), std 2 (Oxalic acid), std 3(Lactic acid), sample 1(F11), sample 5(FP12) and sample 6(FC 22). **B -** Chromatogram under 254 nm



Standard 1- Citric acid | Standard 2- Oxalic acid | Standard 3- Lactic acid



Sample 4- F11 | Sample 5- FP12 | Sample-FC22

Another elaborative work was done on Bioactive potential fungal strain BC 98 against seven no. of Fusarium sp. The records presented in table no 21 showed the % growth inhibition of different solvent extracts of biocontrol agent against pathogenic fungal strains. It was observed that the soxhelet separation and extraction is confirmed as better option over colomn chromatographic separation of bioactive principle produced by this fungi. The fungus was having wide spectrum bioactivity as it was inhibitory to the all seven fungal pathogen belonging to Fusarium sp. Hence, the present study proved the usefulness of this fungal strain towards development of plant protection agent as far as the fusarial diseases are concerned. However, a detailed studies are required to confirm the bioactive potential of this fungal strain against other group of pathogens , so that it can be utilized as wide spectrum biocontrol agent .

Propagation, conservation and re-introduction of RET & other important plants

Propagation & Re-indtroduction of back mangroves of Orisha

(2012-18; State Plan funded)

PI: Dr. Uday Chand Basak

Research Fellows: Pradeep Kumar Maharana, Pramodini Rout, Kapileshwar Mallick, Jiban Jyoti Panda and Bikash Das

Mangroves are constituent parts of tropical and subtropical intertidal forest communities. These are of great ecological and economic significance in providing forestry and fishery products to a large human population, protecting coastal zones from erosion, storms and foods and also in supplying food and shelter for a large no of fishes. Most of the mangrove species of the Mahanadi delta of Orissa are threatened by human intervention, i.e encroachment upon the land for cultivation and shrimp culture, for exploitation of timber, fuel and fodder and for other uses.

The mangrove vegetation of Bhitarkanika and the adjacent Mahanadi delta of Orissa is diverse and seems to be among the richest (in terms of species diversity) of the world. The back-mangrove trees (landward mangroves) such as *Heritiera fomes, H. littoralis, Cynometra ramiflora, Cerbera manghas, Aglaia cucullata, Excoecaria agallocha* etc form characteristic association with other major true mangroves belonging to Rhizophoraceae, Sonneratiaceae, Avicennia spp. etc. Some of the above landward species contribute a considerable population density and thus play a major role in formation of total mangrove vegetation systems. Inspite of an integral part of the total mangrove biodiversity, the above landward species have not yet been received considerable attention for their conservation and propagation. Rather, these spp. are neglected for any mangrove re-forestation activities leading to the threat to loss and imbalance of species diversity in the mangrove ecosystems.

Sea level rise, due to climate change, may be devastating for most of the mangroves in Indian sub-continent especially for salt-sensitive back-mangroves that have no area in which to expand. Substantial number of species will be vulnerable and majority of the species may even face high risk of extinction. Inspite of an integral part of the total mangrove biodiversity, the above landward species have not yet been received considerable attention for their conservation and propagation. Rather, these spp. are neglected for any mangrove afforestation activities leading to the threat to loss and imbalance of species diversity in the mangrove ecosystems. It is likely that RET mangroves *Cerbera manghas* (Status Vulnerable,Ved et al,2008 FRLHT-RPRC pub) and *Heritiera fomes* (Status Endangered, IUCN Red List of Threatened Species, Version 2013.2) non-viviparous 'back- mangrove' (including RET) species in the coastal mangrove ecosystems of Odisha may not compete successfully in the extensive hyper saline conditions and may be depleted/disappear gradually owing to loss of natural regeneration through seed germination. Gradual depletion of mother plants, poor flowering and seed set, post-dispersal predation of seeds/propagules by macrobenthos, over browsing of mangrove seedlings by cattle etc. necessitate vegetative propagation for re-establishment in the denuded and potential areas.

Mangroves inhabiting ecologically challenging intertidal zones are subjected to various abiotic stresses because of unfavorable environmental conditions which adversely affect their growth and development and trigger a series of morphological, physiological, biochemical and molecular changes (Dasgupta *et al.* 2010). Mangroves with high levels of antioxidants, either constitutive or induced, have been reported to have greater resistance to this oxidative damage (Jithesh et al. 2006; Takemura et al. 2000; Parida et al. 2004; Cheeseman et al. 1997). Mangrove plant cells are well protected against these detrimental effects of ROS by a complex antioxidant system comprising non-enzymatic and enzymatic antioxidants (Kathiresan and Bingham 2001).

One of the most common stress responses in plants is overproduction of different types of compatible organic solutes such as proline and glycinebetaine (Serraj and Sinclair, 2002). The organic solutes have been proven to be helpful in osmoregulation (Rhodes and Hanson, 1993). Phenolic compounds such as flavonoids serve as protectors against a wide variety of environmental stresses in plants (Banerjee et al. 2008). Growth was significantly inhibited at a salinity of 0.2M NaCl in case of Cynometra iripa (Desai and Chavan, 2011).

Application of vegetative macro propagation methods offer a unique opportunity to augment the re-introduction work of many back mangrove species in the denuded areas. With this fact in mind, mass propagation and re-introduction work had been started by RPRC during 2013-14 and continued with various important back mangrove species with kind co-operation of Balasore Wildlife Division, Govt. of Odisha.

Considering the above mentioned fact and background, we had recently (2013-14) re-introduced around 2000 nos of vegetatively propagated *Excoecaria agallocha* in the denuded area under Balasore Wildlife Division which boosted us to do more trial with other potential spp. mentioned above.

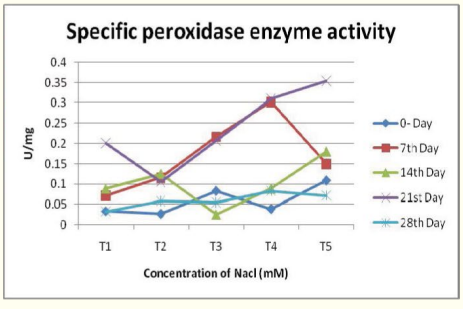
Heritiera littoralis is a timber-yielding as well as medicinally important tree back mangrove species found very sporadically in Odisha coast. Though the IUCN categorized this species as 'Least Concern' category (IUCN 2015.4 RED List), locally the plant with very scattered populations/individual needs to be conserved on priority basis (Mishra *et al.,* 2005; Basak, 2008). This species regenerates naturally through seeds with very poor rate of germination. Furthermore, irregular flowering and fruiting habits, less seed viability make it difficult to produce adequate natural recruits as well as planting materials to facilitate artificial regeneration through seeds. In order to arrest gradual depletion, the reduced, scattered and sporadic populations need to be augmented with the re-introduction of the species propagated through vegetative means on priority. Re-introduction work has been initiated in Bhitarkanika National Park (2017) with kind cooperation of Mangrove Wildlife Division, Rajnagar.

Holistically, these research activities involved optimization of rooting through vegetative propagation in juvenile stem micro-cuttings of *Exceocaria agallocha*, mass propagation & hardening of rooted saplings of *Heritiera fomes, H. littoralis, Cerbera mangha,.Excoecaria agallocha;* biomolecular changes during hardening of the saplings exposed to salt stress ; re-introduction of hardened saplings of *Excoecaria agallocha, Heritiera fomes, H. littoralis, Cerbera mangha* in the wild habitat and finally post re-introduction evaluation of the introduced plants for their sustainable growth & development.

Propagation & Re-introduction of *Excoecaria agallocha*

A total 3000 *Excoecaria agallocha* plants were raised through stem cutting method in the nursery. Propagated plants were subjected to hardening against different concentration of NaCl-salt stress (e.g.,50mM.100mM,150mM and 200mM) in order to acclimatized for re-introduction in the native. Analysed major antioxidant enzymes i.e. Peroxidase, Superoxide dismutase, Catalase and ascorbate peroxidase and total phenol contents during hardening period (4 months) to find out biochemical basis of salt tolerance. For re-introduction trial, 2000 hardened plants were planted during Aug,2013 in an experimental plot in Khadibil area under Balasore Wild Life Division allotted by Forest Division. The re-introduction performance has been monitored & recorded time to time. As per latest data recorded during 2017-18, more than 80% re-introduced plants were found survived. Both 150mM and 200mM NaCl treated *E. agallocha* saplings showed their maximum growth (Height, Collar perimeter, No. of Branches and No. of Leaves) after re-introduction. With this, it was opined that salt acclimatized vegetatively propagated saplings of *E. agallocha,* a back mangrove species, could be successfully used for re-introduction, general plantations as well

Hardened saplings of *E. agallocha*



Biochemical analysis for salt-aclimatization

as species recovery programme in denuded area for mangrove biodiversity conservation.

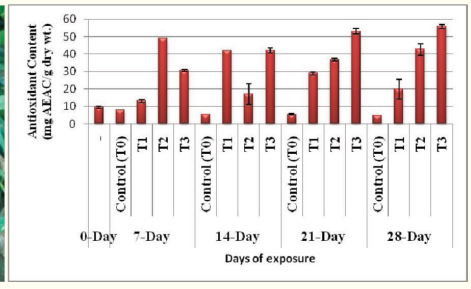
Propagation & Re-introduction of *Cerbera manghas*

A total 250 saplings of *Cerbera manghas* were raised both from stem cuttings and air layers. Experiment was carried out with hardened saplings aided with different concentrations of salinity (NaCl) followed by its biochemical parameters estimation such as DPPH scavenging assay, reducing power assay and osmolytes analysis i.e. proline and glycine betaine. Besides, the morphological parameters (growth and development) of hardened *C. manghas* saplings were also recorded. Initially, 155 nos of saplings were re-introduced at Khadibil area (Chandaneswar) as 1st phase trial in the first week of September, 2015. Further, during 2nd phase, 65 numbers of saplings were re-introduced at the trial plot at Khadibil area (Chandaneswar) dutring 21-22 March, 2016. Unfortunately, this species could not survived after re-introduction.

Reintroduction trial

Successful reintroduction at Khadibil, Balasore

Haredining & re-introduction trial of *Cerbera manghas* (pani ambo)



Effect of salinity on antioxidant content (DPPH) in *H. fomes* during hardening

Propagation & Re-introduction of *Heritiera fomes*

A total 80 numbers of vegetatively propagated *Heritiera fomes* saplings are raised, hardened and maintained under shade net through etiolation process (Wrapped with black adhesive tape) from juvenile mother plants (around 600 nos) by applying growth hormones (IBA (5000ppm) +NAA (2500ppm)). Rooted plantlets were hardened in polybags and subjected to different salinity (NaCl) concentrations at different day intervals.Morphological parameters (Growth and development stage) as well as biochemical parameters i.e. Protein content, Peroxidase, Catalase enzyme activity, Total antioxidant content (DPPH and FRAP) and proline content were analyzed under salinity stress during hardening stage. Initially, 145 nos of *H. fomes* saplings were re-introduced at Khadibil area (Chandaneswar) as 1st phase in the first week of September, 2015.Further, during 2nd phase, 120 nos of *H. fomes* saplings were re-introduced at the trial plot at Khadibil area (Chandaneswar) dutring

Hardened saplings of *H. littoralis*

Re-introduction in Bhitarkanika

21-22 March, 2016. Unfortunately, this species could not survived after re-introduction.

Propagation & Re-introduction of *Heritiera littoralis*

Vegetative propagation of *Heritiera littoralis* through air-layering and stem cuttings have been completed. Hardened saplings were applied with different concentration of sodium chloride (100mM, 200mM, 300mM, 400mM and 500mM) for biochemical and re introduction purpose. A total 99 nos of *Heritiera littoralis* saplings were reintroduced in three different sites (Mahisamara, Suajore and Dangmal) of Bhitarkanika National Park during March-October, 2017. As per data recorded during 2017-18, more than 70% re-introduced plants were survived.

Studies on *in vivo* shoot multiplication in hypocotyls of Rhizophoraceae mangroves: a new approach for scaling up of vegetative propagation

(2012-13; MoEF & CC, GoI funded)

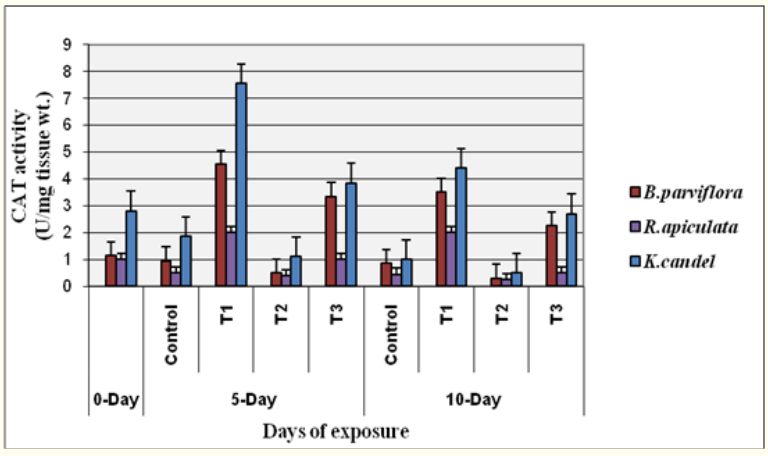
PI: Dr. Uday Chand Basak

Research Fellow: Pramodini Rout

Many true mangroves like Rhizophoraceae family are struggling for survive due to habitat loss and fragmentation. To solve such depletion, application of various scientific methods and techniques are needed to augment vegetative propagation system of Rhizophoraceae family. True mangroves under Rhizophoraceae family have poor vegetative spread. In this context, multiplication by vegetative means was targeted tools. In order to further improvement of vegetative propagation from hypocotyls of Rhizophoraceae mangrove, 'decapitation' method was developed by Basak and Das (2002). *Ex vitro* shoot induction in hypocotyls of Rhizophoraceae mangroves *i.e Rhizophora apiculata, Kandelia candel* and *Bruguiera parviflora* under different salinity conditions with antioxidant enzyme activity was also recently reported (Basak et al., 2013). *In vitro* multiple shoots are also developed from 'callus' regenerated near and upon cut surface of the hypocotyls explants of *Bruguiera gymnorrhiza* (Satuwong et al., 1995). The in vitro method as described by (Ogita et al., 2004) for *Kandelia candel* multiple shoots are developed from hypocotyls and interpreted through histological analysis.

Mangrove reforestation by seed or propagule planting is a common and conventional way to regenerate new individuals especially for tree mangroves belonging to the family Rhizophoraceae. However, habitat destruction and reduced population of mature and seed-producing plants limit the scope of conventional afforestation through propagule planting. For endangered

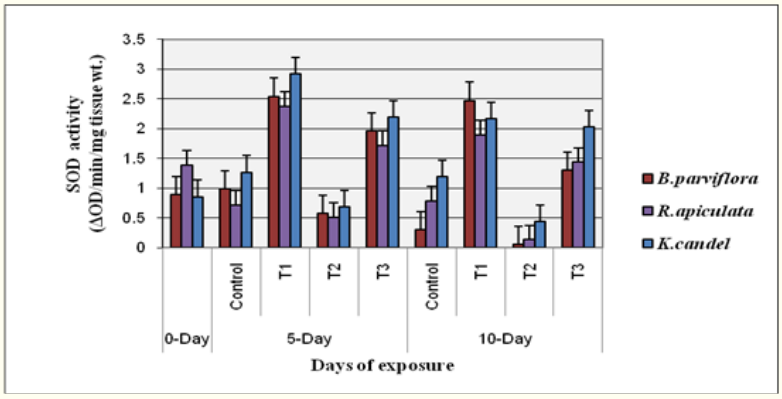
Induction of Multiple Shoots in *Bruguiera parviflora*



Catalase (CAT) activity during multiple shoot development in three mangrove species.

mangroves, it was, therefore, felt essential to standardize technique for vigorous and low cost planting material production through alternative methods such as multiple shoot regeneration through decapitation of hypocotyls. The salt tolerant behaviour of plant has been explained through changes in antioxidant enzymes particularly at time of salt stress in mangroves.

This study primarilly aimed at induction of *in vivo* multiple shoots in hypocotyl of Rhizophoraceae species like *Bruguiera parviflora, Kandelia candel* and *Rhizophora apiculata* and their biomolecular evaluation.



Superoxide dismutase (SOD) activity during multiple shoot development in three mangrove species.

Induction of multiple shoots

The hypocotyls of Rhizophoraceae mangroves especially *Bruguiera gymnorrhiza, Bruguiera parviflora, Kandelia candel and Rhizophora apiculata* had profound multiple shoot inducing ability under ex vitro condition. Highest shoot induction ability was observed in *K. candel* hypocotyls after decapitation followed by *B. gymnorrhiza*, *B. parviflora* and *R. apiculata*. Maximum Shoot numbers per hypocotyl (5.5±2.0) were recorded in *K. candel* and *R. apiculata* scored lowest.

Biomolecular basis of shoot regeneration

In vivo multiple shoot regeneration from hypocotyls of Rhizophoraceae mangroves was influenced by salinity and proline leading to expression of species-specific differential antioxidant enzyme activities. The specific enzymes viz. peroxidase, catalase and superoxide dismutase may be used as indicator to depict pathway of shoot organogenesis in *B. parviflora*, *K. candel* and *R. apiculata.*

Cloning and functional validation of salinity tolerant genes from mangrove plants of Odisha

(2014-15; State Plan funded)

PI: Dr. Giridara Kumar Surabhi

Research Fellows: Sabyasachi Pattanayak

Nearly 20% of the world's cultivated area and nearly half of the world's irrigated lands are affected by salinity. It was estimated that salinization reduces the world's irrigated area for crop production by 1–2% every year. The mangrove species are members of terrestrial families that have adaptations to survive under conditions of high salinity, low oxygen and nutrient availability in the soil. Extreme environmental stress has resulted in a number of structural and physiological adaptations that permit these plants to become established and to survive in harsh environment. The genetic basis for these strategies is, however, virtually unknown: mangroves, like other extremophiles, are poorly represented in the plant molecular literature. In order to grow under salinity stress, the mangrove plants must have acquired some genes/ proteins essential for salt tolerance mechanisms during their evolution. To this end cloning and functional validation of genes from *Rhizophora apiculata* and further analyses may unravel the mystery of molecular mechanism for salinity tolerance in mangrove plants and novel genes identified through our research could be utilized for crop improvement program.

R. apiculata propagules were collected from Batighar mangrove forest area, Kendrapara district, Odisha and planted in culture pots with exposure to natural sunlight in a glass house and maintained for three-months. Three-month-old seedlings were subjected to imposed

salt stress treatments i.e. 0 (control, low salt), 300 and 400mM. Leaf and root samples were harvested on 24h, 3rd and 7th day after treatment (DAT) and samples were frozen immediately in liquid nitrogen and stored at -80°C for further analysis. Total RNA isolated using TRIzol method from both control and salt stressed leaf samples represent driver and tester, respectively. mRNA isolation was performed from total RNA and cDNA synthesis was conducted from (tester and driver) control and salt stressed samples in order to construct "forward" subtraction cDNA library.

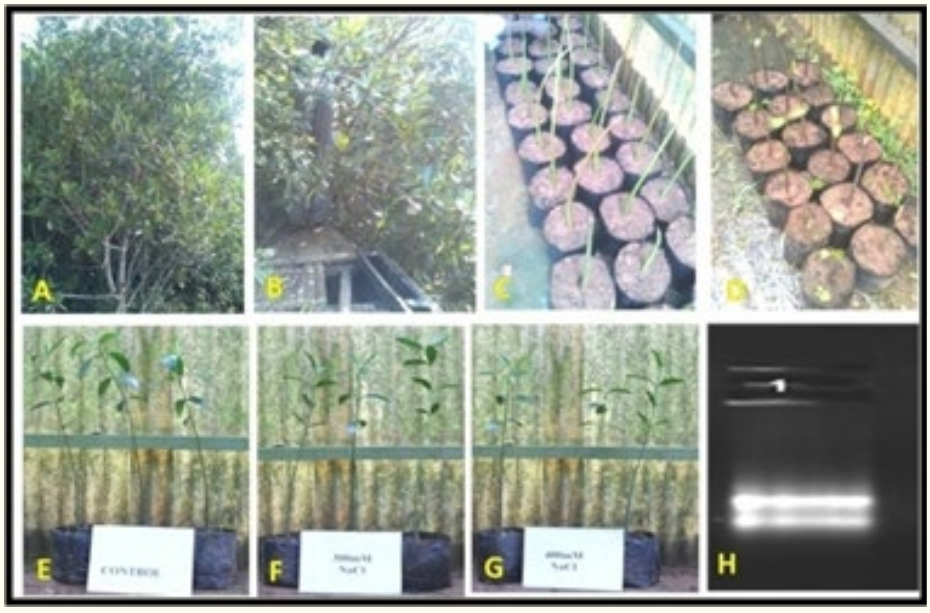


Fig. 1A-H: *R. apiculata* propagules were collected from Batighar mangrove forest area (A and B), propagated in poly bags at RPRC green house and unfurling of first pair of leaves (D). Salt stress treatments were [300 mM and 400 mM] imposed and samples were collected on 24h, 3 and 7-DAT (E-G). Total RNA was isolated from leaf tissue by using TRIZOLplus RNA isolation and purification kit (Life technologies) and was verified RNA integrity on 1.2% agarose gel (H).

Conservation of Orchids of Odisha

(2012-18; F&E (PCCF), GoO, State Plan funded)

PI: Dr. Nihar Ranjan Nayak

Research Fellows: Debashish Behera, Sulagna Subhasmita Jena, Srichandan Giri, Rabinarayan Sahu, Somnath Chhatarjee, Sipin Kumar Thayal, Premananda Mahanta, Kabya Ketu Tripathy

The orchids belonging to the family Orchidaceae are considered as the most diverged comprising of about 25000 species in the group of Angiosperms. The species are classified in five sub-families and approximately 870 genera. Majority of the orchid species are epiphytes and lithophytes nearing about two-third of the orchidswith terrestrial species comprising the remaining third. Due to number of biological problems in the family particularly the type of propagation methods, the members are experiencing extinction risk particularly under current climatic change scenarios. It has been established that the multiple factors (both intrinsic and extrinsic) responsible for the rarity of orchids. Complex flower architecture, requirement of specific pollinator, complicated seed germination process (mycorrhizal requirement) are the major intrinsic factors for the rarity of orchids.

In India, about 1331 species have been reported and majority of them are confined to the north eastern regions. Of these, 134 species reported from the state of Odisha and 96 species are reported from the Similipal Biosphere Reserve. Although the number is less, there are many important species of commercial values are growing in the natural habitat. It is more important to note that in the recent surveys or reports it has been indicated that the population of the orchids are disappearing from the nature in much faster rate. The worst example is the natural population of *Phaius tankervilleae* already disappeared from the natural habitat of Odisha; the major cause might be the habitat destruction, over collection and extremely low rate of propagation. In the state, few of the endemic orchids of India are growing, the best example is the *Dendrobium regium*; populations are under severe threat.Though reported from many parts of the country, from the recent observations, it is reported that the major viable populations are only growing at the Similipal Biosphere Reserve. *Eria meghasaniensis* is exclusively to our state, the populations are under severe threat. Conservation approaches need to be in place to restore the populations.

Population Analysis

Population analysis of the wild orchids is one of the important steps required for the conservation of orchids. In the research program, the population of the two extremely rare orchids of Odisha have been analysed.

Eria meghasaniensis

The populations of the orchid *Eria meghasinensis* are located at Meghasani hills of Similipal Biosphere Reserve, based on the information available from the book "Orchids of Odisha" (Misra, 2004). At the Meghasani Hills, from our observations 14 populations found, mostly confined on the host plant *Syzygium cerasoides*indicating the possibility of host preference. Altogether, 139 plants were identified and it was found that the lengths of the plants were 7-15 cm (fig.1). The plants are producing the flowers every year and also producing seeds on each flowers. The capsule sizes are small bearing less number of seeds. However, under natural conditions seedling production not reported. The growth of the populations are extremely low, might be confining to the vegetative propagation.

Fig. 1: *Eria meghasaniensis* at Similipal Biosphere Reserve
a. Individuals growing on the host tree, **b.** Flower of the species produced during the month of October.

Dendrobium regium

While analysing the population two types of flowers were observed from Similipal Biosphere Reserve, one with magenta colour flower (Fig. 2) and the other with white coloured flower. However, the white coloured flower are not seen from our recent observations. It is evident that about 300 individuals are growing at different habitats of which the major population are available at the Jenabil region Similipal Biosphere Reserve. The forest is highly dense and type is of semi-evergreen. The area is recorded with an annual rainfall of 1420 mm and average temperature is of 26°C. From the observation of the populations at different areas, it is seen that the populations are declining rapidly. Though reported from the Kendujhar and Koraput, from our recent observations not a single plant could be detected.

Fig. 2: *Dendrobium regium at* Similipal Biosphere Reserve

Fig. 3: Different stages of seedling development in *Phaius tankervilleae*
a. Seed bearing capsule, **b.** Seed germination on nutrient medium, **c.** Seedling production under in vitro conditions and **d.** Acclimatization on soil under greenhouse conditions.

Mass Propagation of Wild Orchids Through Tissue Culture

Propagation through in vitro culture of seeds

Orchid seeds under natural conditions require external supplementation of nutrients for germination as the seeds lack nutrient reservoir in the endosperm. In recent years, tissue culture techniques are being used extensively for the mass propagation of the orchids. The major purpose of the standardization of mass propagation methods is to be used for the restoration of the population under natural conditions. Seedlings are ideal for the restoration purpose because they are genetically different. Protocols have been standardised for 37numbers of wild orchids of Odisha. Many of these like *Dendrobium regium*, *Cymbidium bicolor*,*Tainia*

Fig.4: Different stages of seedling development of *Aerides multiflora* **a.** Flowers of the species, **b.** Seed germination on nutrient medium, **c.** Seedling production under in vitro conditions and d. Acclimatization on soil under greenhouse conditions.

Fig. 5: Mass propagation of *Dendrobium regium* through *in vitro* culture of vegetative parts

hookeriana, Phaius tankervilleae etc. (Fig.3& 4)During the study, the effect of growth regulators on the seed germination and subsequent seedling development have been standardised. It has been seen that the growth regulators found to be play a major role in seedling development under *in vitro* conditions.

Propagation through in vitro culture of vegetative parts

In many cases it has been seen that availability of the seeds for mass propagation is the problem. In such cases, it is required for development of protocols using vegetative parts. In general, in orchid, the vegetative propagation is an extremely slow and tedious process under natural conditions, however using *in vitro* culture techniques thousands of plants could be produced from a single explant. Protocols have been developed for few wild orchids using vegetative parts.Young shoot buds of *Dendrobium regium*were collected from the mother plants and cultured on ½ MS medium supplemented with growth regulators. About 30 numbers of new shoots could be induced from a single explant, these new shoots could be sub-cultured on to new medium for multiplication and within a year thousands of plants could be produced. Among the different growth regulators tested, N6-benezylaminopurine (BAP) found to be highly efficient in producing new shoots (Fig. 5).

Fig. 6 : Introduction of seedlings of *Cymbidium bicolor and Dendrobium regium* at Similipal Biosphere Reserve

Restoration of Population of Wild Orchids

The population of many wild orchids found to be decreasing in an alarming rate under natural conditions. Though it is evident for each and every orchid of Odisha, initially steps have been taken for restoration of few of the extremely rare orchids. Seedlings of *Dendrobium regium*, *Cymbidium bicolor* and *Tainia hookeriana*successfully introduced into different natural habitats (fig. 6).

Fig. 7: Different activities of training programme conducted at Kendhujhar

Conducting Training Program on Conservation of Orchids

Training programs were conducted at 3 different places involving the forest personnel (Fig. 7).The training provided the knowledge on the importance of orchids, their biology and the propagation methods used for orchids. Practical demonstrations were made how to identify the orchids and on the detail on the conservations measures could be implemented under natural conditions. A small booklet prepared that provided information on the orchids of Odisha given to the participants.

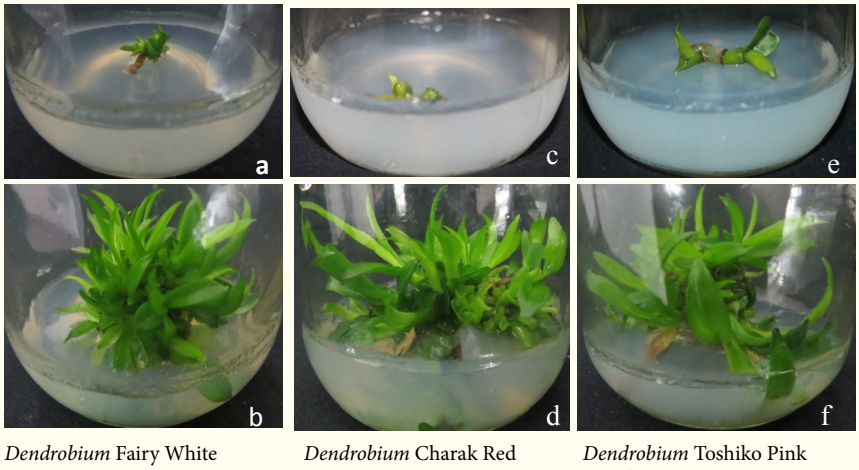
Production of Quality Planting Materials of Ornamental Orchids

(2013-18; State Plan, RKVY funded)

PI: Dr. Nihar Ranjan Nayak

Research Fellows: Debashish Behera, Sulagna Subhasmita Jena, Rabinarayan Sahu, Debabrata Dash, Soumya Ranjan Sahu, Rudranarayan Dehuri, Monalisha Rath

Orchids are the doyen in the horticultural world because of their extraordinary flower architecture, colour, vase life and fragrance. *Phalaenopsis, Cattleya, Dendrobium, Cymbidium, Oncidium, Paphiopedilum* and many more are the leaders in the present flower industry around the world. While majority of these orchids are used for the potted flowers, the *Dendrobium* orchids are extensively used for the cut flower industry. They have many colors and have an excellent vase life, can last for many days as cut flowers.These cut flowers are mostly used for the different flower arrangements as well as for different decorations. Among the different *Dendrobiums*, the varieties of Sonia orchids are most widely used for these purposes. These varieties differ from each other in their flower colour arrangements. In order to meet the market demand, these varieties are being cultivated in large scale and flowers produced are used as cut flowers. In India, there are many agencies are producing these for commercial purpose, however, not sufficient to meet the demand in the country. Currently, majority of the flowers are being imported from foreign countries. The major hurdle in this regard is the supply of quality planting materials. The industry demands that all the plantlets used for the purpose are not only healthy but also need to produce flowers of good quality and more importantly need to initiate flower uniformly. In recent years, biotechnological tools, mostly the plant tissue culture techniques are extensively used for this purpose in producing the planting materials in mass scale. The seeds of orchids could be cultured on the nutrient mediums, 90% of the germination could be achieved and healthy seedlings could be raised within short period of time. However, the industry does not like to use the seedling for cut flower production as there exists genetic variations among the seedlings that may affect the flower quality. Through tissue culture techniques genetically uniform plants could be generated in mass scale by culturing the young juvenile shoot buds. From a single explant with the use of growth regulators, thousands of plantlets could be generated.But it is required to ensure that the plantlets produces are of 100% identical to that of the mother plants as there is possibility that the growth regulators used in the medium could produce genetically variants in the process known as "Somaclonal Variations".In



Dendrobium Fairy White (a & b) | *Dendrobium* Charak Red (c & d) | *Dendrobium* Toshiko Pink (e & f)

Fig. 12: Mass Propagation of *Dendrobium* hybrids (*D*. Fairy White, *D*. Charak Red & D. Toshiko Pink) through *in vitro* culture of vegetative parts.

order to identify these variants molecular markers are extensively used.

Few projects have been taken up during last five years to produce quality planting materials of ornamental orchids to support the market in the country. From the mother plants, young shoot bud explants were collected to be used for mass propagation purpose (fig.8).Effect of different growth regulators on the induction and multiplication of shoots were thoroughly studied. The plantlets produced from different mediums were tested for the efficiency of the production of identical plants using ISSR molecular markers (fig.9).For few species seeds are being used for the mass propagation. Under these projects so far mass propagation protocols have been standardized for 34 number of orchids and planting materials of 13numbers of orchids are available for sale. For the production of quality planting materials for *Dendrobium* Soniaorchids, ISSR molecular markers have been developed and being used for the identification of somaclonal variations.

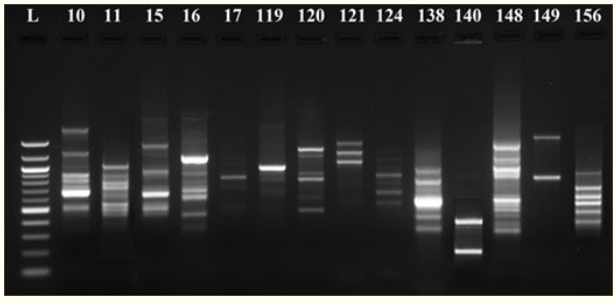


Fig.9 : SSR marker profiles of *Dendrobium* Charak Red

Ex situ conservation of selected endangered medicinal plants using Biotechnological tools (*Cordia macleodii* Hook.f. & Thoms and Blepharispermum subsessile DC)

(2013-17; State Plan funded)

PI: Dr. C Kalidass

Research Fellows: Sonali Das, Ankit Srivastava, Pranati Nayak

Currently, worldwide efforts are being made to check the alarming erosion of plant diversity. Two main approaches being used to conserve plant diversity losses are *in situ* and *ex situ* conservation. *In situ* conservation is of primary importance for maintaining the broadest range of plant diversity. As a supplement to this approach *ex situ* conservation plays an important role in backing up plant species which are particularly threatened or are rare in the wild. However, in recently years, plant tissue culture (*in vitro* culture) offers the potential of extending these traditional conservation and propagation methods to an even boarder range of species and tissue types.

1. *Cordia macleodii* Hook.f. & Thoms. belong to the family Boraginaceae, is reported for its known as Sikari/ Phanki by the tribals of Odisha, an ethnomedicinal plant has been highlighted for its wound healing, aphrodisiac and hepatoprotective activities and also its considered as an important medicinal plant of India.
2. *Blepharispermum subsessile* DC. (Asteraceae), is found to be very rare in the Eastern Ghats of Odisha, a less explored folklore medicinal plant is found in the forest of Odisha. The whole plant is used as Raasnaa, a potent Ayurvedic drug, by traditional practitioners, and is claimed to be beneficial in treatment of rheumatism, ophthalmic disorder, skin diseases, menstrual irregularities, diarrhoea etc.

The purpose of this study was to evaluate the conservation status of the two endangered plant species mentioned above and the usefulness of the Red List Categories.

Field survey was carried out to identify the location of the targeted species *Cordia macleodii* and *Blepharispermum subsessile*. *Cordia macleodii* was identified at Bhawanipatna, Kalahandi forest division mainly at Bripuda forest, near the village of Goudtula. Similarly *Blepharispermum subsessile* was identified on two different localities namely Khaligadu forest, Birhuman forest. Explants and seeds were collected from these areas for lab experiments. Moreover, It is a seasonal plant; species were present in the month of July to August for the rainy season only. Conventional propagation methods were attempted from stem cuttings with leaves totally removed and leaves intact

of *Cordia*. They were treated with auxins (IBA, NAA, IAA) of different concentration of 100-1000 ppm and 1000-5000 ppm, the stem cuttings showed shoot proliferation, but root has not been produced due to seasonal variation and other physiological factors such as soil condition, climatic factors. Nodes, internodes & leaf explants were used for *in vitro* studies of *Cordia macleodii* and it has response for nodal explants raised for shoot initiation and nodes, internodes & leaf have was achieved for three types, that callus is transferred into shoot medium and *Blepharispermum subsessile* were cultured on various concentration of MS media with plant growth regulators (BAP, IBA, IAA, NAA and GA_3, 2,4-D). After 20 days of inoculation, shoot germination started. Elongation of shoot is requiring more time in *Blepharispermum*. Previously *Cordia* culture was not possible due to phenolic exudation and endo-pathogen but now it is controlled and nodal culture was initiated with basal callus. Basal callus was sub-cultured to produce more amount of callus. Brown coloured callus was observed. Then it was treated with PGR- BAP+GA_3 (0.5-2.5mg/l) with PVP and another without PVP but with same concentration for shoot generation. Leaf callus was initiated with 0.5mg/l 2,4-D after 22 days of inoculation . *In vitro* seed germination of *Blepharispermum subsessile* is initiated with PGR BAP+IBA+GA_3 (1.0+1.0+0.5) after 10 days of inoculation and also recorded for the shoot multiplication and elongation. Therefore, standardization of protocol for different culture of these two species has been standardized.A study was carried out to standardize protocol for direct & indirect regeneration and mass propagation of *Blepharispermum subsessile* DC. A method for high frequency shoot bud regeneration from cotyledon of *B. subsessile* DC is reported for the first time. It has been successfully standardized and described for adventitious buds and also high frequency multiple shoot induction. It is efficient and reproducible to get healthy plants in short period with high survival rates. Histological analysis indicated that shoots originated from secondary somatic embryonic regions. The direct mode of regeneration of these shoot buds was evident by the absence of intervening callus and continuity of their vascular bundles with that of the embryonic tissue

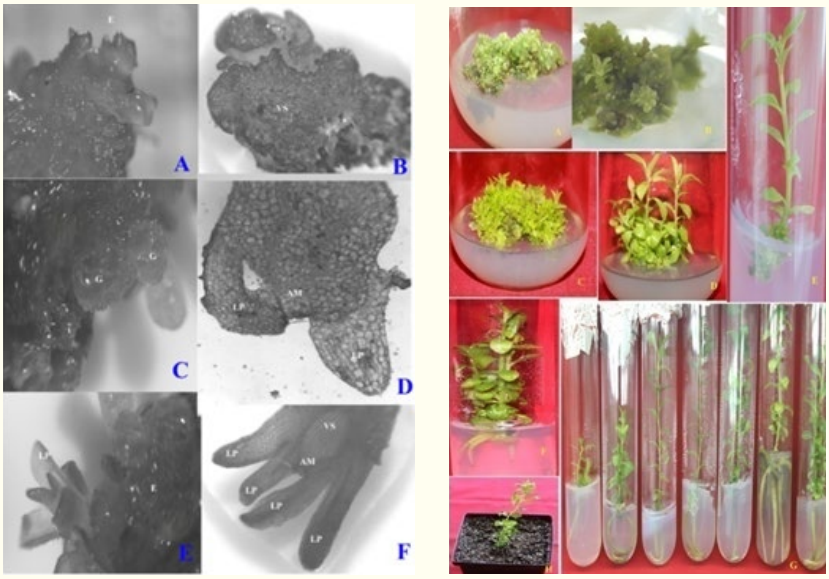
In vitro seed germination of *Blepharispermum subsessile*

Rooting of stem cutting of *Cordia macleodii*

of cotyledons. The seeds of *B. subsessile* were black or white or dark brown in color and oval shape with tapering ends. *In vitro* seed germination of *B. subsessile* has been standardized for the optimum concentration of BAP with GA_3, the growth regulators found to enhance the seed germination process as compared to BAP. Finally, we have developed standard protocols for *in vitro* propagation technique, such micro/ *in vitro* seed propagation technique can be adopted for its mass propagation.

An experimental study was carried out for conventional propagation through seeds and vegetative propagation method of *Cordia macleodii*. In the first experiment stem cuttings of *Corida macleodii* were tried for root induction. Treatments with different plant growth regulating substances at various concentrations (100-5000 ppm). Results indicate that the growth regulators have considerable effect on induction of rooting in stem cutting. Above 600 - 900 ppm of IBA stem cuttings gave good sprouting, but showed no rooting. On the other hand above 1000 – 5000 ppm IBA 50% of the stem cutting showed rooting after 120 days. The second experiment involved different pre-treatments such as scarification, cold and hot treatment, GA_3 treatment for dormancy. The germination was recorded in seeds pre-treated with 4000 & 5000ppm GA_3 with 24 hrs soaking period. Addition of other treatment did not promote seed germination of *Cordia macleodii*. For the first time, this result indicated *Cordia macleodii* seed germination and rooting of stem cutting and also established *ex situ* experimental garden of *Cordia macleodii* for germplasm conservation.

Particle induced X-ray emission (PIXE) was used to investigate mineral accumulation during different developmental stages of direct organogenesis from cotyledon explants of *Blepharispermum subsessile* beginning from shoot bud initiation and formation to *in vitro* regenerated roots. Mineral uptake and accumulation appeared selective and varied between different stages of shoot bud initiation and formation (stage 1), proliferation of leafy shoots (stage 2) and *in vitro* regenerated roots (stage 3). The concentrations of two macro elements, K and Ca were found in higher quantity during proliferation of shoot buds to leafy shoots stage suggesting their role in cell division, bud



Rooting of Stem cutting and seed germination of *Cordia macleodii*

Histology of adventitious shoots regeneration from cotyledonary explants

In vitro studies of *Blepharispermum subsessile* DC.

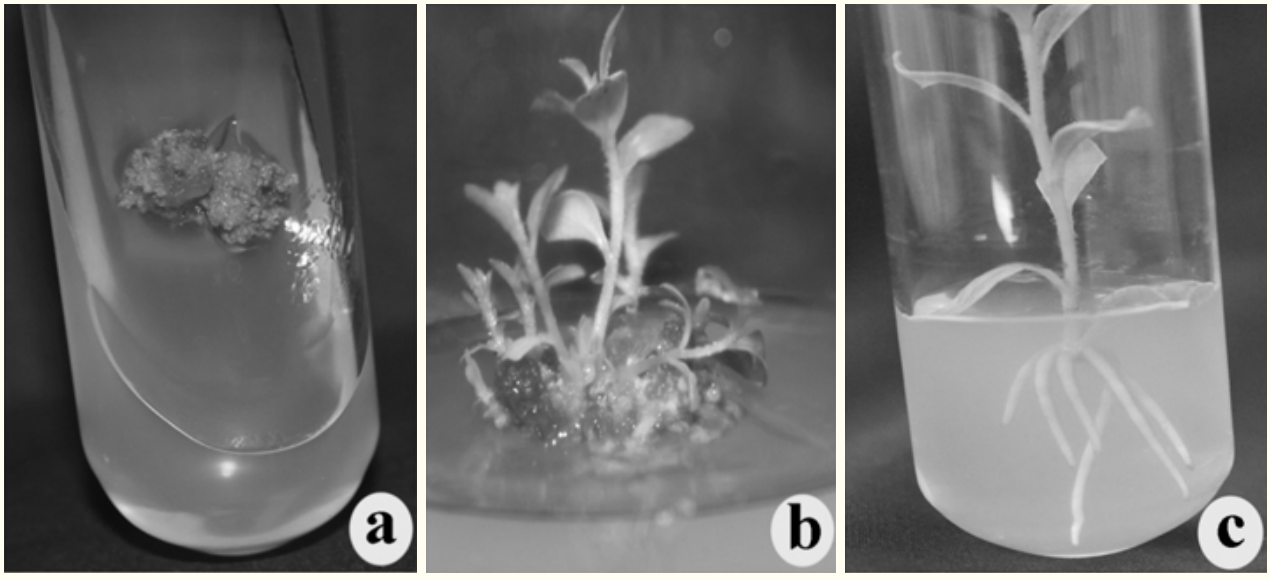
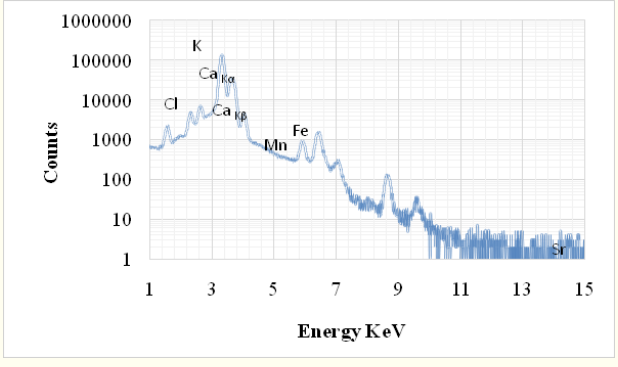


Fig. 1. Plant regeneration through adventitious shoot organogenesis in cotyledon explants of *Blepharispermum subsessile*

a. Shoot bud induction from two cultured cotyledon segments after 5days in culture on MS basal medium supplemented with 2.0 mg/l BA P + 0.2 mg/l NAA.

b. Proliferation of shoot buds into leafy shoots in the same medium after 2 weeks in culture.

c. In vitro shoot rooted on 1/2 MS supplemented with 1.0 mg/l IAA after 2 weeks in culture.



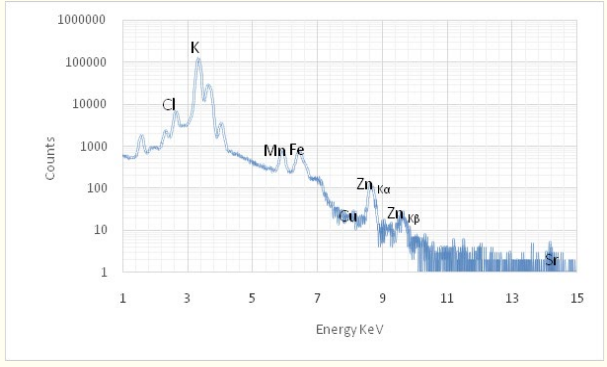


Fig. 2. Representative PIXE spectra of cotyledon derived *in vitro* culture of *B. subsessile* (stage 1; shoot bud initiation and formation) from MS + BAP (2.0 mg/l) + NAA (0.2 mg/l).

formation and multiplication of the plant. Most of the micro-nutrients such as Mn, Fe, Ni, Cu and Zn were found to be accumulated in higher quantities in *in vitro* regenerated roots as they provide the plant with a larger surface area and hence a greater potential for mineral uptake (Fig. 2 - 4). The results of PIXE test suggest that the information on the accumulation of elements during developmental stages *in vitro* could be useful for formulating a media for the induction of high frequency regeneration of in this important endangered medicinal plant species for its *ex situ* conservation.

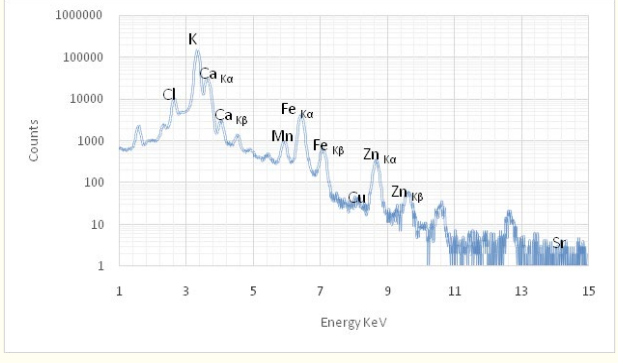


Fig. 3. Representative PIXE spectra of cotyledon derived *in vitro* culture of *B. subsessile* (stage 2; proliferation of shoot buds to leafy shoots) from MS + BAP (2.0 mg/l) + NAA (0.2 mg/l).

Centralized Nursery for Bamboo: Commercial Production of Bamboo species through conventional vegetative propagation method

(2014-16; OBDA,GoO funded)

PI: Dr. Uday Chand Basak

As regard to the collection and conservation of Bamboo species, RPRC has a rich field gene bank of around 40 species of bamboos in the Bambusetum. Like commercial production of horticultural and medicinal plants, the centre now considered large scale production of economically important bamboo species as one of the R & D activities to benefit the progressive growers and farmers with the logistic assistance from Odisha Bamboo Development Agency.

The work was initiated to establish a 'Permanent Central Nursery' for regular production of economically viable bamboo species, which will also act as demonstration-cum-production centre for interested bamboo-growers.

Production & sale of bamboo QPM

Around 17000 economically important bamboo species viz. *Dendrocalamus strictus* (salia) & *Bambusa arundinacea* (kanta) was produced under Odisha Bamboo Development Agency-funded project to benefit the progressive growers and farmers. The above bamboo seedlings was made available for sale in the RPRC.

Bamboo QPM in RPRC

Studies on Medicinal plants and Wild edible fruits

Biological screening of medicinal plants for cytotoxic, antioxidant, antifilarial, antifungal and anticancer activities

(2012-18; State Plan funded)

PI: Dr. Sunita Bhatnagar

Research Fellows: Sunita Sahoo, Dipti Ranjan Behera, Sailendra Panda, Soumya Ranjan Pattanaik, Rashmi Ranjan Dash, Shakti Ketan Prusty, Mukul Pathy

Cytotoxic and Antioxidant activities

Acetone extract of *Pancratium verecundum* showed more than 70% activity in leaf extract. Where as chloroform extract of bulb showed 90% activity at higher doses.

Table 1: - *C. viscosum* (leaf) Bioassay

Doses(µl)	Hexane	Chloroform	Acetone	Methanol
25	10.358±5.251	23.804±4.363	24.334±8.471	14.762±8.823
50	23.143±3.854	36.835±5.901	31.911±9.149	26.082±8.619
100	49.759±7.454	48.020±6.137	42.177±9.326	68.714±5.675
200	63.283±8.387	63.144±7.411	**90.654±12.941**	72.222±4.811

Anticancer Activities

Three fractions from Combretum roxburghii, Combretum densiflorum and Combretum albidum were subjected to anticancer activity in cell lines. In trypan blue dye test, Dose dependent activity was observed in Jurkat cell lines against fraction CBDFEME, Although they were active in primary screening, On cell lines they showed mild activity.

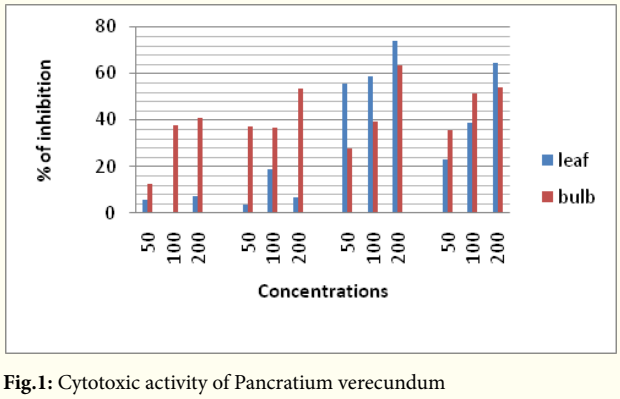
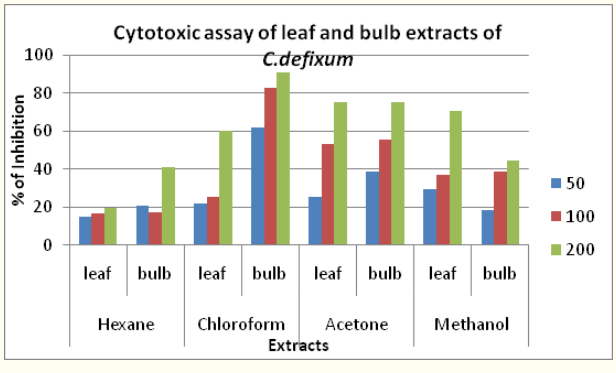


Fig.1: Cytotoxic activity of Pancratium verecundum

Antifilarial Activity

In vitro worm motility assay showed that all the plant extracts such as hexane, chloroform, acetone and methanol of *T. bellerica*, *T. chebula* and *T. catappa* exhibited macrofilaricidal activity at 5 and 10mg/ml after 4 hrs of incubation, where DEC (Diethylcarbamazine) showed macrofilaricidal activity after 24 hrs of



Acetone extract of the leaf of *Clerodendron viscosum* showed significant cytotoxic activity. While all the leaf extracts of *Clerodendron indicum* showed promising antioxidant activities in TLC based antioxidant assays. All the yellow bands in the chromatogram are probable antioxidant molecules.

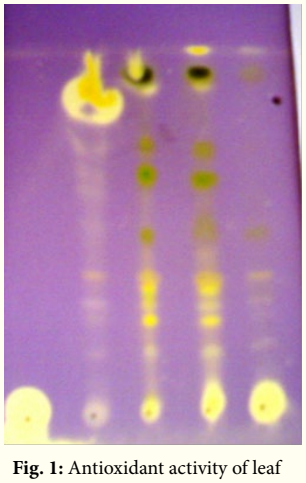


Fig. 1: Antioxidant activity of leaf extracts of *Clerodendron indicum*.

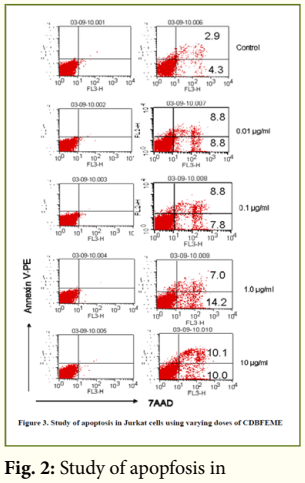


Fig. 2: Study of apopfosis in Jurkar cells using varying doses of CDBFEME

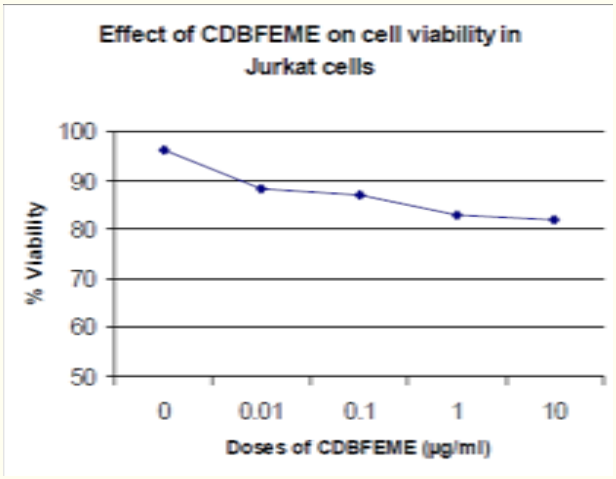
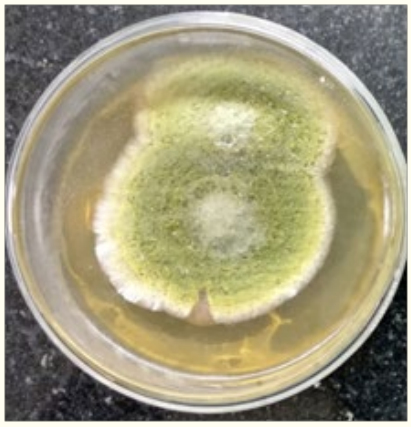


Fig. 3: Effect of CDBFEME on cell viabillity in jurkat cells.

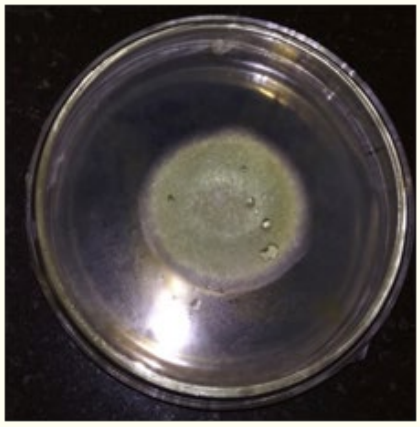
incubation. Results confirmed that between all four extracts, methanol extracts of all the plants showed maximum activity that immobilized the worms completely after four hours of exposure at 10 mg/ml. The entire control worms were active and alive till the end of the test period.

Antifungal Activity

Chloroform and ethyl extracts of *Pancratium verecundum* exhibited 15-22% inhibition in the radical growth of *Aspergillus flavus*, remaing extracts were comparable to the experimental controls and hence no inhibition was obtained in them.



CONTROL



Ethyl Extract of Pancratium Verecundum

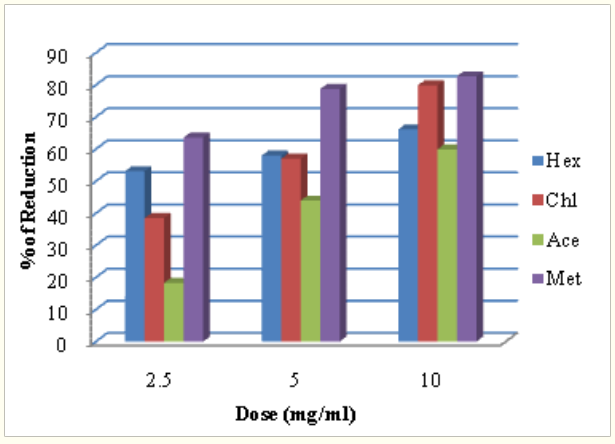


Fig 3: MTT assay of *Terminalia bellerica* extracts

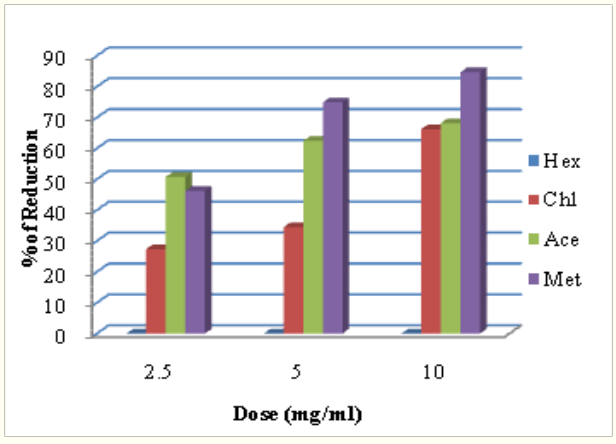


Fig 4: MTT assay of *Terminalia chebula* extracts

Bioassay guided isolation of active principles from selected medicinal plants

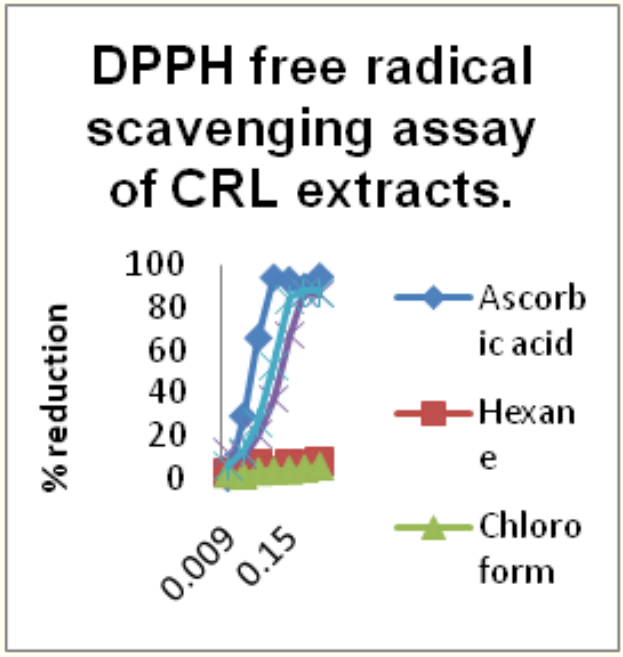
(2012-18; State Plan funded)

PI: Dr. Sunita Bhatnagar

Research Fellows: Dipti Ranjan Behera

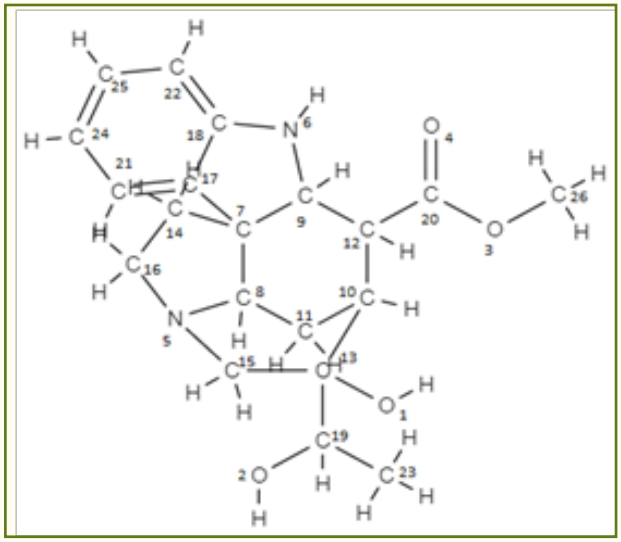
Bioassay guided isolation of antioxidant principles from Combretum roxburghii leaf extracts.

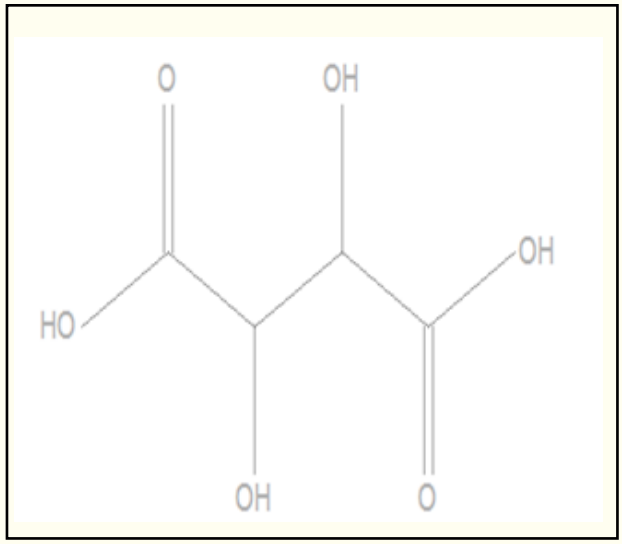
Bioassay guided isolation resulted in the isolation of three pure fractions from the acetone extract of *Combretum roxburghii* leaf extracts, as it exhibited significant antioxidant activity along with methanol extract, out of three fractions two were mixtures of one to three molecules but one of the fractions was a pure molecule, structure of which is shown in the figure. 2

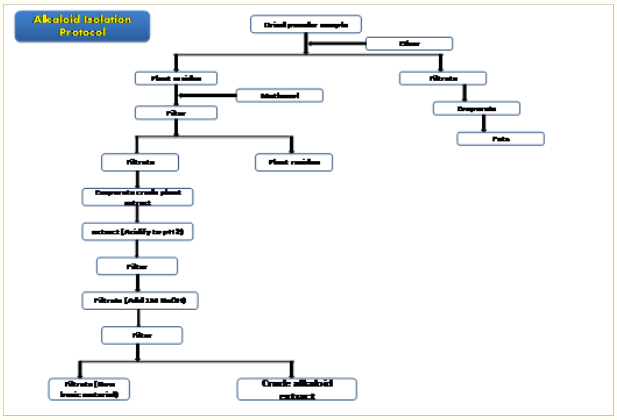


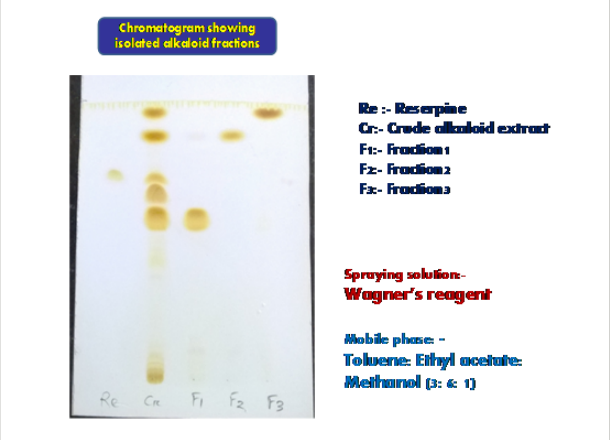
Bioassay guided isolation of antifilarial principles

Bioassay guided isolation of antifilarial principle lead to the isolation of three molecules, figures of which are as follows.









Isolation of alkaloids from ***Rauvolfia tetraphylla***

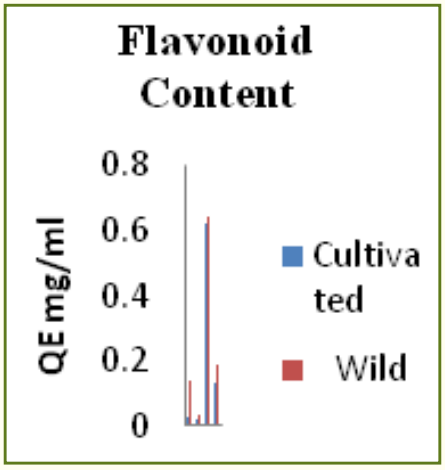
Comparative analysis of wild and cultivated varieties of medicinal plants.

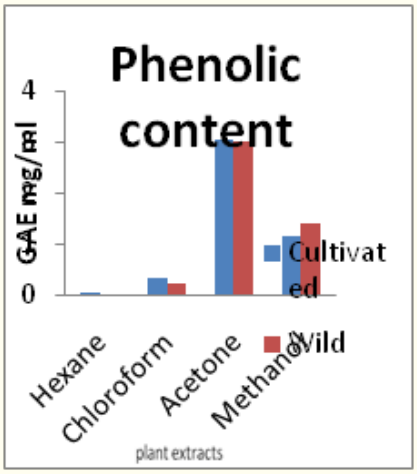
(2012-18; State Plan funded)

PI: Dr. Sunita Bhatnagar

Research Fellow: Manasi Sahoo

Achievements: Variation in the cultivated and wild varieties was not very significant, irrespective of the habitat, medicinal potential of the two remain similar in most of the cases. Slight variation was obtained in the flavonoids content of hexane extracts of both.





Selection of suitable protocols for the propagation of medicinal plants

(2012-18; State Plan funded)

PI: Dr. Sunita Bhatnagar

Research Fellows: Saroja Baral, Sankar Sahoo

Medicinal plants are collected from the wild and overexploitation of the same renders them scarce. *Celastrus paniculatus* is one such medicinal plant commonly known as jyotishmati. Seeds are used in a number of medicinal oils and medicines, collection of seeds from the wild results in reduction of natural regeneration of the medicinal plant. An effort was made to find the suitable protocol for vegetative propagation for the plant.

Air layering method gave best results with 60% rate in case of propagation of vulnerable medicinal plant *Celastrus paniculatus*. Other methods like stem cutting and root layering were not found suitable.



Conservation & bio-molecular characterization of wild *Saraca asoca* populations in Odisha

(2012-14; State Plan funded)

PI: Dr. Uday Chand Basak

Research Fellows: Manisa Dash and Smruti Mohanty

Saraca asoca (Roxb.) de Wilde. syn. *S. indica* auct. non Linn. is mainly known for its drug , extracted from its stem bark. Saraca asoca has a 'critically endangered' conservation status in the IUCN Red List of Threatened Species (IUCN 2004), and is restricted to Deccan plateau, as well as the middle section of the Western Ghats in the western coastal zone of the Indian Subcontinent and Sri Lanka . It is also found in few evergreen areas of Eastern Ghats particularly in Odisha. Under the project Molecular screening of elite\plus tree of Saraca asoca (Roxb.) de wild from natural population of Similipal Biosphere Reserves and to establish a gene bank for large scale propagation for ex situ conservation plant Samples of Saraca asoca (leaves and bark) were collected from five populations of Orissa-Similipal Biosphere Reserves (SBR) Champagarh Protected Forest, Amana Reserve forest, Kapilash Reserve forest and Puri & Bhubaneswar to screen the elite clones through morphological, molecular and phytochemical markers. We have taken the data of 14 important morphological characteristics and also collected plant samples for DNA/phyto-chemical analysis. 186 samples were screened through morphological and molecular markers. Phytochemical (Phenol,Tannin and Flavonoid) has also been done. Quantification of marker compound (Catechin and Leucocyanidin) from the bark sample through HPLC analysis for selection of elite clone has been completed. Molecular analysis was carried out about 186 plant samples collected from different populations using RAPD primers were collected from various localities of Odisha, India, to determine the extent of genetic diversity at molecular level by Inter-simple sequence repeats marker (ISSR) analysis. Nine efficient primers were screened and amplified 104 polymorphic bands which exhibited 94.51% polymorphism. Plantation of about 300 rooted air layering plantlets according to

Field Gene Bank of *Saraca asoca* established in RPRC

populations (Champagarh, Similipal, Bhubaneswar) and hormonal combinations for the purpose of mass propagation has been established.

Quantitative and qualitative assessment of total flavonoid, a secondary metabolite from the methanolic extracted bark samples of *Saraca asoca* collected from different natural forest reserves of Odisha (Kapilash RF - 16 bark samples, Similipal RF - 25 bark samples, Champagarh RF - 25 bark samples and Tamana RF - 25 bark samples) were completed.

The average flavonoid content (in % dry weight) in bark samples ranged from (min amt -0.98 % in Champagarh to max amt - 1.68 % in Tamana. However, in Kapilash reserve forest, the average flavonoid content (in % dry weight) is found to be 1.50% and in Similipal reserve forest it is found to be 1.55%.

Qualitative estimation (Isolation and Identification of required flavonoid compound (quercetin) was done through TLC. TLC of crude sample i.e methanolic extract of *Saraca asoca* bark samples collected from Kapilash RF (16 bark samples), Similipal RF (25 bark samples), Tamana RF (25 bark samples) and Champagarh RF (15 bark samples was completed.

Mass propagation for ex-situ conservation of *Saraca asoca* through air layering (Second Phase); about 180 healthy plants have been propagated successfully with a survivability of 60 %.

Production of quality planting materials (QPM): standardization of protocol for vegetative propagation of some high valued and threatened Medicinal plants of Odisha

(2012-13; NMPB, GoI funded)

PI: Dr. Uday Chand Basak

Research Fellows: Dipika Dash, Manisha Mohapatra

Piper longum L. is an endangered RET listed herb. Almost all of its parts are well known for medicinal value and usage as spice. But now-a-days this plant is in verge of extinction due to deforestation, over harvesting in wild. So for the conservation of this plant, mass multiplication was achieved through vegetative propagation using different micro cuttings like vine node cuttings and leaf cuttings. Furthermore the biomolecular compounds of these plants were also assessed quantitatively to justify the QPM produced.

This research study included production of QPM of *Piper longum* through vegetative propagation; quantitative estimation of protein content in leaf cuttings of *Piper longum* and vine node cuttings of *Operculina turpethum* to justify the QPM produced.

In order to achieve QPM of *Piper longum,* mass multiplication of *P. longum* was carried out through vegetative propagation procedure using different types of micro cuttings viz. vine node cuttings with single node and two types of leaf cuttings (Apical and Petiolar).

The vine node cuttings showed 80-85% rooting percentage with 90-95% survivability. Around 2000 nos. of *P. longum* plants were propagated. Furthermore leaf cuttings showed a little lower rooting percentage i.e. 70-75% with 75-80% survivability.

- From the results, the protein content from the adventitious roots was found to ranging from 6-15% fresh wt and the highest protein content was found in 20th day of sampling. The highest amount of protein was found in the adventitious roots of apical cuttings using IBA and NAA in small concentration.
- For production of QPM of *Operculina turpethum* through vegetative propagation process, different types of micro-cuttings (nodal cuttings, single node plus two leaves, single node plus small Shoot-bud) were treated with two different types of hormonal combinations along with control.
- From the results, the protein content from the adventitious roots of *Operculina turpethum* was found to be ranged from 0.02-0.4% fresh wt and the highest protein content was exhibited in 20th day of sampling. The highest amount of protein was found in the adventitious roots of nodal vine cuttings with single leaf using IBA and NAA in small concentration.

Vegetative propagated QPM of *Piper longum*

- For vegetative macropropagation for mass multiplication to produce quality planting material (QPM), *P. longum* plants were subjected to various propagation techniques using various auxin treatments. Both the vine nodal cuttings and leaf cuttings were found to be excellent as macro cuttings to produce QPM. Furthermore the biochemical estimation of proteins in both *P. longum and O. turpethum* was found to be remarkable.
- To justify the QPM of the selected RET medicinal plants produced, the biomolecular active principles Piperine & Embelin of the respected plants *Piper longum* & *Embelia tsjeriam-cottam* respectively were evaluated by quantitative and qualitative assessment through Spectrophotometric and HPLC method of analysis. From the above experimentation both piperine and embelin were found in a very remarkable amount in the different plant parts that means in roots and both male and female spikes of *P. longum* and in fruits of *E tsjeriam-cottam* plants.

Production of QPM of *Embelia tsjeriam-cottam* (baibidanga) : Propagation, Conservation and estimation of 'embelin' content

(2014-16; State Plan funded)

PI: Dr. Uday Chand Basak

Research Fellows:Manisha Mohapatra

Embelia tsjeriam-cottam (baibidanga) is an important RET medicinal plant containing 'embelin' as the major phyto-constituents, which is used for several drug formulations and has market demand. It has multidimensional use in both Ayurveda and in modern pharmaceutical industries. The wild resource of this plant gradually become exhausted and found sporadically in western Odisha. To promote conservation, domestication and cultivation of this RET plant, RPRC has initiated it's propagation studies with the consultation of experts from medicinal plants board very recently. Conservation of this medicinal plant species is a complementary

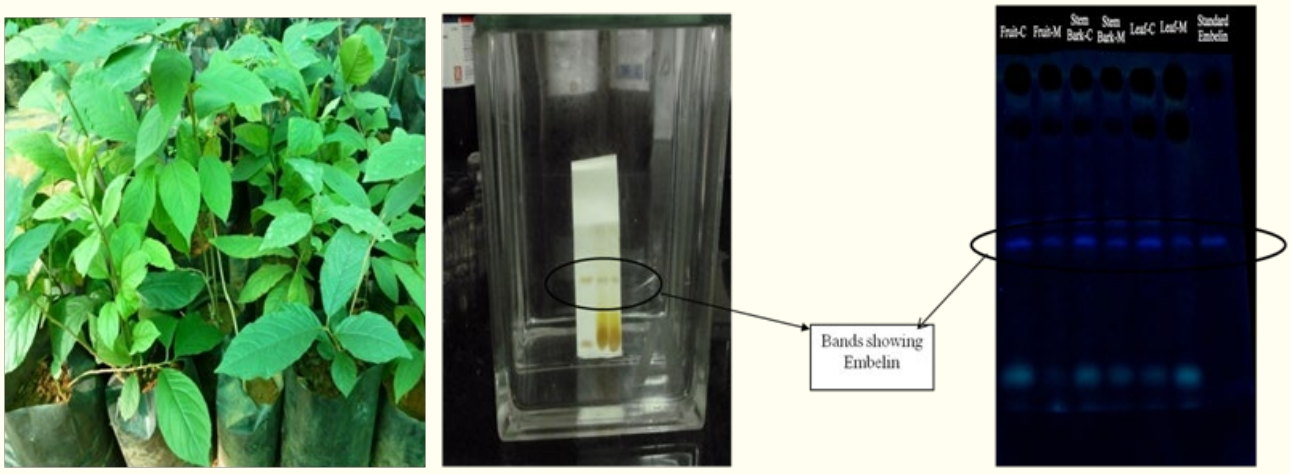
action to conserve the genetic diversity too. Availability of authentic plants and seeds of certified quality is a major constraint in undertaking large-scale propagation and cultivation. For this purpose, protocols should be established to produce ample amount of Quality Planting Materials (QPM) to meet market demand as well as for conservation point of view with the utilization of various macropropagation methods. As initiated recently in RPRC, *E. tsjeriam-cottam* can be mass multiplicated through stem/stump cutting process. The quality of these planting materials can be checked by quantifying the bio-molecules present in it by taking different plant parts. Though reports are available regarding the medicinal properties of *Embelia tsjeriam-cottam* and its Embelin content from the seeds, yet very little and scattered information is gathered regarding the Embelin content of *Embelia tsjeriam-cottam* in other plant parts like stem-bark, leaves etc which can be ascertained even at the seedling stage.

The research work involved mass multiplication of *Embelia tsjeriam-cottam,* through vegetative propagation for production of quality planting materials (QPM) as well as ex-situ conservation; assessment of quantity and quality of embelin present in both wild and cultivated plants.

Propagation & ex-situ conservation of *Embelia tsjeriam-cottam* & analysis of embelin

As regard to mass propagation and QPM production of *E. tsjeriam-cottam,* stump cuttings/wildings can be used for mass multiplication of this vulnerable plant. Around 100 nos of vegetatively propagated QPM raised and maintained in the nursery. Ex-situ conservation has been initiated by planting the propagated QPM in the field of nursery premises.

In connection with evaluation of Embelin content, the present study revealed that embelin was also present in leaf and stem bark parts apart from seeds of *E. tsjeriam-cottam*. This finding is also corroborative with the reports of various workers (Swamy *et al.,* 2007; Raghu *et al.,* 2011). While the seed parts showed highest yield of embelin content (4.88% dry wt.), the stem bark possessed 1.14% dry wt. of embelin followed by leaf (0.96% dry wt.). Hence both the leaf and stem bark parts can also be used as alternative/substitute to the seeds for getting embelin.



Ex-situ conservation & isolation of embelin in *Embelia tsjeriam-cottam*

Evaluation of unexplored *Ardisia solanacea* and *Aegiceras corniculatum* plants of Myrsinaceae family as embelin and other related compounds producing substitutes for overexploited RET medicinal species *Embelia ribes* & *E. tsjeriam-cottam* (2016-2018)

(2016-18; NMPB, GoI funded)

PI: Dr. Uday Chand Basak

Research Fellows:Manisha Mohapatra and
Swadha Baral

Commercially, the bio-active compound Embelin has largely been exploited from *Embelia ribes* and *E. tsjeriam-cottam* of the family Myrsinaceae for use in ayurvedic system of medicines leading to threat towards (nearly) extinction of these RET species!!. In this project proposal, *Ardisia solanacea* and *Aegiceras corniculatum* belonging to the same family are suggested/selected to be possible substitute(s) for the above RET plants. Most of the embelin-based ayurvedic formulations are depended on extracts from fruits, roots and barks leading to destruction of the stock plants. In this study, leaves and fruits are proposed to be used as source of Embelin & other related compounds as non-destructive methods of extraction to validate the proposed substitute species.

This research study aimed to evaluate and ensure *Ardisia solanacea* and *Aegiceras corniculatum* as suitable substitutes for RET listed medicinal plants *Embelia ribes* & *E. tsjeriam-cottam* pertaining to adequate occurrence of major active phytochemical 'embelin'& other related compounds in leaves & fruits.

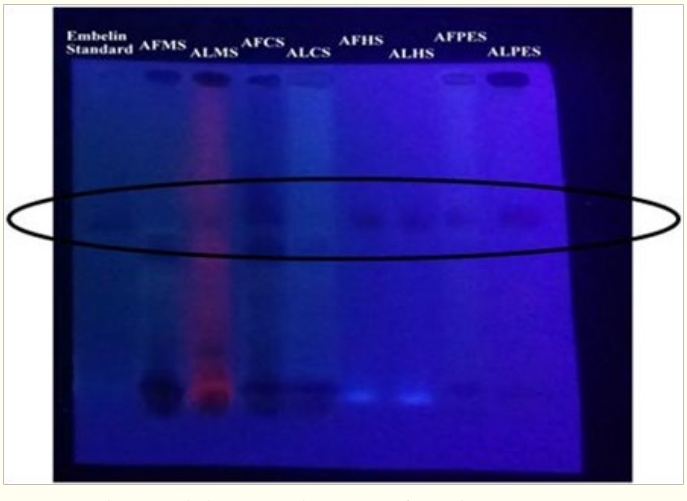
The samples (leaf and fruit) of *A. corniculatum* were collected from Bhitarkanika mangrove forest areas of the Odisha coast, where as the *A. solanacea* samples were collected from fruit garden of Regional Plant Resource centre, Bhubaneswar, Khurda.

Soxhlet extracted samples yielded crude embelin in a range of 0.12-1.82 % w/w for *A. corniculatum* and 0.1-0.32% w/w for *A. solanacea.*

Embelin content in samples of *A. corniculatum,* when estimated through spectrophotometric method of analysis, was found to be 0.37-0.44% dry wt. in case of leaf samples and 1.85-1.95% dry wt. in case of fruit samples.

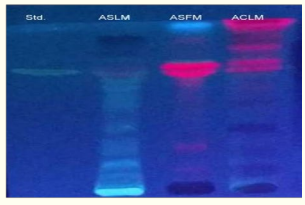
Evaluation other secondary metabolites

For isolation of unknown (other related quinone) compounds, separation of Methanolic extracts of *A. solanacea* was done through column chromatography method with isolation of two fractions. Quantitative assessment of EGC in leaf and fruit extracts of *A. corniculatum* with methanolic solvent systems was done through spectrophotometric analysis. Quantitative assessment of quercetin in leaf and fruit extracts of *A. corniculatum* with methanolic solvent systems was done through spectrophotometric analysis .



TLC Sheet : Embelin in sample extracts of test plant

EGC content in leaf and fruits of *Ardisia solanacea* and *Aegiceras corniculatum*



Isolation of Quercetin in *Ardisia solanacea* and *Aegiceras corniculatum* leaf and fruits

Phytochemical analysis and biological screening of *Homalium nepalense, Homalium tomentosum* and *Homalium zeylanicum* for antioxidant, anti-diabetic, anti-inflammatory and hepatoprotective activities

(2013-17; State Plan, S&T Dept.,GoO, NMPB, GoI funded)

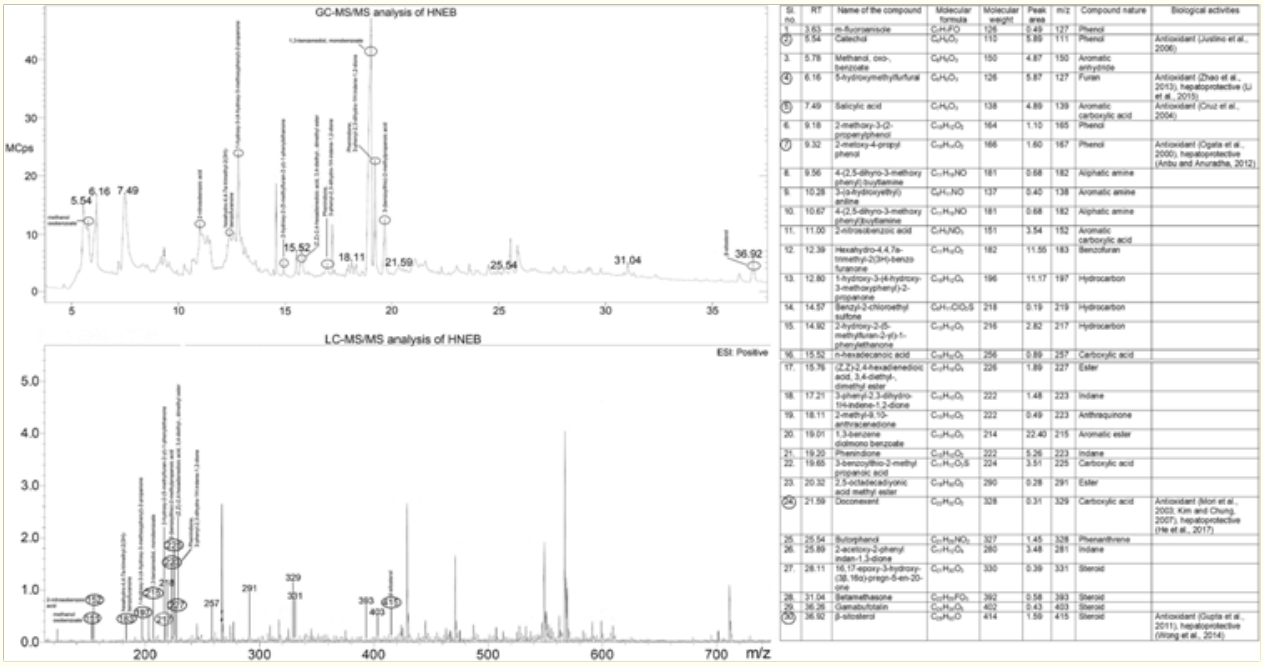
PI: Dr. Atish Kumar Sahoo

Research Fellows: Priyanka Dash,Nikhilesh Paliwal,Swata Smita Pani, Deeptimayee Rout and Satish Kanhar

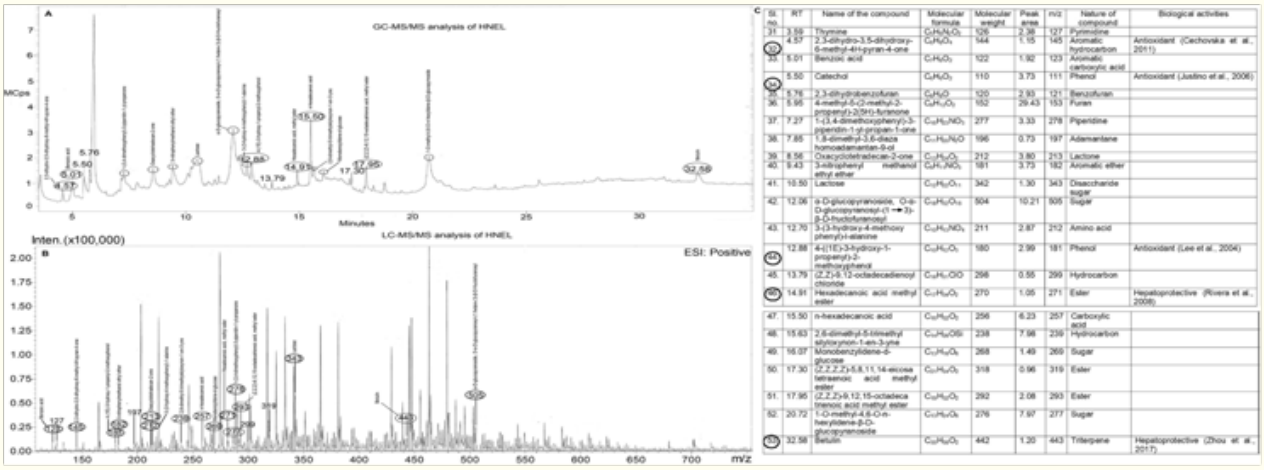
Liver disease is still a worldwide health problem. Unfortunately, conventional or synthetic drugs used in the treatment of liver diseases are inadequate and sometimes can have serious side effects. In view of severe undesirable side effects of synthetic agents, there is growing focus to follow systematic research methodology and to evaluate scientific basis for the traditional herbal medicines that are claimed to possess hepatoprotective activity. Likewise, diabetes mellitus is an endocrine disorder that is characterised by hyperglycaemia. The pharmaceutical drugs are either too expensive or have undesirable side effects. However, for a number of reasons, complementary medicine has grown in popularity in recent years. These projects have undertaken plants under genus *Homalium* family: Flacourtiaceae which are endangered and red listed plants (IUCN report) and are available in North-eastern states, West Bengal, Odisha, Bihar, Eastern Ghats of Andhra Pradesh, and Western Ghats of India. *Homalium tomentosum* Benth., a deciduous medium-sized tree up to 30-40 m tall, Found in north-eastern India, Bengal. *Homalium nepalense* (Wall.) Benth. commonly known as Cheduchettu. A deciduous medium-sized tree up to 30 m tall and, it usually occurs where the dry monsoon is well pronounced from north-eastern. And *Homalium zeylanicum* (Gardner) Benth., belongs to family Flacourtiaceae, commonly known as 'Kalladamba'. It is distributed in Western Ghats, Andhra Pradesh, Tamil Nadu, Kerala of India. The endangered plant species under the genus *Homalium* used ethnobotanically for many ailments as the bark and leaves of this plant is having many traditional uses in diabetes, rheumatism, and wound healing activities. But there is no scientific validation for its different therapeutic properties. Hence these projects have been undertaken to establish validate scientifically for different diseases like hepatoprotective, diabetes and inflammation.

The project has been undertaken to explore the Indian *Homalium* species i.e. *H. tomentosum*, *H. nepalense and H. zeylanicum* for its antioxidant and hepatoprotective activity, while *H. zeylanicum* was taken for further studies for antidiabetic which supports the ethnobotanical claim for hepatoprotective and antidiabetic activities. Total phenolic and flavonoid contents of the leaves and bark part of three Indian *Homalium* species were estimated. In order to realise medicinal values from potential plant sources, it is important to measure the antioxidant activity using various radicals and oxidation systems. From the above-mentioned experimental design, it is established that leaves and bark of *H. nepalense* possess better antioxidant quality than other two *Homalium* species that need further study and clinical tests. Bark of the plant was proved to be more potent than the leaves.

The purpose of this study was to evaluate ameliorative effects of *Homalium* species on CCl_4-induced hepatocellular injury in rats. Oxygen-radical absorbance-capacity (ORAC) and cell-based-antioxidant-protection-in-erythrocytes (CAP-e) were performed and found that the ethyl acetate fractions of bark (HNEB) and leaf (HNEL) showed a remarkable degree of antioxidant activities in a dose dependent manner. Antioxidant potential HNEB was higher than HNEL and was comparable with trolox. HNEB and HNEL at 300 and 400 mg/kg showed significant hepatoprotective activities against CCl4-induced hepatotoxicity as evidenced by restoration of SGOT, SGPT, ALP, TB and TP level. The level of TBARS, SOD, CAT and GSH were significantly improved and restored towards normal value. Both fractions at 400 mg/kg showed remarkable improvements in marker levels as comparable to silymarin. Histopathological observations of liver tissues revealed the reduction of necrosis with appearance of sinusoidal space, central vein, and bile duct both in case of HNEB and HNEL. GC-MS and LC-MS confirmed occurrence of a total 53 no. of phytocompounds in HNEB and HNEL. Based on their



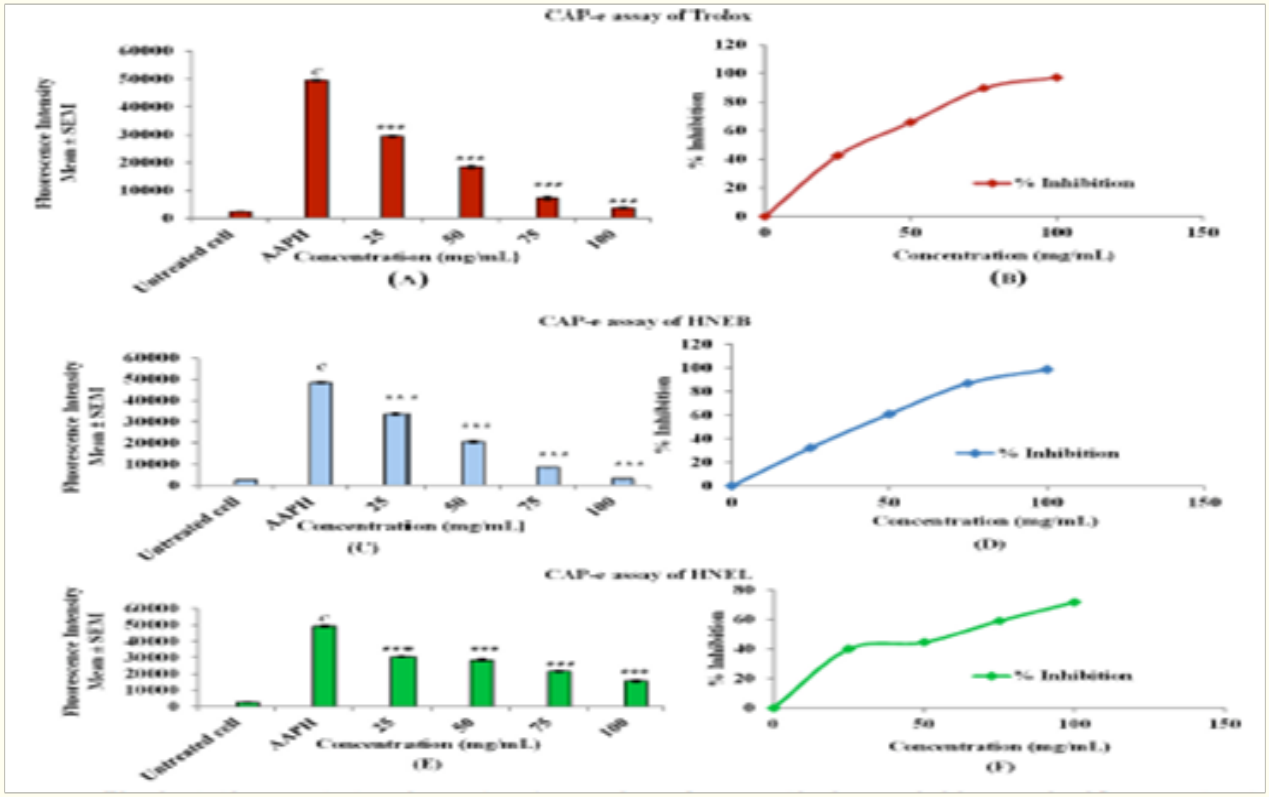
Sl. no.	RT	Name of the compound	Molecular formula	Molecular weight	Peak area	m/z	Compound nature	Biological activities
1.	3.63	m-fluoroanisole	C_7H_7FO	126	0.49	127	Phenol	
(7)	5.54	Catechol	$C_6H_6O_2$	110	5.89	111	Phenol	Antioxidant (Justino et al., 2006)
3.	5.78	Methanol, oxo-, benzoate	$C_8H_8O_3$	150	4.87	150	Aromatic anhydride	
(4)	6.16	5-hydroxymethylfurfural	$C_6H_6O_3$	126	5.87	127	Furan	Antioxidant (Zhao et al., 2013); hepatoprotective (Li et al., 2015)
(5)	7.49	Salicylic acid	$C_7H_6O_3$	138	4.89	139	Aromatic carboxylic acid	Antioxidant (Cruz et al., 2004)
6.	9.18	2-methoxy-3-(2-propenyl)phenol	$C_{10}H_{12}O_2$	164	1.10	165	Phenol	
(7)	9.32	2-metoxy-4-propyl phenol	$C_{10}H_{14}O_2$	166	1.60	167	Phenol	Antioxidant (Ogata et al., 2000); hepatoprotective (Anbu and Anuradha, 2012)
8.	9.56	4-(2,5-dihyro-3-methoxy phenyl)-buyltamine	$C_{11}H_{15}NO$	181	0.68	182	Aliphatic amine	
9.	10.28	3-(a-hydroxyethyl) aniline	$C_8H_{11}NO$	137	0.40	138	Aromatic amine	
10.	10.67	4-(2,5-dihyro-3-methoxy phenyl)buyltamine	$C_{11}H_{15}NO$	181	0.68	182	Aliphatic amine	
11.	11.00	2-nitrosobenzoic acid	$C_7H_5NO_3$	151	3.54	152	Aromatic carboxylic acid	
12.	12.39	Hexahydro-4,4,7a-trimethyl-2(3H)-benzofuranone	$C_{11}H_{18}O_2$	182	11.55	183	Benzofuran	
13.	12.80	1-hydroxy-3-(4-hydroxy-3-methoxyphenyl)-2-propanone	$C_{10}H_{12}O_4$	196	11.17	197	Hydrocarbon	
14.	14.57	Benzyl-2-chloroethyl sulfone	$C_9H_{11}ClO_2S$	218	0.19	219	Hydrocarbon	
15.	14.92	2-hydroxy-2-(5-methylfuran-2-yl)-1-phenylethanone	$C_{13}H_{12}O_3$	216	2.82	217	Hydrocarbon	
16.	15.52	n-hexadecanoic acid	$C_{16}H_{32}O_2$	256	0.89	257	Carboxylic acid	
17.	15.76	(2,Z)+2,4-hexadienedioic acid, 3,4-diethyl-, dimethyl ester	$C_{12}H_{18}O_4$	226	1.89	227	Ester	
18.	17.21	3-phenyl-2,3-dihydro-1H-indene-1,2-dione	$C_{15}H_{10}O_2$	222	1.48	223	Indane	
19.	18.11	2-methyl-9,10-anthracenedione	$C_{15}H_{10}O_2$	222	0.49	223	Anthraquinone	
20.	19.01	1,3-benzene didimono benzoate	$C_{13}H_{14}O_3$	214	22.40	215	Aromatic ester	
21.	19.20	Phenindione	$C_{15}H_{10}O_2$	222	5.26	223	Indane	
22.	19.65	3-benzoylthio-2-methyl propanoic acid	$C_{11}H_{12}O_3S$	224	3.51	225	Carboxylic acid	
23.	20.32	2,5-octadecadyonic acid methyl ester	$C_{19}H_{34}O_2$	290	0.28	291	Ester	
(24)	21.59	Doconexent	$C_{22}H_{32}O_2$	328	0.31	329	Carboxylic acid	Antioxidant (Mori et al., 2003; Kim and Chung, 2007); hepatoprotective (He et al., 2017)
25.	25.54	Butorphanol	$C_{21}H_{29}NO_2$	327	1.45	328	Phenanthrene	
26.	25.89	2-acetoxy-2-phenyl indan-1,3-dione	$C_{17}H_{12}O_4$	280	3.48	281	Indane	
27.	28.11	16,17-epoxy-3-hydroxy-(3β,16α)-pregn-5-en-20-one	$C_{21}H_{30}O_3$	330	0.39	331	Steroid	
28.	31.04	Betamethasone	$C_{22}H_{29}FO_5$	392	0.58	393	Steroid	
29.	36.26	Gamabufotalin	$C_{24}H_{34}O_5$	402	0.43	403	Steroid	
(30)	36.92	β-sitosterol	$C_{29}H_{50}O$	414	1.59	415	Steroid	Antioxidant (Gupta et al., 2011); hepatoprotective (Wong et al., 2014)

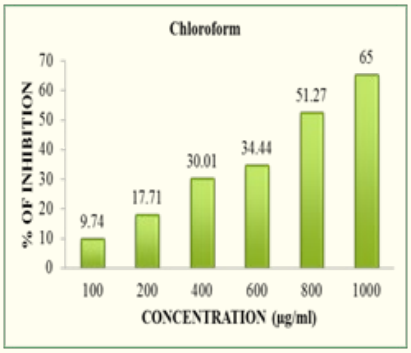


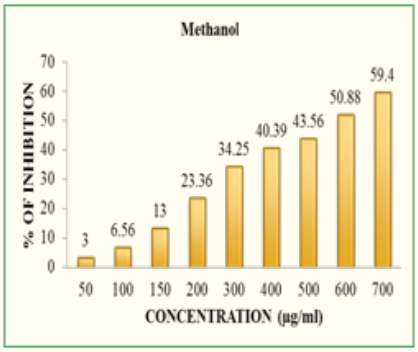
Sl. no.	RT	Name of the compound	Molecular formula	Molecular weight	Peak area	m/z	Nature of compound	Biological activities
31.	3.99	Thymine	$C_5H_6N_2O_2$	126	2.38	127	Pyrimidine	
(32)	4.57	2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one	$C_6H_8O_4$	144	1.15	145	Aromatic hydrocarbon	Antioxidant (Cechovska et al., 2011)
33.	5.01	Benzoic acid	$C_7H_6O_2$	122	1.92	123	Aromatic carboxylic acid	
(34)	5.50	Catechol	$C_6H_6O_2$	110	3.73	111	Phenol	Antioxidant (Justino et al., 2006)
35.	5.76	2,3-dihydrobenzofuran	C_8H_8O	120	2.93	121	Benzofuran	
36.	5.95	4-methyl-5-(2-methyl-2-propenyl)-2(5H)-furanone	$C_9H_{12}O_2$	152	29.43	153	Furan	
37.	7.27	1-(3,4-dimethoxyphenyl)-3-piperidin-1-yl-propan-1-one	$C_{16}H_{23}NO_3$	277	3.33	278	Piperidine	
38.	7.85	1,8-dimethyl-3,6-diaza homoadamantan-9-ol	$C_{11}H_{20}N_2O$	196	0.73	197	Adamantane	
39.	8.56	Oxacyclotetradecan-2-one	$C_{13}H_{24}O_2$	212	3.80	213	Lactone	
40.	9.43	4-allylphenyl methanol ethyl ether	$C_{11}H_{13}NO_3$	191	3.73	182	Aromatic ether	
41.	10.50	Lactose	$C_{12}H_{22}O_{11}$	342	1.30	343	Disaccharide sugar	
42.	12.06	α-D-glucopyranoside, O-α-D-glucopyranosyl-(1→6)-β-D-fructofuranosyl	$C_{18}H_{32}O_{16}$	504	10.21	505	Sugar	
43.	12.70	3-(3-hydroxy-4-methoxy phenyl)-l-alanine	$C_{10}H_{13}NO_4$	211	2.87	212	Amino acid	
(44)	12.88	4-[(1E)-3-hydroxy-1-propenyl]-2-methoxyphenol	$C_{10}H_{12}O_3$	180	2.99	181	Phenol	Antioxidant (Lee et al., 2004)
45.	13.79	(Z,Z)-9,12-octadecadienoyl chloride	$C_{18}H_{31}OCl$	298	0.55	299	Hydrocarbon	
(46)	14.91	Hexadecanoic acid methyl ester	$C_{17}H_{34}O_2$	270	1.05	271	Ester	Hepatoprotective (Rivera et al., 2008)
47.	15.50	n-hexadecanoic acid	$C_{16}H_{32}O_2$	256	6.23	257	Carboxylic acid	
48.	15.63	2,6-dimethyl-5-trimethyl silyloxynon-1-en-3-yne	$C_{14}H_{30}OSi$	238	7.98	239	Hydrocarbon	
49.	16.07	Monobenzylidene-d-glucose	$C_{13}H_{16}O_6$	268	1.49	269	Sugar	
50.	17.30	(Z,Z,Z,Z)-5,8,11,14-eicosa tetraenoic acid methyl ester	$C_{21}H_{34}O_2$	318	0.96	319	Ester	
51.	17.95	(Z,Z,Z)-9,12,15-octadeca trienoic acid methyl ester	$C_{19}H_{32}O_2$	292	2.08	293	Ester	
52.	20.72	1-O-methyl-4,6-O-α-hexylidene-β-D-glucopyranoside	$C_{13}H_{24}O_6$	276	7.97	277	Sugar	
(53)	32.58	Betulin	$C_{30}H_{50}O_2$	442	1.20	443	Triterpene	Hepatoprotective (Zhou et al., 2017)

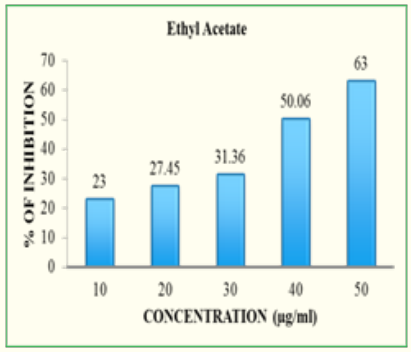
retention times-(RT) and mass-to-charge-ratios-(m/z), some of the major bioactive compounds were catechol (5.89%), 5-hydroxymethylfurfural (5.87%), salicylic acid (4.89%), eugenol (1.60%), doconexent (0.31%), β-sitosterol (1.59%), 2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one (1.15%), coniferyl alcohol (2.99%), hexadecanoic acid methyl ester (1.05%), and betulin (1.20%). H. nepalense possesses significant hepatoprotection effect because of its antioxidant constituents.

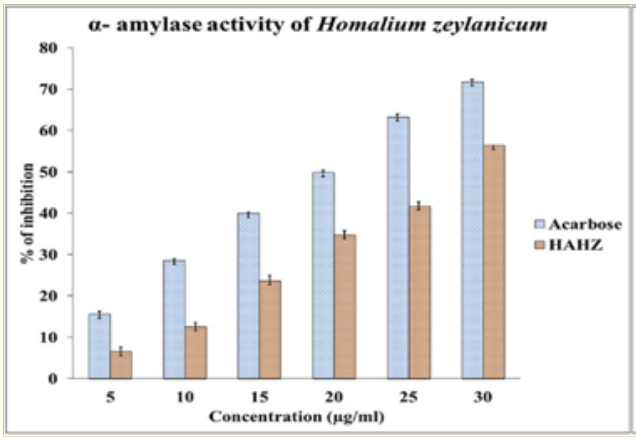
For the diabetic study the *H. zeylanicum* was subjected for *in-vitro* anti-diabetic studies and was found IC_{50} value of ethyl acetate extract (bark) was 25 µg/ml, which is found to be most active one than other extracts; as compared with the standard drug i.e. Acarbose Protein agglutination of anti-inflammatory study was performed and bark of *H. zeylanicum* was found to more potent anti-inflammatory activity and as compared with the standard drug like Diclofenac All the results indicated its sound pharmacological potential. Hence, it is concluded that the plant parts might be effective and can be optional herbal drugs to cure diabetic. Further to prove the anti-diabetic activity of *H. zeylanicum*, the isolation of bioactive molecules may be undertaken in order to find out the exact mechanism of action. It also describes isolation and structure determination of lucidenic acid A, which is the first report in this plant. The chemical structure of the triterpenoid was elucidated using ^{1}H, ^{13}C NMR and high resolution-MS. IC_{50} of DPPH,

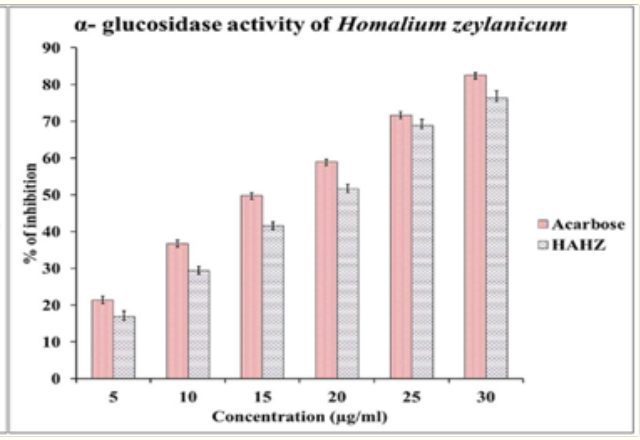

CAP-e assay of Trolox
Fluorescence Intensity Mean ± SEM
% Inhibition
Untreated cell
AAPH
25
50
75
100
Concentration (mg/mL)
% Inhibition
(A)
(B)
CAP-e assay of HNEB
(C)
(D)
CAP-e assay of HNEL
(E)
(F)


Chloroform
% OF INHIBITION
9.74
17.71
30.01
34.44
51.27
65
100
200
400
600
800
1000
CONCENTRATION (µg/ml)

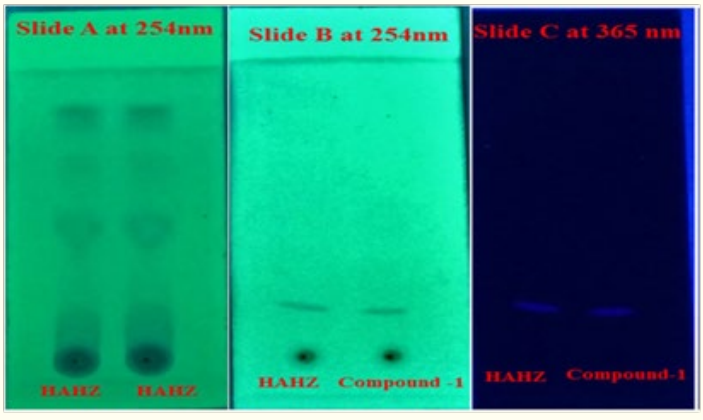

Methanol
% OF INHIBITION
3
6.56
13
23.36
34.25
40.39
43.56
50.88
59.4
50
100
150
200
300
400
500
600
700
CONCENTRATION (µg/ml)

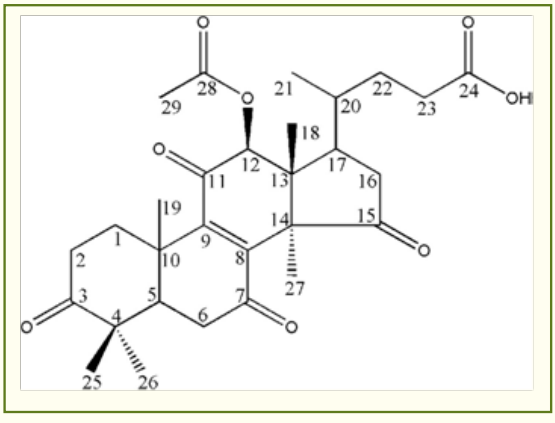

Ethyl Acetate
% OF INHIBITION
23
27.45
31.36
50.06
63
10
20
30
40
50
CONCENTRATION (µg/ml)


α- amylase activity of Homalium zeylanicum
% of inhibition
Acarbose
HAHZ
5
10
15
20
25
30
Concentration (µg/ml)


α- glucosidase activity of Homalium zeylanicum
% of inhibition
Acarbose
HAHZ
5
10
15
20
25
30
Concentration (µg/ml)

nitric oxide, hydroxyl, superoxide and metal chelating activities were of 36.23 ± 0.27, 40.11 ± 0.32, 35.23 ± 0.57, 43.34 ± 0.22 and 11.54 ± 0.08 µg/mL, respectively. IC_{50} of α-amylase and α-glucosidase activities were 29.12 ± 0.54, and 18.55 ± 0.15 µg/mL. Total phenolic and total flavonoid contents were recorded at 233.65 mg/g GAE and 172.7 mg/g QE. Regarding kinetic behaviour, HAHZ showed competitive inhibition on α-glucosidase and mixed competitive inhibition on α-amylase. Lucidenic acid A was confirmed by spectroscopic studies. Anti-inflammatory activity of lucidenic acid A was determined by using protein denaturation assay with IC_{50} 13 µg/mL but HAHZ showed 30.34 ± 0.13 µg/mL. Phenols and flavonoids could be attributed to inhibition of intestinal carbohydrases for anti-diabetic activities whereas triterpenoids could be responsible for anti-inflammatory activity of *H. zeylanicum*.





Phytochemical screening and toxicity profiling of *Geophila repens* as a potential source for drug against Alzheimer disease

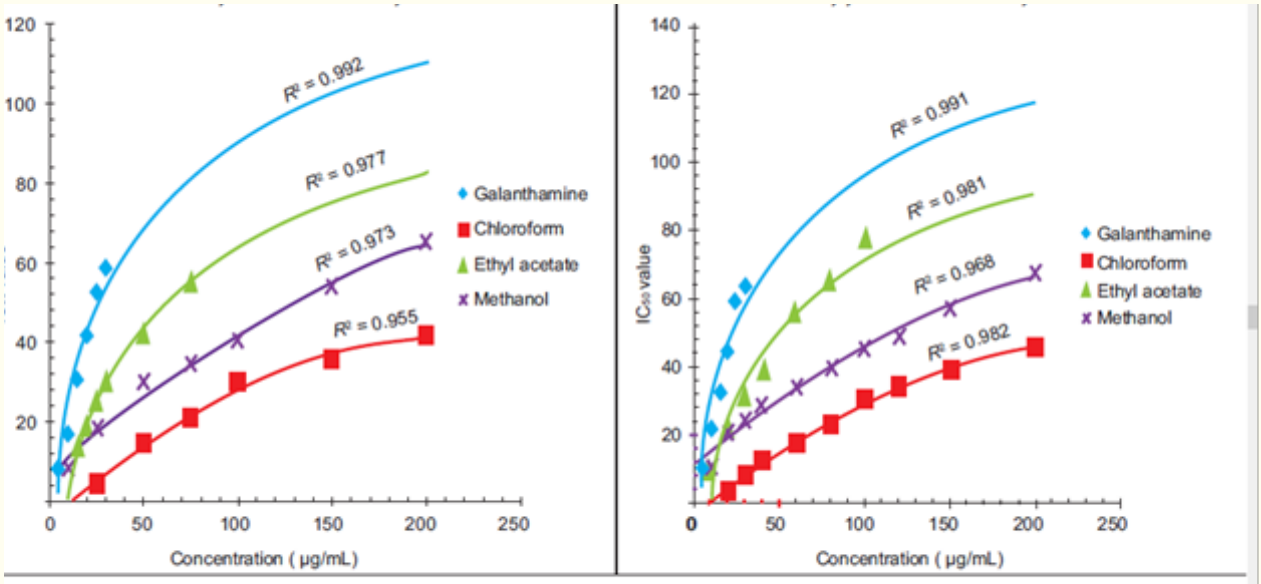
(2012-14; State Plan funded)

PI: Dr. Atish Kumar Sahoo

Research Fellows: Monika Kumari and Umesh Chandra Dash

Geophila repens D. Don. (Rubiaceae), a small creeping perennial prostrate pubescent herb with long stems and rooting at nodes, found in India, China, tropical Africa. It is commonly known as "Snake Pennywort" and in Sanskrit it is known as "Krishnamanduki" in India. *G. repens* locally called as Karimuthil, is identified as an endangered species according to IUCN, claimed to have memory enhancing properties by the tribals used the leaf juice for enhancing memory (Divakar et al., 2010). So further investigation on this plant for the presence of phytochemicals in order to find out the mechanism of *G. repens* as a radical scavenger and memory enhancer properties were carried out.

Antioxidant activity of *G. repens* extracts was assessed by performing 1,1-diphenyl-2-picrylhydrazyl (DPPH), nitric oxide (NO), superoxide (SOD), hydroxyl (OH) and total antioxidant capacity (TAC) assays. Anticholinesterase activity was investigated by quantifying the AChE and BChE inhibitory activities of chloroform (CGR), ethyl acetate (EGR) and methanol (MGR) extract fractions from *G. repens* leaves. A rapid high-performance thin-layer chromatography (HPTLC) bioautographic method for the detection of AChE and BChE inhibition was performed. Among all extract fractions, EGR exhibited the highest half maximal inhibitory concentration (IC_{50}) in DPPH, SOD, NO, OH and TAC assays, with IC50 of (38.33 ± 3.21), (45.14 ± 1.78), (59.81 ± 1.32), (39.45 ± 0.79) and (43.76 ± 0.81) µg/mL respectively. EGR displayed competitive, reversible inhibition of AChE and BChE activities with IC_{50} of (68.63 ± 0.45) and (59.45 ± 0.45) µg/mL, respectively. Total phenolic and flavonoids contents of EGR were found to be 360.42 mg gallic acid equivalents and 257.31 mg quercetin equivalents per gram of extract. Phytoconstituents of the EGR extract that were inhibitors of cholinesterase produced white spots on the yellow background of HPTLC plates in the bioautographic test. A rapid HPTLC bioautographic assay was introduced for the screening of *G. repens*,



Anticholinesterase activities of different fractions of *Geophila repens*

esterase and butyrylcholinesterase inhibition assays were performed for chloroform, ethyl acetate and methanol fraction of *ens*. Reference drug galanthamine was considered for both the assays. IC_{50}: half maximal inhibitory concentration.

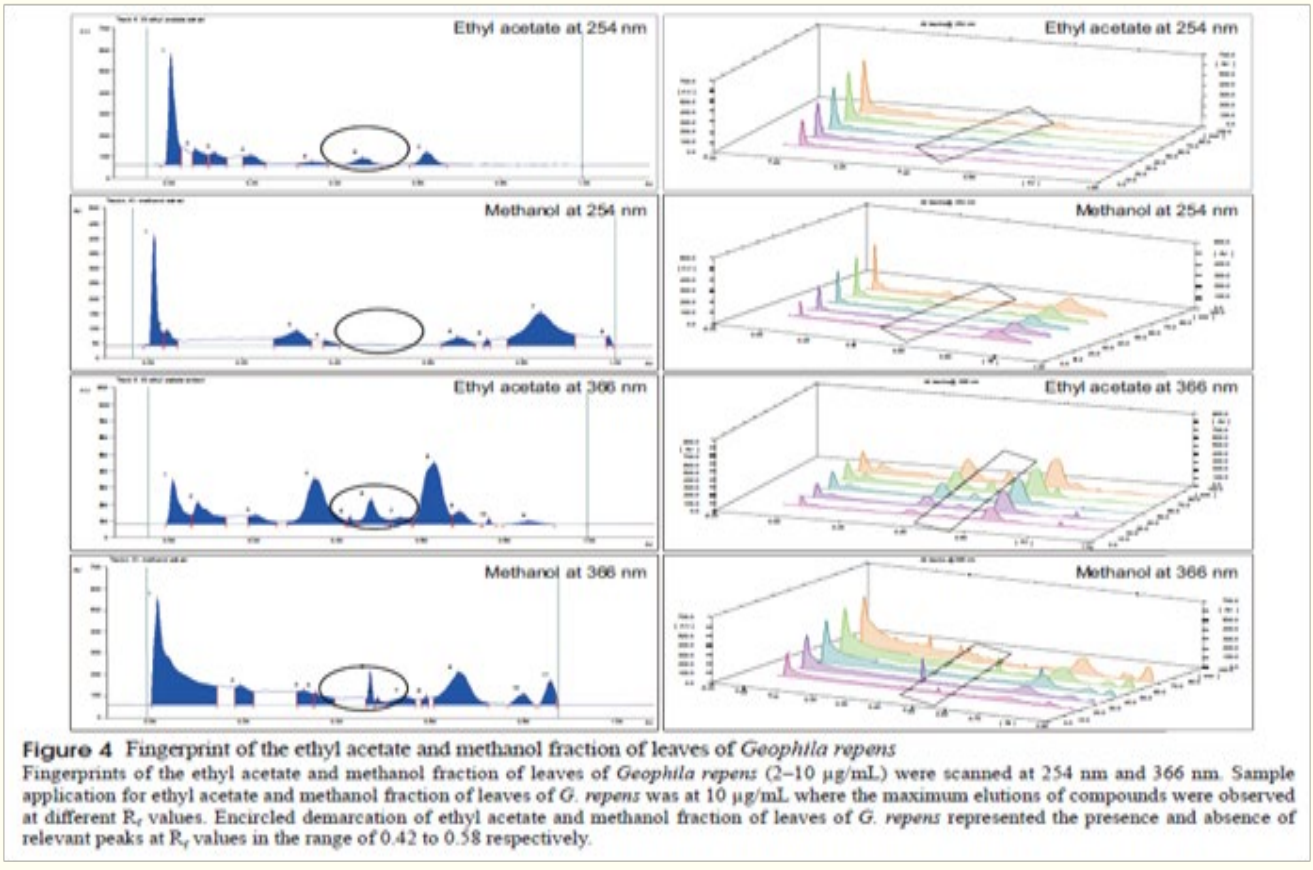


Figure 4 Fingerprint of the ethyl acetate and methanol fraction of leaves of *Geophila repens*

Fingerprints of the ethyl acetate and methanol fraction of leaves of *Geophila repens* (2–10 µg/mL) were scanned at 254 nm and 366 nm. Sample application for ethyl acetate and methanol fraction of leaves of *G. repens* was at 10 µg/mL where the maximum elutions of compounds were observed at different R_f values. Encircled demarcation of ethyl acetate and methanol fraction of leaves of *G. repens* represented the presence and absence of relevant peaks at R_f values in the range of 0.42 to 0.58 respectively.

which gave quick access to information concerning both the activity and the localisation of bioactive molecules (Rf: 0.42-0.58) in complex plant matrices before isolation. The results of this study revealed that phenols and flavonoids could be responsible for the antioxidant, anticholinesterase activities of *G. repens*.

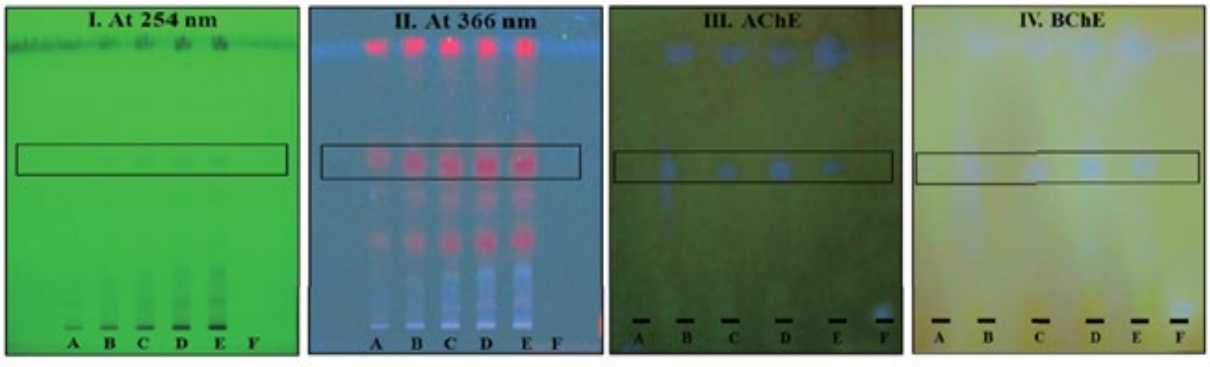


Figure 5 Fingerprint of the ethyl acetate fraction of leaves of *Geophila repens*
Fingerprints of the ethyl acetate fraction of leaves of *Geophila repens* (2–10 µg/mL; A, B, C, D and E respectively) and the reference drug galanthamine 10 µg/mL (F) were scanned at 254 nm and 366 nm. Plates I and II were scanned at 254 nm and 366 nm. High-performance thin-layer chromatography bioautography of Plates III and IV showed the acetylcholinesterase (AChE) and butyrylcholinestarase (BChE) inhibitions respectively as both plates developed a yellow background that appeared with white spots in the R_f range of 0.42 to 0.58 becoming visible after 10–15 min. The assay was carried out using silica gel 60 F_{254} plates which was eluted with chloroform:ethyl acetate:methanol (6.0:0.7:0.8). Detail assay protocol may be followed in the experimental section.

Phytochemical investigation and biological evaluation of *Hydrolea zeylanica* : Anti-diabetic, and anti-inflammatory studies

(2015-17; State Plan funded)

PI: Dr. Atish Kumar Sahoo
Research Fellows: Manisha Kabi, Suman Kumar Mekap and Sandeep Kumar Swain

Hydrolea zeylanica is used as leafy vegetables as the leaves and young shoots are roasted and taken as food and also used in medicine (Cook, 1996; Archana &Ashwani, 2014; Sibangini & Malaya, 2013). In ethnobotanical survey of some wet land plants of South Odisha, *H. zeylanica* which is commonly known as "Balubalia-kasindri" in locals and used to make a paste of whole plant with coconut oil, is applied in minor cuts, wounds and boils as antiseptic for quick healing (Anima & Malaya, 2011). In the Hazaribag District of Jharkhand, India, peoples are used as antiseptic and the decoction of the leaves is useful in healing ulcer when young shoots are eaten as vegetables (Cook, 1996; LalHari and Mishra, 2012). Besides that, *H. zeylanica* is used as medicines for different ailments like diabetes, wound healing and healing ulcer (Niroula and Singh, 2010; Santosh and Satya, 2010; LalHari and Mishra, 2012; Banik et al., 2010; Jaya P., 2013). Till date, there is no scientific evidence on this medicinal plant which is used as a vegetable in Odisha and other parts of India. It needs a though scientific investigation on this plant in order to explore the medicinal properties of this plant.

The above investigation revealed that the ethyl acetate leaf extracts of *H. zeylanica* showed significant antioxidant activity in various *in vitro* methods and IC_{50} values of ethyl acetate extract was 186.63, 204.10 and 143 µg/ml and the IC_{50} value for the standard drug i.e ascorbic acid was recorded as 23.5µg/ml, 17.33 µg/ml and 45 µg/ml for DPPH assay, hydroxyl radical assay and superoxide anion radical inhibition assay respectively, while the hydroalcohol extract inhibits more glycosylation of hemoglobin with the formation of advance glycated end-product (AGEs) with IC_{50} 510.67±1.99 µg/ml than the other extracts of *H. zeylanica*. In antiulcer activity in both Diclofenac sodium induced and Pyloric ligated ulcer model, the results of the *H. zeylanica* ethyl acetate extract treated groups showed potent gastric protection effect when compared with the standard drug Ranitidine treated animal group. The percentage of ulcer inhibition was found to be 33.82 and 60.07 % for *H. zeylanica* 300 and 400 mg/kg treated rats in diclofenac sodium induced model and 27.62 and 50.12 % for *H. zeylanica* 300 and 400 mg/kg treated rats in pyloric ligated ulcer model. The ulcer index measured in different groups showed strong evidence for the antiulcer activity of the leaf extract of *H. zeylanica*.

Anticholinesterase activities of some traditional Indian Spices

(2016-17; State Plan funded)

PI: Dr. Atish Kumar Sahoo

Research Fellow: Umesh Chandra Dash

Esterase family of Hydrolases such as acetylcholinesterase (AChE), butyrylcholinesterase (BChE) and Carboxyl esterase (CE) have been estimated in Alzheimer's disease (AD) model. In AD a loss of acetylcholine activity directly correlates with memory dysfunction due to the activation of acetylcholinesterase and butyrylcholinesterase enzymes. Therefore, the effective treatment methods include restoration of cholinergic function and elevation of ACh level through inhibiting AChE and BChE. To inhibit these enzymes some of the commonly used Indian kitchen spices will be undertaken in this proposal. The reasons of the selected Indian species are because of their memory enhancer properties. Peoples of Indian subcontinents are more often used as a memory enhancer besides other medicinal values. The selected Indian spices with their memory enhancer properties are cited here and thus the project may further strengthen their valuable properties as a memory enhancer property. Such Spices are as

Cuminum cyminum (Fennel Seeds/ Jeera) (Suresh &Suman, 2014),

Cinnamomum zeylanicum or*Cinnamomum verum* (Darchini) (Meena et al., 2012),

Trigonella foenum-graecum (Fenugreek Seeds or Methi) (Wesam et al., 2015),

Syzygium aromaticum (Cloves) (Debjit et al., 2012),

Curcuma longa (Turmeric Powder/Haldi) (Jagdeep et al., 2009),

Glycyrrhiza glabra (Liquorice) (Muhammad et al., 2014),

Zingiber officinale (Ginger/Adrak) (Shaikh et al., 2013)

The present study investigated and determined the potential *in vitro* anticholinesterase (AChEI and BChEI) inhibitory activity of commonly used 7 Indian spices {*S. aromaticum* (AChEI- 56.54 ± 1.65 and BChEI- 115.54 ± 1.55), *C. zeylanicum* (AChEI- 65.76 ± 1.43 and BChEI- 71.76 ± 1.23), *C. cyminum* (AChEI- 59.54 ± 1.32 and BChEI- 94.54 ± 1.92), *T. foenum* (AChEI- 85.45 ± 1.60 and BChEI- 99.45 ± 1.30), *G. glabra* (AChEI- 85.65 ± 1.29 and BChEI - 96.65 ± 1.69), *Z. officinale* (AChEI- 52.54 ± 1.69 and BChEI - 90.54 ± 1.29) and *C. longa* (AChEI- 66.54 ± 1.61 and BChEI- 89.54 ± 1.41)} and all of these spice extracts have higher concentration of flavonoid, phenolic and alkaloid content. *In vitro* cholinesterase inhibition assay of all above spices have the potential memory enhancing property by modulating the flow of choline for signal transmission in the nervous system. Hence, it is concluded that all spices might be effective and can be optional herbal drugs to cure neurological related diseases.

Evaluation of Bioactive Polysaccharides for antitumor and immuno-modulatory activity from wild edible Mushrooms found in Odisha

(2015-16; DBT, GoI funded)

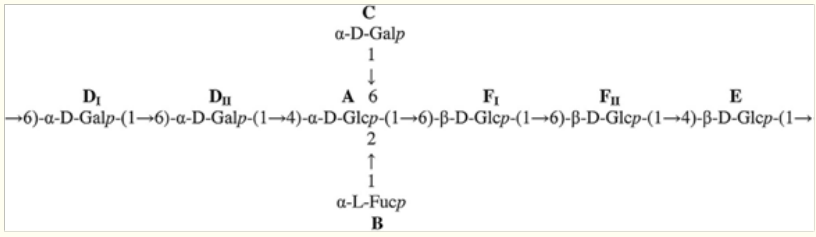
PI: Dr. Atish Kumar Sahoo

Research Fellow: Prabhat Kumar Nayak

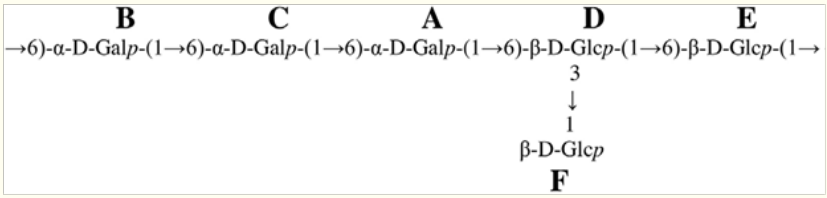
The current project is to address certain key issues linked to prospecting natural resources for human welfare while generating many primary data relating to fungal biochemistry and pharmacoepia. The bio-prospecting of fungal resources for isolation of novel bioactive compounds and standardization and validation of the potential molecules with the mushroom extract. The project will give a lead about the presence of chemical constituents and its mechanism behind the antioxidant activities. The project would provide the scientific approach of edible mushroom for its therapeutic values in terms of antitumour as well as immunomodulatory activities. The project will emphasize on bioactive isolation of polysaccharides and proteoglucan for its therapeutic uses such as antitumour and immunomodulatory activities.

A water-soluble heteroglycan (PS-II) with average molecular weight 7.27×10^4 Da, was isolated from

the fruiting bodies of an edible truffle mushroom *Tuber rufum* (Pico) var. by hot water extraction. The structural investigation of PS-II has been carried out using acid hydrolysis, methylation analysis, periodate oxidation, and 1D/2D NMR experiments. It was composed of D-glucose, D-galactose, L-fucose in a molar ratio of nearly 4:3:1 respectively. On the basis of these experiments, the repeating unit of the PS-II was found to contain a backbone of two (1→6)-ά-D-galactopyranosyl, one (1→4)-ά-D-glucopyranosyl, two (1→6)-β-D-glucopyranosyl, and one (1→4)- β-D-glucopyranosyl residues, out of which (1→4)- ά-D-glucopyranosyl residue was branched at O-2 position with terminal ά-L-fucopyranosyl residue and at O-6 position with terminal ά-D-galactopyranosyl residue. Ameliorative activities of the PS-II were observed at different concentrations (25, 50, 100, 200, 400 µg/ml) and it maintained the redox balance as well as reduced the lipid peroxidation to protect the cell damage.



water soluble heteroglycan (PS-II) with an average molecular weight ~60 kDa was isolated from the hot aqueous extract of an edible mushroom *Lentinus fusipes*. The structural characterization of PS-II was carried out using total acid hydrolysis, methylation analyses, periodate oxidation, Smith degradation and1D/2D NMR experiments. Total acid hydrolysis indicated the presence of D-galactose and D-glucose in a molar ratio of approximately 1:1. The chemical and NMR analyses revealed that the proposed repeating unit of the PS-II had a backbone chain consisting of three (1→6)-linked ά-D-galactopyranosyl residue and two (1→6)-linked β-D-glucopyranosyl residues, one of the β-D-glucopyranosyl residue was branched at O-3 position with a terminal β-D-glucopyranosyl. The PS-II exhibited significant in vitro splenocyte and macrophage activations with optimum dose of 20 µg/ml and 80 µg/ml respectively. Flow cytometry study revealed the protective role of the PS-II against nicotine stimulated lymphocytes. Moreover, the ROS scavenging property of PS-II was also established using DPPH radical scavenging assay.



Antinutrients, antioxidant, essential aminoacids and pectin in wild edible fruits of Odisha

(2012-18; S&T Dept., GoO, State Plan funded)

PI: Dr. Uday Chand Basak

Research Fellows: Satarupa Mishra, Madhulita Patanaik, Jyotimayee Nayak, Pragyan Aparichita Patra, Pramodini Rout, Swadha Baral, Mansiha Mohapatra, Rashmita Pradhan, Subhashree Dhal and Lizaranee Behuria

The wild edible fruit plants are important constituents of biodiversity and their exploitation has become a valuable livelihood strategy for rural population and urban dwellers. High quality minor fruit plants are a better route to food security than many of today's mass produced varieties which are sometimes very low in nutrient contents. In view of the ever- increasing human population pressure and fast depletion of natural bio-resources poses threat to agriculturists to feed the same, there is a need to optionally utilize wild edible fruits to the fullest extent possible. A concept of functional food' has taken place, which denotes food that not only serves to provide nutrition but also can be a source for prevention and cure of many diseases. Functional foods are often also termed 'food supplements' or 'nutraceuticals'. The state of Odisha is a land of many indigenous species of wild edible fruits and nuts. Of the estimated approximately 3000 species of higher plants, about 150 wild edible fruit species occur in

different dry and moist deciduous forests of Odisha has been reportedly used by tribal and rural communities (Mahapatra *et al*., 2010). Even today tribal people and rural people that dwell in nearby forests depend on these wild fruits and pass on valuable information on the utility and choice of wild species of fruits to their next generation. Virtually all the food that is available today from plants has been selectively bred for both flavour and ease of eating, and fruit is certainly no exception. As a result wild edible fruits are neglected in most food composition surveys. Extensive reports can be found in the literature regarding nutritional value present in commercialized fruits but there is a lack of a comprehensive investigation on nutritional value contained in wild edible fruits despite the wide variety of exotic fruits that are consumed by rural populations.

During recent years there has been a growing interest to evaluate various wild edible fruit plants for their nutritional value (Ajesh et al., 2012). Valvi and Rathod (2011) also has evaluated mineral content in some wild fruits from Kolhapur district with an aim to add the promising fruit plants towards commercialization. Nazarudeen (2010) had analysed the nutritional content in ten lesser known wild fruits and compared them with known cultivated fruits from which he concluded that wild fruits are nutritionally rich than cultivated fruits. Valvi et al., 2011 had reported antioxidant activities in three wild fruit species while Karuppusamy et al., 2011 had evaluated total phenolics, flavonoids and antioxidant properties in six species of lesser known edible fruits from Western Ghats of India.

Though wild edible fruits form a good source of protein, fat, carbohydrate, sugar, minerals, flavonoid, phenolic etc. no scientific reports were available on nutritional values of the edible wild edible fruits of Odisha until recently (Mahapatra et al., 2012, Nayak and Basak, 2015). Similarly, few reports had been published so far related to antioxidant properties and antinutritional factors present in wild edible fruits of Odisha (Basak et al 2013, Patnaik and Basak, 2014, Rout and Basak, 2014). Natural antioxidants play an important role in reducing oxidative stress and prevent from certain degenerative diseases while antinutritional factors interfere with metabolic process and affect the availability of nutrients required by the body.

It has been felt wise to analyse the level of anti-nutritional contents in addition to their nutritional properties so the users could be informed to make the right decision to consume. The study has also been aimed at comparing the nutritional status of wild edible fruits against their cultivated counter parts so that it would give useful information about the actual nutritional status of wild edible fruits for domestication and conservation to arrest possible over exploitation. Fruits, especially wild fruits are an important sources of protein (Nayak and Basak,2015; Mahapatra et al.,2012). On the other hand, essential amino acids-rich food consumption is must as they are not produced by the human body and acts as feed supplements, complete diet and medicinal benefits to the humans. However, presence of essential amino acids in wild edible fruits used by a large segment of tribals of Odisha has not yet been scientifically evaluated. Analysis have veen initiated to evaluate essential aminoacids in the wild edible fruits reportedly used by tribals belonging to Koraput, Gajapati, Dhenkanal, Keonjhar, Mayurbhanj and many other districts of Odisha to prioritize bioprospecting, conservation and domestication of promising species. Pectin is a plant cell wall polysaccharide, and a natural product which is found in the cell walls of all higher plants and it has long been used for its gel formation and stabilizing properties in a wide range of applications from food to the pharmaceutical and cosmetic industries. Pectin study may encourage further bioprospecting of these wild edible fruits for preparation of jams and marmalades for commercialization.

Till date, around 85 nos of wild edible fruits were subjected to analysis of their nutritional aspects by PI and his research team in the laboratory, RPRC and many of these fruits were found rich in nutritional, antioxidant and low antinutritional properties which encouraged taking up systematic analytical studies on this important subject to cover almost all available and valuable wild edible fruits of Odisha. (Mahapatra et al., 2012; Basak et al., 2013, Rout and Basak, 2014; Patnaik and Basak, 2014; Nayak and Basak, 2015 (a) & 2015 (b); Rout and Basak, 2015; Swadha and Basak et al., 2017 and Patra and Basak et al., 2017). The wild edible fruits had been collected from various forest regions of Odisha i.e. Kapurmal, Mukhiguda, Ambpani, Gungunia and Chilliguda (Kalahandi); Chitrakonda and Kalimela (Malkangiri); Khakrapadar, Papdahandi and Maidalpur (Nabarangpur); Sukhiaguda and Purnagarh (Koraput); Khamara, Muktaposi, Kukudajhara and Kankadahada (Dhenkanal); Taratarini (Ganjam); Ramnagar (Balasore);

Phultota and Bakulabana (Puri) and Sapua reserve forest (Nayagarh). Till now, we have covered 9 districts in Odisha for collection of fruits from various forest fringes.

During the year, 2017-18, a preliminary screening and optimization of more than 10 wild edible fruits has been initiated for finding pectin properties and we had successfully isolated pectin from most of them. Considering the impact of these wild fruits on the rural and tribal economy, wild fruits necessitate systematic investigation for optional use of the resource.

On the basis of high protein content, essential amino acids i.e. (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) in selected 14 wild edible fruits have been identified and isolated using TLC and HPTLC method. Estimation of 8 essential amino acids had been analyzed using UV Spectrophotometer.

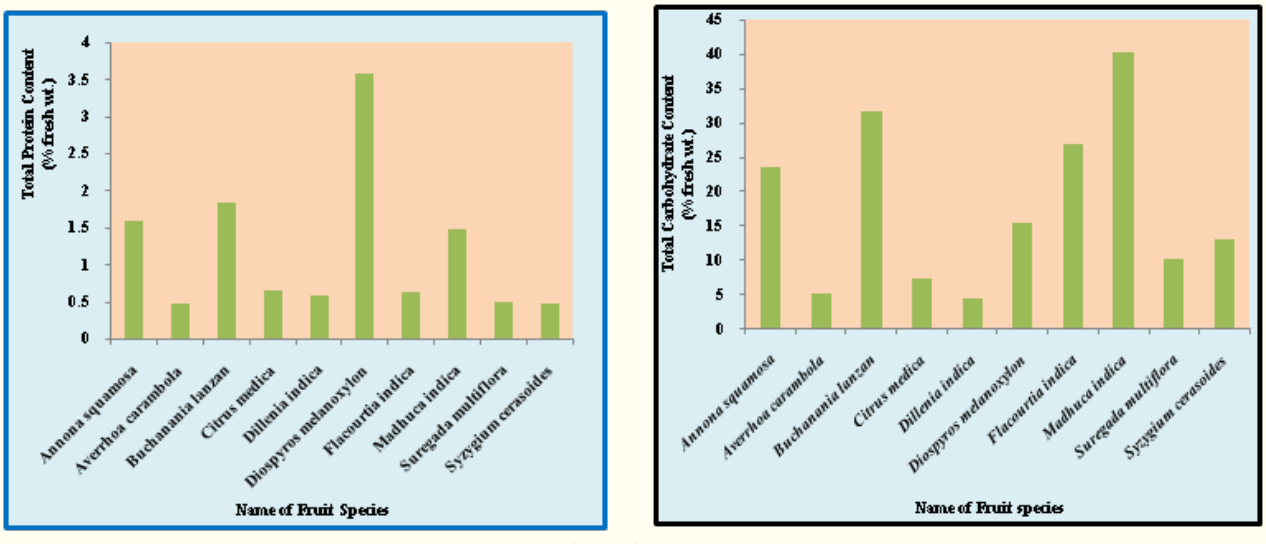
Carissa carandas **(Karanda Koli)**

Nutritional Analysis

Wild edible fruits were screened for proximate analysis like moisture, acidity, carotenoid, total protein, total carbohydrate, total sugar, reducing sugar, non-reducing sugar. Protein content was found prominent in *Ardisia solanacea* (14.4%fwt.). Highest moisture content was observed in *Polyalthia cerasoides* (82.7%fwt.). Total Carbohydrate content was found preferably high in *Memecylon umbellatum* i.e. (35.75 % fwt.) *Diospyros malabarica* had highest sugar content i.e. (32.33%fwt.) whereas highest reducing sugar content was found in *Diospyros sylvatica* i.e. (25.33%fwt.). The moisture content was relatively high in *Carissa carandas* i.e. 84.81% fwt. Moisture determination is one of the most important and most widely used measurements in processing and testing of food

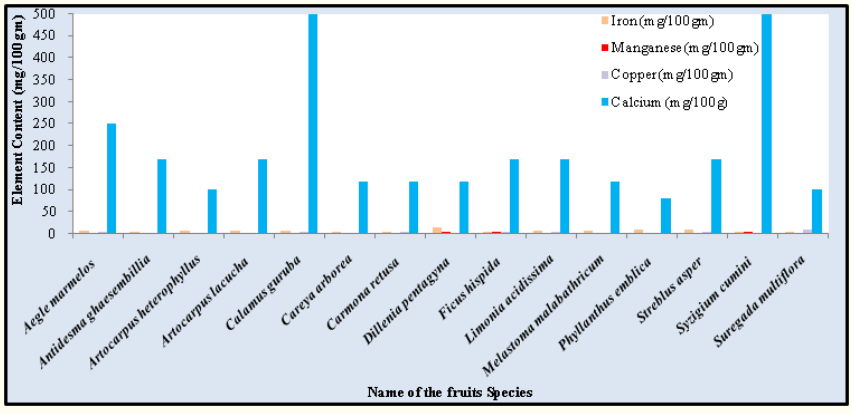
Mineral Analysis

Elemental analysis like Potassium, Iron, Copper, Manganese and Sodium was determined in some wild edible fruits. Potassium was present at a high concentration with 490 mg/100g in *Carissa carandas* followed by *Cordia dichotoma* with 310mg/100g. *Calamus gurba, Syzygium cumini, Aegle marmelos* contain high amount of calcium. *Streblus asper, Dillenia pentagyna, Melastoma malabathricum* contain higher Iron content. *Calamus gurba, Streblus asper, Carmona retusa, Aegle marmelos* contain highest Copper content. *Ficus hispida, Dillenia pentagyna* and *Syzygium cumini* has highest manganese content. The highest Calcium content was observed in *Calamus guruba* and *Syzigium*



Total Protein and Total Carbohydrate content in some wild edible fruits of Odisha

cumini 500 mg/100g and lowest in *Phyllanthus emblica* 80 mg/100g. The highest Iron content was found in *Dillenia pentagyna* 16.0 mg/100gm and lowest was seen in *Careya arborea* 4.2 mg/100gm.



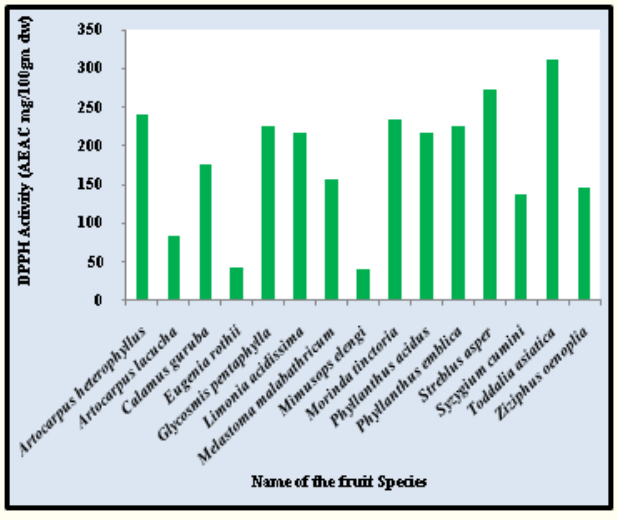
Elemental Analysis of Wild Edible Fruits of Odisha

Antioxidant analysis

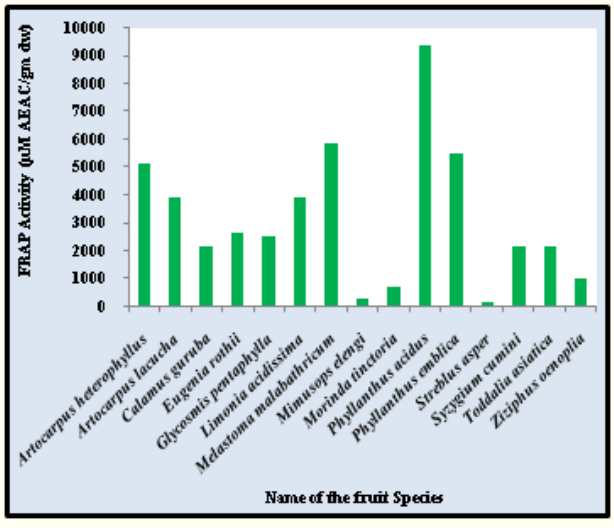
Antioxidant content were estimated (in around 20 wild fruit species) basing on the parameters Peroxidase activity, Catalase, SOD, DPPH and FRAP. Highest Peroxidase activity was found in *Antidesma ghaesembila* followed by *Calamus gurba, Dillenia pentagyna, Aegle marmelos, Limonia acidissima*. DPPH free radical scavenging activity of wild edible fruits of Odisha was seen highest in *Toddalia asiatica* 310.85 AEAC mg/100g dw and lowest in *Mimusops elengi* 40.69 AEAC mg/100g dw. FRAP activity highest in *Melastoma malabathricum* and lowest in *Bridelia retusa*. The most promising fruit for antioxidant properties are *Antidesma ghasembila, Aegle marmelos, Calamus gurba, Dillenia pentagyna, Phyllanthus acidus, Melastoma malabathricum, Carissa spinarum*. FRAP Activity of wild edible fruits of Odisha was seen highest in *Melastoma malabathricum* 5878.35 µM AEAC/g dw and lowest in *Streblus asper* 153.09µM AEAC/g dw. Catalase enzyme activity was highest in *Antidesma ghaesembila* and lowest in *Dillenia pentagyna*. Superoxide dismutase (SOD) activity was highest in *Morinda tinctoria* and lowest in *Bridelia retusa*.

Antinutrient analysis

The highest level of oxalate (25.08mg/g) was observed in *Aegle marmelos* followed by *Phyllanthus emblica* (11.07mg/g). *Antidesma acidum* had the lowest level of oxalate (0.95mg/g). For the other species, this value varied between (0.95-25.08 mg/g dry wt.). Lowest value of phytate content showed both in *Mimusops elengi and Eugenia rothii* (3.62 mg/g dry wt.). This value varied between (9.52-3.62 mg/g dry wt.). The highest level of Tannin content was found in Carmona retusa followed by *Aegle marmelos* and lowest level of Tannin content was found in *Ziziphus mauritiana*. Saponin content was found in *Artocarpus heterophyllus* followed by *Ficus hispida, Syzygium cumini* and *Bridelia retusa*. Highest fibre content was found in *Antidesma acidum* followed by *Toddalia asiatica, Ficus hispida* and *Calamus gurba*. Lowest fibre content was found in *Carissa spinarum* (Rout and Basak,2014;Rout and Basak,2015)



DPPH Activity in some Wild Edible Fruits of Odisha

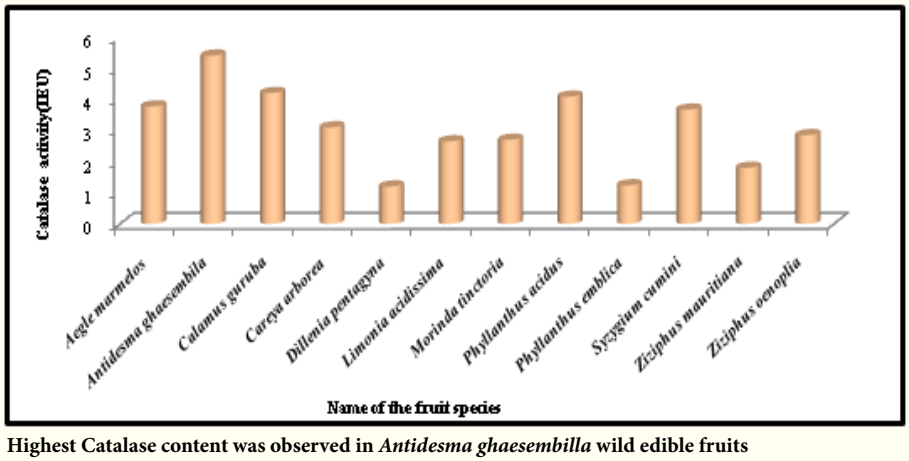


FRAP Activity in some Wild Edible fruits of Odisha

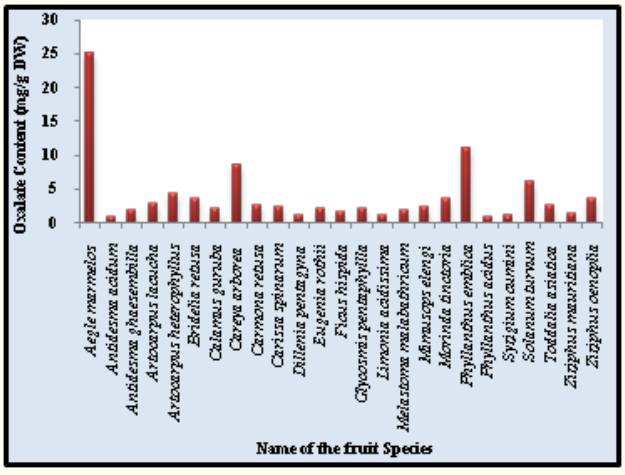
Essential amino acid analysis

Most of wild edible fruits are normally consumed based on factors such as taste, availability, and inherited ancestral practices. Although ethno-medicinal usage and edibility of wild fruits had been described by tribals and rurals, yet scientific reports on their essential amino acids value of wild fruits is lacking. According to the

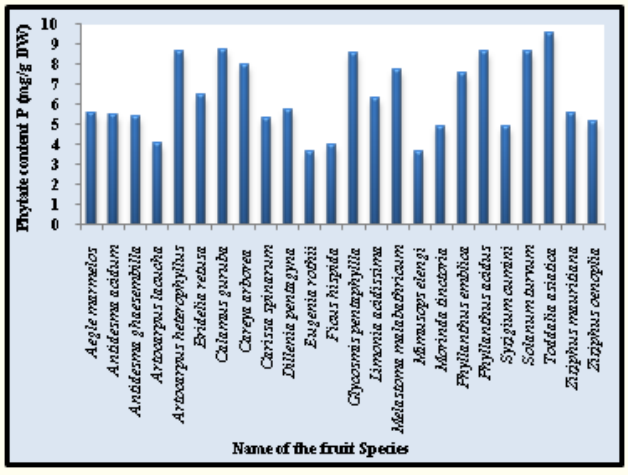
Antidesma ghaesembilla



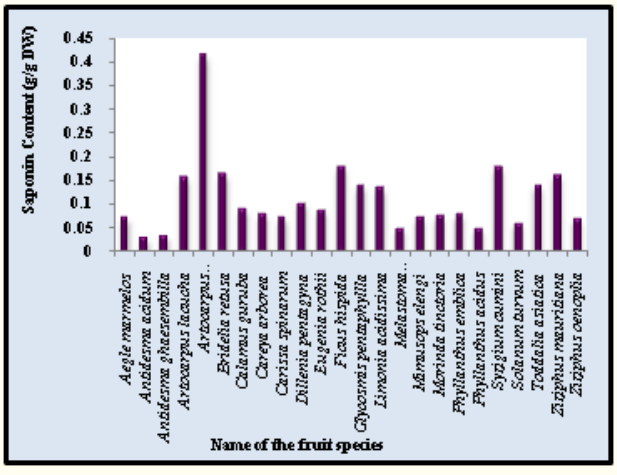
Highest Catalase content was observed in *Antidesma ghaesembilla* wild edible fruits



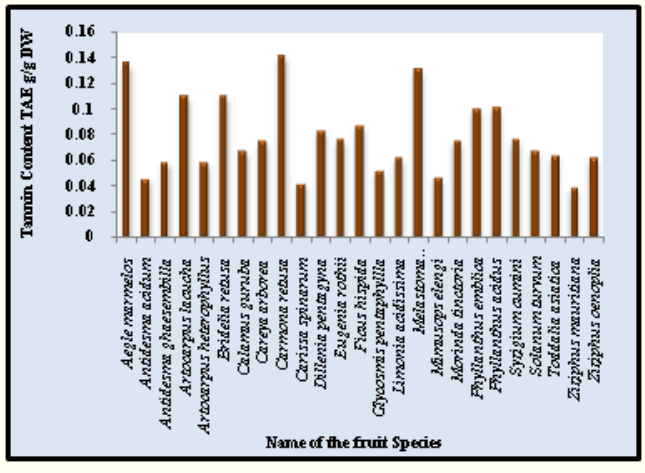
Oxalate content in 25 selected wild edible fruits



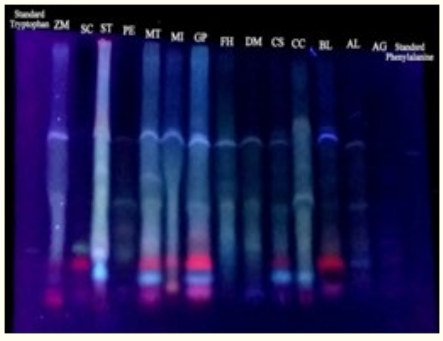
Phytate content in 25 selected wild edible Fruits

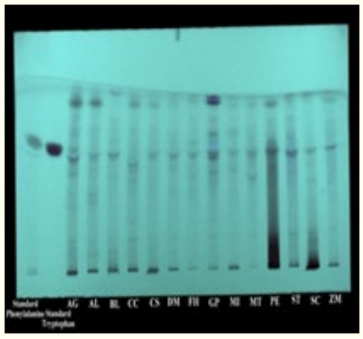


Saponin content in 25 selected wild edible fruits of Odisha

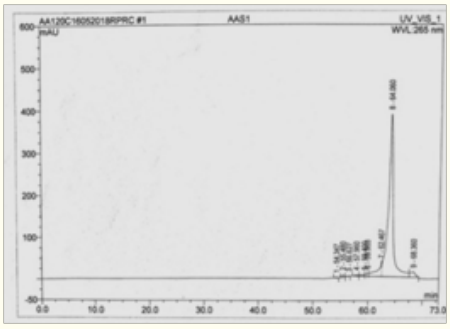


Tannin content in 25 selected wild edible fruits of Odisha





TLC and HPTLC sheet showing presence of essential Phenylalanine t hrough



EAA amino acids in 14 wild edible fruits of Odisha HPLC

results obtained from this study, wild varieties of fruits like *Antidesma ghaesembilla* and *Diospyros melanoxylon* showed promising essential amino acid content. Out of the assigned 18 wild edible fruit samples, total of 16 fruits have been collected from different forest regions of Odisha**.** After pretreatments (defatting and acid hydrolysis) methionine content was estimated through spectrometric analysis and its content was found to be in a range of 0.019-0.08% dry wt. Butanol: Glacial Acetic Acid: Water (5: 1: 5) has been optimized as suitable mobile phase for the identification and isolation of methionine, Leucine, Isoleucine and Histidine content from the crude extracted fruitsamples. The purified Methionine and Leucine compounds has been isolated from following eight crude fruit extracts (i.e. *Carissa carandas, Morinda tinctoria, Carissa spinarum, Ziziphus mauritiana, Buchanania lanzan, Madhuca indica, Ficus hispida and Phyllanthus emblica*) through TLC method. In the series of identification and isolation of Methionine, Leucine, Histidine and Isoleucine the Rf values were found to be 0.51, 0.54, 0.34 and 0.48 respectively. However, further study should continue to obtain substantial quantitity of essential amino acids in more unexplored species using HPLC as well as GC-MS technique.

Pectin analysis

Based on screening of the study on pectin yield and subsequent degree of esterification, it can be concluded that all the fruits analyzed *Citrus medica*, *Phyllanthus emblica, Annona squamosa*, *Artocarpus lacucha*, *Limonia acidissima*, and *Ficus auriculata* acquired the potential for utilization as raw materials as a source of pectins as it is a natural, biodegradable, non-toxic material and requires lower production cost. However, futher study on characterization of pectin is required to obtain good quality natural pectin for bioprospecting.

Pectin yield in *Citrus medica* wild edible fruit species

Studies on Bio-energy production

Production of Biofuel

(2012-18; DBT,GoI , State Plan funded)

PI: Dr. Nihar Ranjan Nayak

Research Fellows: Nitesh Kumar Mund, Debabrata Dash ,Satya Ranjan Das

There are many types of biofuel such as bioethanol, biodiesel and biohydrogen which could be produced using renewable sources, however, bioethanol is the most suitable as it is easily produced and is compatible with the existing engines as a blending fuel, in many cases the blending has been used up to 20%., moreover, emissions with the use of the bioethanol are less toxic as compared to others because it contains 35 % oxygen helping for complete combustion of the fuel. In USA, the bioethanol used are prepared from the fermentation of sugars of the corn starch and in Brazil mostly using the sugars from the sugarcane; these practices are not encouraged in majority of the countries as these are competing with foods. In order meet the target of Govt. of India, 20% blending of petrol with ethanol, it is required to develop or standardize the protocols for the saccharification of lignocellulosic biomass (produced

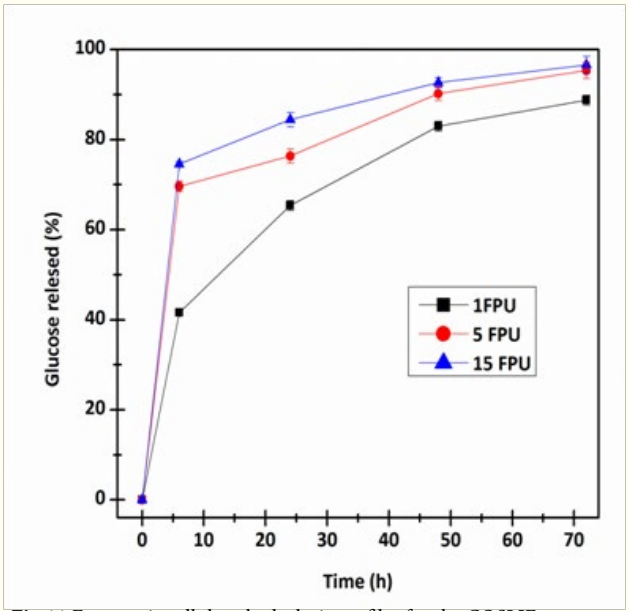


Fig.11: Enzymatic cellulose hydrolysis profiles for the COSLIF-pretreated *A. mangium*atdifferent enzyme loadings

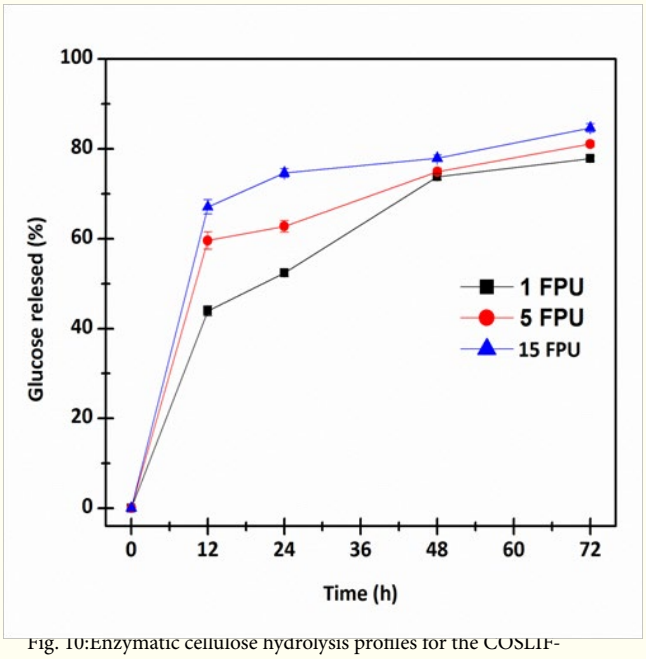


Fig. 10:Enzymatic cellulose hydrolysis profiles for the COSLIF-pretreated *G. sepium*at different enzyme loadings

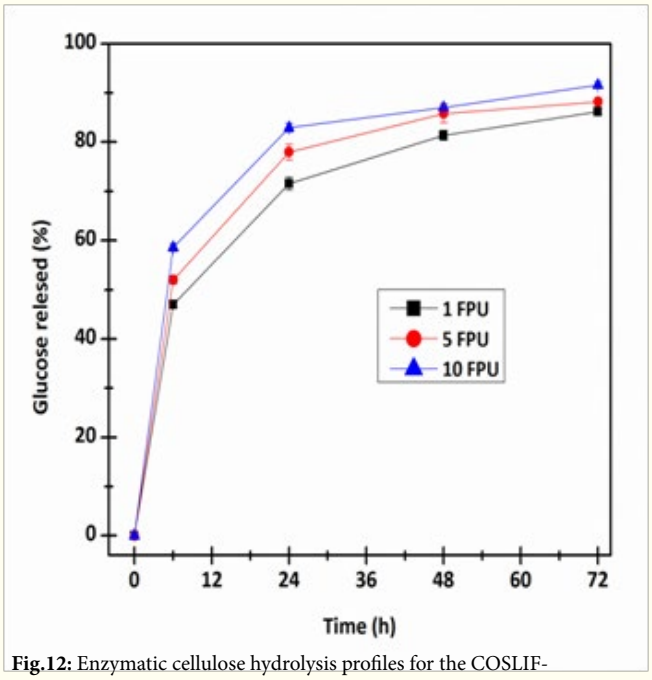


Fig.12: Enzymatic cellulose hydrolysis profiles for the COSLIF-pretreated *P. karka*at different enzyme loadings

from different trees and grasses as well as from agriculture and forest residues) that release the sugar molecules stored which are building blocks of cellulose. This technology need to replace the current method of production of ethanol in India that mostly uses the sugar from sugarcane. The technology should avoid the use of any food material. Saccharification is one of the major steps for ethanol production uses two critical steps like the pretreatment of biomass mostly with the use of chemical that separates the cellulose from other cell wall materials and the enzymatic digestion of the cellulose for the release of sugar. These sugars could be used for the production of ethanol through fermentation. Our state is producing significant amount of biomass, majority are from the agricultural residues. Many of the fast growing trees and grasses growing in the state also could be used as dedicated energy crops, utilizing the unused soils significant amount of biomass could be produced. However, for all the biomass, the saccharification process needs to be standardized. During the last five years the protocols have been standardised for efficient release of glucose molecules from the different biomass mentioned below.

Gliricidia sepium

This is fast growing and has high biomass production capacity. Also produce good number of coppice. Biomass are soft containing high cellulose should be good for conversion into fuel.

Phragmites karka

This species is the only member of the genus Phragmites growing in the state of Odisha. In the state of Odisha it is growing abundantly in Chilika Lake. It can grow on fresh water as well as on salt contaminated area. This plant has tremendous potential for large scale biomass production and has severe invasive characteristics.

Agave sisalana

*It is commonly known as Sisal, generally grown as a fibre crop.*The sisal plant is slow growing, has a 7–10 year life-span and typically produces 200–250 commercially usable leaves in life time. The fibers account for only about 4% of the plant by weight. This plant shows an excellent water management skill because it following CAM pathway.

Acacia mangium

This species is a multipurpose tree of the family Mimosaceae. This is fast growing with a good wood quality and thus being planted for commercial purpose. It shows good resistant to drought and thus ideal to be planted in drier areas as well as areas containing mine waste dumps. Like many other legumes, it is able to fix nitrogen in the soils.

Horticulture and Floriculture

Mass propagation of different verities of banana through tissue culture

(2012-2018; State Plan funded)

PI: Dr. Bandita Deo

Research Fellows: Mainak Sinha, Jagabandhu Sahoo, Bikram Keshari

Banana production in Odisha is very low, contributing only 2% to the total banana production in the country . But banana cultivation is an important source of income to the farming community. Odisha is abundant with indigenous dessert banana land races having some peculiar characters that could be utilized for banana improvement. Varieties grown in India are Dwarf Cavendish, Robusta, Monthan, Poovan, Nendran, Red banana, Nyali, Safed Velchi, Basarai, Ardhapuri, Rasthali, Karpurvalli, Virupakshi, and Grandnaine etc. Main banana growing states are Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh, and Karnataka. In Odisha Patakpura, Champa, Grand Naine, Dwarf Cavendish, Bantala are the popular cultivars are grown in Ganjam, Puri, Khurda, Gajpati, Cuttack, Dhenkanal, Angul, Sundargarh, Sambalpur, Bargarh, Deogarh, Koraput, Keonjhar, Rayagada, Mayurbhanj districts of the state. Odisha produces about 467,730 tonnes of Banana from an area of 24,730 ha with an average productivity of 18.91 t/ha (NHB Data, 2015-2016).Through conventional methods adequate no. of plants suckers are not available for plantation at farmer's field. The project was initiated to develop a standardized protocol for mass propagation of banana and through tissueculture a large quantity of disease-free elite planting material will be produced. The protocol of local Musa species Patakpura and Champa through tissue culture has not developed yet. So an attempt has been taken for standardizing protocols by using different plant growth hormone through in-vitro culture.

Banana cultivation in the state of Odisha has gone up in order to be self-sufficient, however, still has not meet the target. For this the major requirement is the availability of the good quality planting material which is generally developed through tissue culture. The current demand for the state of Odisha is 65, 00000 that includes many varieties like, Grand Naine (G9), Bantal, Patakapura etc. At present, majority of these are being procured from different private and government sectors. Within the state, Regional Plant Resource Centre has developed a banana tissue culture based production centre and supplying plantlets of different banana varieties to the farmers of Odisha since last 20 years. This institute already has standardized the protocols of *in vitro* propagation of many banana varieties. With the existing protocol good number of plantlets could be produced from a single rhizome generally used for banana tissue culture. However, there is tremendous scope to improve the protocols particularly the process need to be cost effective and should avoid the use of highly toxic chemicals.

In our experiment for surface sterilization of the explants two sterilants were used i.e. Sodium hypochlorite and calcium hypochlorite (bleaching powder), among the two sterilant calcium hypochlorite was found better for controlling the infection and it had not any adverse effect on the explants even in long duration time (30 minutes). Bleaching powder at higher concentration (30%) has turned out to be better sterilizing agent (Fig. 1)than mercuric chloride alone at 0.5% for 45 minutes. Also sodium hypochlorite at 1.75% found to be good for surface sterilization.

Cytokinins proved to be the most efficient growth regulator for production of multiple shoots from number of explants like axillary buds, shoot tips, cotyledonary nodes, leaf and root tissues etc. Higher concentrations, although induced shoot multiplication, produce abnormal shoot and have difficulty in elongation. In case of banana rhizomes, higher concentrations found to be essential for induction and multiplication of shoot buds. In most of the cultivars tested in the induction BAP 6.0 mg/l found to be essential for the shoot induction. In the multiplication medium, also higher concentrations of BAP (3.0 mg/l) are being used in many cultivars of banana. Basing on these finding we have tested two types of cytokinins (BAP and Kn) in

Figure 1: Banana suckers treated with 30 % Calcium Hypochloride.

various concentrations in the induction medium as well as in the multiplication medium. In this case of GajaBantal, we have found similar kind of observations as that of other verities. Higher concentrations are required for the shoot induction as well as for multiplication medium. Lower concentrations although produced shoot buds, the efficiency was very low as only 253 number of shoots could be produced after six rounds of sub-culture. This number will not be economically viable as the cost of production of plantlets will increase significantly. With the 6.0 mg/l of BAP in the induction medium and 3.0 mg /l BAP in the multiplication medium produced 631 numbers of shoots after six rounds of sub-culture in the multiplication medium. In the multiplication medium, the plantlets regenerated were devoid of roots as they are from higher cytokinins (Fig. 2). Similar kinds of observations were also reported from other plant species including the other cultivars of banana. In these experiments, NAA and IAA used for root induction and it was found that IAA is more efficient in the induction of roots in the banana plantlets.

In this study, it was concluded that from the modified MS (1962) medium supplemented with different concentrations of BAP (2 mg/L, 3 mg/L, 4 mgL-1, 5 mg/L, 6 mg/L,), the applications of BAP in the Tissue culture media needs to be carefully monitored.

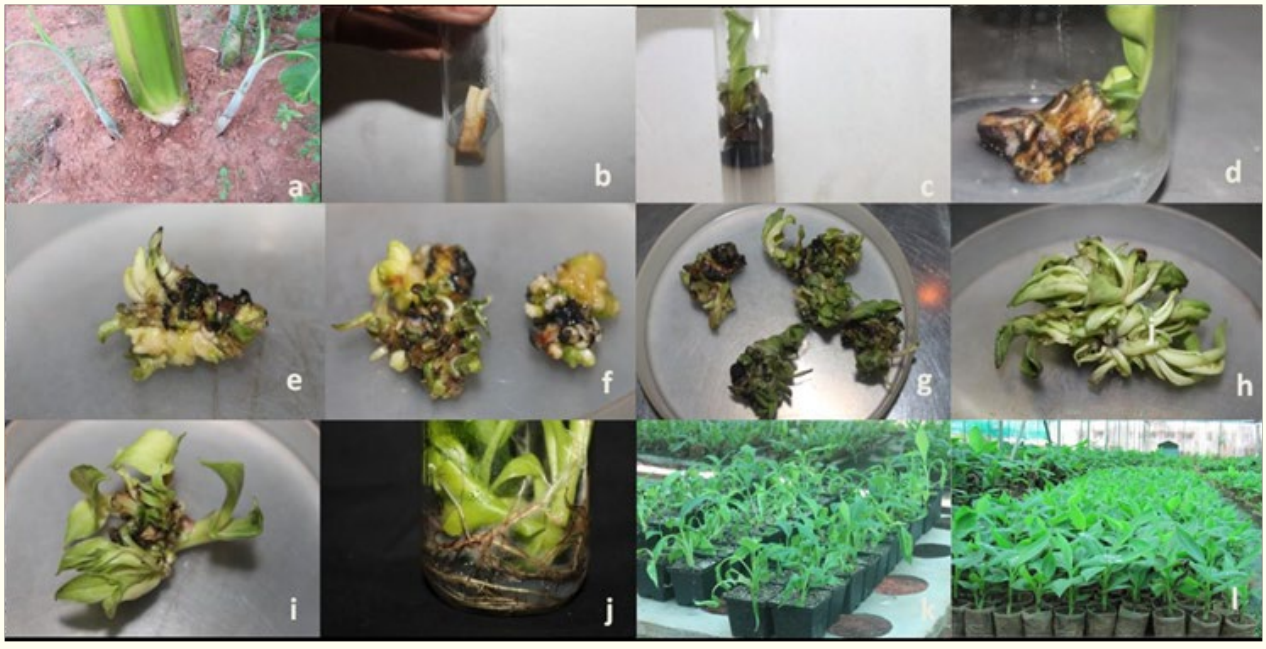


Fig. 2 : Rhizome culture for banana mass propagation:

(a) Sucker grown at Banana mother block (RPRC) ;(b) Initial culture; (c) Initial culture after 21 days (deposition of phenolic on the surface of explant turns it in to black);(d)Observation after first subculture; (e) Observation after second sub culture; (f) Observation after third sub culture; (g) Observation after fourth sub culture; (h) Observation after fifth sub culture; (i) Explant inoculated in elongation medium; (j) Explant inoculated in rooting medium; (k) plantlets transferred to primary hardening chamber; (l) Secondary hardening chamber.

The effect of different concentrations of 6- benzyl amino purine (6BAP) on Patakpura variety (*Musa* sp.) banana explants was investigated. After ten weeks in all types of media, the response, proliferation and multiplication of Patakpura (*Musa* sp.) explants were observed and recorded. Less response of explants was observed in two types of media (2 BAP and 4 BAP) and recorded. High response of explants was observed in MS medium (6 BAP) supplemented with 5.0 mg/l of 6BAP and recorded. The results indicated that, the multiplication rate was decreased with decreasing the concentration of BAP in MS medium because less bud formation (cease of the cell division) and also the multiplication rate decreasing with increasing the concentration of BAP in MS medium due to abnormality development of the buds.

To establish the normal growth rate and multiplications of plantlets of Patakpura(*Musa* sp.) *in vitro* conditions required 5 mg/L of BAP was suitable in medium. During the *in vitro* culture of Patakpura and Champa, the explants were cultured on different mediums supplied with different concentration and combination of plant growth hormones. In multiplication culture, the explants were grown for 3-4 sub-cultures in each multiplication medium. Out of the entire medium, the explants with optimum results were maintained up to 6 sub-cultures in the same multiplication mediums. The observations on the basis of different parameters such as the number of shoot buds, number of individual shoots, growth rate, etc were collected and analyzed from random 10 explants during the final sub-culture period. For rooting culture, IAA and NAA were used at different concentrations in MS medium.

Medium containing only BAP and IAA were marked to induce shoot proliferation. Better results were obtained when explants were cultured on medium containing BAP along with IAA and NAA.Between BAP and KIN

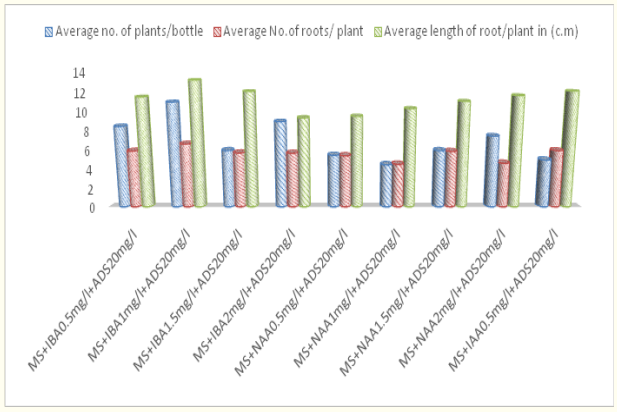


Fig. 3: Root proliferation of Patakpura explants during rooting culture after 21 days of inoculation.

Fig. 4: Patakpura explants cultured on medium containing BAP + IAA + NAA.

Fig. 5: Champa explants cultured on medium containing KIN+ BAP + IAA + NAA.

used in this study, the BAP proved better performance in initial culture for Patakpura and Champa variety. On the other hand, mineral nutrients are being used as the basic component of culture media which play a vital role in rapid growth and quality of morphogenesis of tissue.The in vitro propagation method developed in this study can serve as a convenient method for large-scale, disease free, homogenize development of banana cultivar studied.Three different concentration of rooting (IAA, IBA and NAA) medium were prepared. Each root induction medium were prepared in four different concentration of auxin i.e.0.5mg/l, 1mg/l, 1.5mg/l and 2mg/l. The above data showed that the different concentration of auxin had different result i.e. no of plants in a bottle, no of roots/plant and length of roots/plant. Here IBA showed the best result than that of IAA and NAA in four different IBA concentration, only 1mg/l IBA gave the good result.

Regional Plant Resource Centre is the largest tissue culture Banana production unit of Odisha. Different varieties like cv. GajaBantala, cv. Robusta, cv. Grand naine, cv. Patkapura and cv. Champa are being produced in aseptic condition inside the laboratory. The production of different varieties of banana was done according to the need of the farmers of the state.

Figure 6: Banana plantlets of varieties GajaBantal, Patakpura, Champa, Grand naine in nursery of RPRC.

Through this research efficient, safer and cost-effective protocols was developed which is useful for easy and time bound production of banana plantlets in plenty. Our centre was able to supply more quantity of different varieties of banana including our local varieties according to the requirement of our farmers of the state as well as outside state within a short period.Through the experimental study various effects of different phytohormones were observed during *in vitro* micropropagation of Patakpura variety which will be helpful for development of protocol for its mass propagation in future.

Introduction of new Musa spp. cv. Yangambi-Km5 In Odisha and its micro propagation

(2015-2017; State Plan funded)

PI: Dr. Bandita Deo

Research Fellow: Bikram Keshari

Yangambi has numerous fruit in its bunch that has a very pleasant taste when it is ripe. It is a vigorous plant that remains productive on poor soils and which has become well known for its thick peel being resistant to black leaf streak disease, caused by Mycosphaerellafijiensis, which ultimately increases the self-life of this banana cultivar. So it is considered that it can be cultivated in manyparts of Odisha having poor soil quality

The project actively focused on the introduction of a new variety in Odisha throughadvance tissue culture technique. Successfully establishment of mother block was done at RPRC through a plantation of Tissue cultured plants of Yangambi variety which was initially collected from Horticulture research station, Kovvur, Andhra Pradesh. Morphological data of plants like height, circumference, no. of leaves were taken.

Figure 7: Establishment of Yangambi Mother Block

For the development of a protocol for Yangambi variety different experiments were conducted by using different growth hormones like Benzyl amino purine, Kinetin, Indole acetic acid, Naphthalene acetic acid. A protocol consisting of growth regulator combination, for the in-vitro mass propagation of Yangambivariety, have been standardized. Virus indexing test was done from NRCB, Trichy, Tamil Nadu, India and confirmed that all the Yangambi plants are virus free. Inflorescence was observed after seven months and the fully mature bunch was perceive on the nine-month after plantation. The bunch is immense in size and hold around 160-180 nos. of fingers.

Figure 8: Banana Bunch in Yangambi Plants

The color is yellow and the taste is in between our local variety Patakpura and Champa. We hope it will be highly appreciated by the farmers of Odisha as well as improve the economic status of the state.

Primary Hardening

Yangambi plantlets having 6-8 cm shoots with 3-4 small roots are planted in individual in a primary bed with soilrite.

Secondary Hardening

After primary hardening for 2-3 weeks, the Yangambi plantlets are transferred from micropots bed to polybags in secondary hardening. Organic manure is either in the form of farm yard manure. Plantlets from micropots are, dipped in fungicide solution (0.1% bavistin) and planted in polybags containing suitable substrate. After 5-6 weeks, the plants become ready for field planting having 3-5 well developed leaves and a good mass of fibrous roots are send to sell counter. Through this project 9,500 number of Yangambi plantlets produced.

Figure 9: Yangambi small plantlets well maintained in secondary hardening in polybag.

Analysis of different effects of phytohormones during in vitro propagation of banana

(2016-2017; State Plan funded)

PI: Dr. Bandita Deo

Research Fellow: Bikram Pradhan

Though demand of banana plants through tissue culture is very high it is very much essential to produce large number of plantlets within a short period. From various research studies it is known that the growth and development of tissue culture plantlets mainly depend upon the activities of growth regulators like Cytokinin and Auxin. Various experiments will be conducted to get most suitable findings for rapid regeneration of *Musa* plantlets. So this type of study is very much essential for mass propagation of Banana.

Experiments were conducted to determine the optimum concentrations of phytohormones for meristem culture of banana cv. GajaBantal by observing the effect of different culture conditions during induction, multiplication and rooting stage for standardization

of cost effective protocols. The explants with meristematic region obtained from the banana corm by removing leaf sheets were cultured on MS medium containing different concentrations of hormones viz. 6-benzylaminopurine (BAP), Indole-3-acetic acid (IAA),α-naphthalene acetic acid (NAA) and adenine sulphate (ADS).

During GajaBantal*in vitro* culture among different combination of phytohormones used for initial culture, MS medium supplied with 6 mg/l BAP in addition with 2 mg/l IAA and 100 mg/l ADS showed remarkable results. In case of multiplication culture the explants cultured on MS medium along with 3 mg/l BAP + 1 mg/l IAA + 0.25 mg/l NAA (Fig. 1-A) had bearing highest number of shoot buds (143) and also more number of individual shoots were developed.

For root induction two different types of MS medium such as solid (with Agar), liquid (without Agar) and solid + Activated charcoal (50 mg/l) mediums supplied with IAA were utilized. Out of various treatments the shoots grown on MS medium (solid + Activated charcoal) along with 1 mg/l IAA (Fig. 10-B) showed optimum results.

Figure 10: A- Explants cultured on medium containing with 3 mg/l BAP and **B-** Root induction medium containing activated charcoal (50 mg/l) and IAA (1 mg/l).

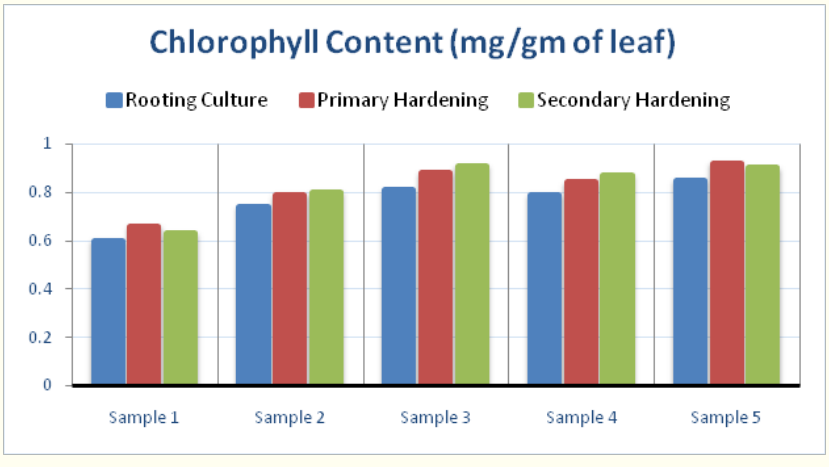


Figure 11: Chlorophyll analysis of tissue cultured GajaBantal plants at different stages.

The leaf samples of five different shoots cultured in rooting medium enriched with activated charcoal (50 mg/l) and1 mg/l IAA after 21 days of inoculation were taken for chlorophyll analysis. Leaf samples of five banana plantlets growing in primary and secondary hardening were also taken for pigment analysis. The chlorophyll content was found in more quantity plants growing in secondary hardening stages in comparison to primary hardening and rooting culture stages. The changes in chlorophyll content may be caused due to physical stress during hardening process and also depended on growth factor.

From the above studies more efficient protocol was developed for rapid propagation of GajaBantal. Leaf samples of five randomly selected plantlets of GajaBantal produced through tissue culture were sent to ICAR - National Research Centre for Banana, Thogamalai Road, Thayanur, Tiruchirapalli, Tamil Nadu for testing four major viruses such as BSV, BBTV, BBrMV, CMV. The results were negative in all the samples which proved that the plantlets were free from diseases.

Collection of elite disease free suckers from different areas of Odisha

(2017-2018; RKVY, GoO funded)

PI: Dr. Bandita Deo

Research Fellows: Bikram Pradhan, Arundhati Das, Nimisha Mohapatra

The local variety of Banana cv. GajaBantal (Plantain) and Patakpura (Dessert) have a high demand in the markets of Odisha and its neighboring states, but due to lack in production the demand is not fulfilled. The production of these varieties is depending on availability of healthy disease free planting material as well as proper farming techniques. Due to unavailability sufficient numbers of GajaBantal and Patakpura plantlets and disadvantages of vegetative propagation, the cultivation of these local varieties are decreasing day by day. The project will focus on developing standardized cost effective protocols which will help in production of large quantity of tissue cultured planting material as well as create awareness regarding the farming practice and implementation of modern agricultural techniques for the cultivation of these local varieties and also increase socio-economic developmental benefits of the farmers of the state.

The objective of the project was to collect elite disease free suckers from different areas of Odisha. During our survey it was observed that healthy, disease free and high yielding plants of GajaBantal and Patakpura were cultivated in the adjoining coastal areas of Puri district. Tour programs were conducted to collect suckers (Fig. 12) from Nimapara, Balipatna, Kakatpur and also the adjoining areas of Puri and Khurdha district.

Banana Mother Block was developed through plantation with local varieties of *Musa* spp. such as Bantal (GajaBantal) and Patakpura for germplasm conservation and also for easy availability of suckers for initial tissue culture work. Plantation of total 80 nos. of tissue cultured plants of different varieties Patakpura and GajaBantal produced In RPRC Banana Tissue Culture Laboratory were planted in this plantation site (Fig. 13).

Fig. 12: Collection of GajaBantal and Patakpura suckers from cultivation fields.

The pH of the soil was 5.68 which is suitable for banana cultivation. In first phase 80 nos. of pits holes (1 ft X 1ft) were made in 8 rows with 10 no's of pits in each row. To each pit 10 kg of cow manure and 250 gm. of Neem cake powder was added. Water and fertilizer were applied at regular time interval (Fig. 14 and 15).

Fig. 13: Collection of GajaBantal and Patakpura suckers from cultivation fields.

Fig.14: Watering the plants at regular time interval.

Fig. 15: Appling fertilizers to Banana plants.

Genetic fidelity testing for tissue culture raised banana at RPRC by using PCR based molecular tools

(2013-14; State Plan funded)

PI: Dr. Giridara Kumar Surabhi
Research Fellows: Sabyasachi Pattanayak

Micro-propagation of banana has gained attention due to its potential to provide genetically uniform, pest, and disease-free planting materials. However, the large scale commercial production of banana using tissue culture processes bears several risks. Factors such as explant source, time of culture, number of sub-cultures, genotype, media composition, phytohormones, the level of ploidy, and genetic mosiacism are capable of inducing *in vitro* variability. Accurate verification of cultivar identity, checking propagation material and patent protection is important because very few cultivars satisfy standards for fruit quality and clonal fidelity. It is mandatory to monitor genetic fidelity of tissue culture raised plantlets, as per the guidelines of National Certification System for Tissue Culture Raised Plants (NCS-TCP), Department of Biotechnology (DBT), Government of India.

Genomic DNA was isolated from fresh leaves of the mother plant (used as an explant source) and twenty randomly selected micro-propagated plantlets from different batches by the modified CTAB method. The quality and quantity of purified total DNA was assessed by micro volume spectrophotometer (mySPEC, Sigma, Austria) as well as visually on 0.8% agarose gel using ethidium bromide staining. DNA sample was diluted to 25ng/µl with Tris-EDTA buffer for downstream experiments. The micro-propagated banana plantlets of *Musa acuminata* cv. Bantala and cv. Grand Naine that were developed from suckers were screened for genetic variation, if any, using ISSR markers. Similarly, the mother maintained

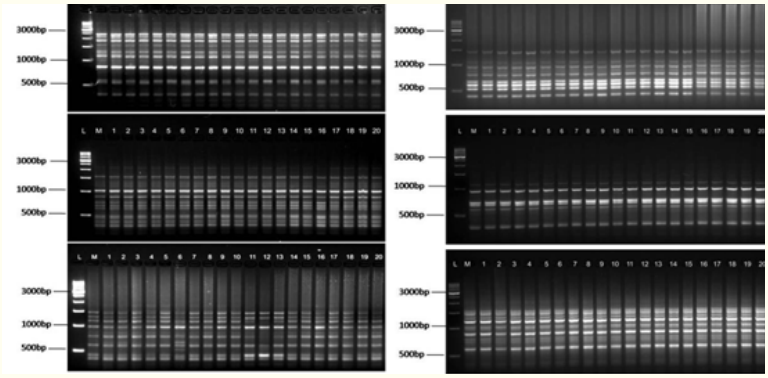


Fig. 1: Gel images showing the homogenous amplification pattern in 20 randomly chosen tissue culture raised plantlets of 'cv. Bantala' (left panel) and 'cv. Grand Naine' (right panel) by ISSRs. L- Represents 500bp DNA ladder, M- represents the mother explants source and, Lane 1-10 represents 1st batch, Lane 11-20 represents 2nd batch.

ISSR primer sequence (5'- 3')	Annealing temperature (°C)	Total number of bands	Approximate size range (bp)
$(AC)_8YT$	60	10	100-1500
$(GA)_8YC$	46	11	500-1500
$(CA)_8G$	52	9	200-1500
$(CA)_8RG$	51	10	300-1400
$(AG)_8YT$	50	6	200-900
$TGG(AC)_7$	59	9	700-1600

Table 1: ISSR primers used to screen twenty micro-propagated banana plantlets of cv.Bantala and cv.Grand Naine, amplicons generated and size range of the amplicons (corresponding fingerprinting profiles were depicted as Figure1).

S.No.	Cultivar	Genome
1	Cheni Champa	AAB
2	Red Green Banana	AAA
3	Hybrid H.531 ('Poovan' × 'Pisang Lilin')	
4	Ney Poovan	AAB
5	Patkapura (Satasankha)	AAB
6	Robusta	AAA
7	Karpuravalli	AAB
8	Amrutapani	AAB
9	Champa Patia	AAB
10	Martman (Rasthali)	AAB
11	Ganga tulasi	AAB
12	Red Banana	AAA
13	Champa	AAB
14	Grand Naine	AAA
15	Patkapura	AAA
16	Bantala	BBB

Table 2: List of Musa cultivars considered in the present study.

in the field was also subjected for genetic analysis, where the DNA banding patterns for each primer was highly uniform and monomorphic to the field grown mother clone from which the culture had been established (Fig. 1). Further, in this study true-to-type nature of the *in vitro* raised plantlets was confirmed by using ISSR markers.

Deciphering the genetic identity of banana:

The success and pace of progress of crop-improvement program depend to a large extent on the availability of diverse germplasm and information on their characteristics. In the present investigation, genetic relationships of 16-bananas, including some exotic varieties (Table-2), were assessed based on inter simple sequence repeats (ISSR). Out of 26-ISSR primers screened, 18-ISSR primers (Table-3) were produced totally 2168 clear, reproducible and scorable band classes, resulting in a total of 1608 polymorphic bands. The number of scorable bands for ISSR primers varied from 1 [(AC)8 YT] to 13 [(GA)8 YC and (AG)8 YT], with an average of 7 bands per primer. The highest level of polymorphism (100%) was obtained with primer (AC)8 YT, whereas the lowest was 77.8% and was obtained with primer AGAGGTGGGCAGGTGG (Table 3).

The dendrogram was constructed based on the Jackards similarity coefficient matrix using UPGMA method (Figure 2, Panel B). The first cluster includes variety Red Green Banana, Robusta, Amrutapani, and Martman and rest of the verities into second cluster. The present study clearly demonstrated that the clustering patterns based on ISSR markers data could discriminate 16 banana cultivars into groups (sub-clusters) based on DNA polymorphism content and genetic diversity. Interestingly, four cultivars, namely Martman, Amrutapani, Robusta, and Red Green Banana are closely related and genetically distant from rest of the 12 cultivars studied.

Sl. No.	Primer sequence	Annealing Temperature (°C)	Amplified bands		
			Total	Polymorph bands	% polymorphism
1	$(AC)_8YT$	60	66	66	100
2	$(CA)_8RG$	51	152	88	57.89
3	$(GA)_8YT$	53	85	85	100
4	$(CA)_8G$	52	126	110	87.3
5	$(AC)_8T$	49	136	88	64.7
6	AGAGGTGGG CAGGTGG	52	135	55	40.74
7	$(CT)_8T$	44	108	76	70.37
8	$TGG(AC)_7$	59	154	122	79.22
9	$(AG)_8YT$	50	121	57	47.1
10	$(GAA)_6$	48	126	110	87.3
11	$(GA)_8A$	44	149	133	89.26
12	GAGGGTGGAGGATCT	63	133	101	75.93
13	$(AG)_8C$	47	139	107	76.97
14	$(GA)_8YG$	50	118	54	45.76
15	$(GA)_8YC$	46	144	128	88.88
16	$(GA)_8C$	43.3	120	104	86.66
17	AGGGCTGGAGGGC	65.7	82	66	80.48
18	$(AG)_8YA$	50	74	58	78.36

Figure 3: List of primers, their sequences, number and size of the amplified fragments generated by 18 ISSR primers.

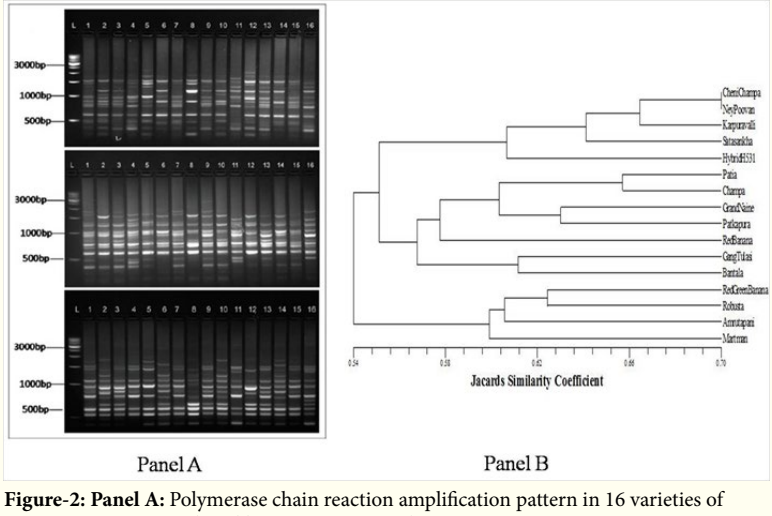


Figure-2: Panel A: Polymerase chain reaction amplification pattern in 16 varieties of *Musa accuminata* produced by using inter simple sequence repeats primers. L - represents 500 bp DNA ladder and 1-16 represents Cheni Champa, Red Green Banana, Hybrid H.531, Ney Poovam, Patkapura (Satasankha), Robusta, Karpuravalli, Amrutapani, Champa (Patia), Martman, Ganga tulasi, "Red Banana, Champa, Grand Naine, Patkapura, and Bantala, respectively. **Panel B:** UPGMA-based dendrogram representing genetic relationships among 16 *Musa acuminata* varieties based on Jaccard's similarity coefficients.

Proteomic analysis of banana fruit to identify fruit ripening process related key proteins

(2013-18; State Plan, S&T Dept. funded)

PI: Dr. Giridara Kumar Surabhi

Research Fellows: Silpa Pattanaik; Mhabir Prasad Das, Subhankar Mohanty

Bananas and plantains are major fruit crops in many countries. India stands as the largest producer of banana with an annual production of 28.4 million tons on 796,500 ha., which contribute to 27% of the world production and about 38% of the total fruit crop production in the nation (FAOSTAT, 2011). In developing countries, post-harvest losses of fruits and vegetables account for almost 50% of the produce. India, the world's second largest producer of fruits and vegetables, loses 35-40% of the produce due to excessive softening. Our lab is focusing on identifying novel candidate proteins responsible for softening (ripening) process of banana through advanced proteomic approach. In view of the fact that no report is available on banana molecular regulation of ripening to date, the research program will be helpful in identifying some good candidate genes controlling the ripening process and in reducing post-harvest loss of fruit crop.

Based on change in fruit color and texture different ripening stages were identified (Fig.1) and samples were considered for the study. Phenol extraction of the proteins from banana pulp and peel tissues at climacteric stage resulted in the preparation of high-quality proteins for SDS-PAGE separation. Distinct qualitative and quantitative differences were noticed in the protein separation pattern between the methods followed in the present study. The majorities of phenol extracted proteins were resolved between 30 and 100 kDa, and whereas most of these protein bands were absent in TCA-acetone extracted protein samples in the same molecular weight range (Figure 2 'a' and 'b').

IEF was performed with 150 µg of the proteins (pre-climacteric and climacteric stages) followed by 2-DE on 12% SDS-PAGE gel (Figure 2). The majority of the protein spots was distributed (using pH 3-10 IPG strips) in molecular weight/pI range from 30 to 190 kDa and 4.0 to 8.0. Quantitative and qualitative differences were

Figure 1A: A, 20-DAF; B, 40-DAF; C, 60-DAF; D, 80-DAF, E, 90-DAF (Day After Flowering).

Figure 1B: F, 2-DAR; G, 4-DAR; H, 6-DAR; I, 8-DAR, J, 10-DAR (Day After Ripening).

Fig.1: Banana under different developmental (upper panel) and ripening stages (lower panel).

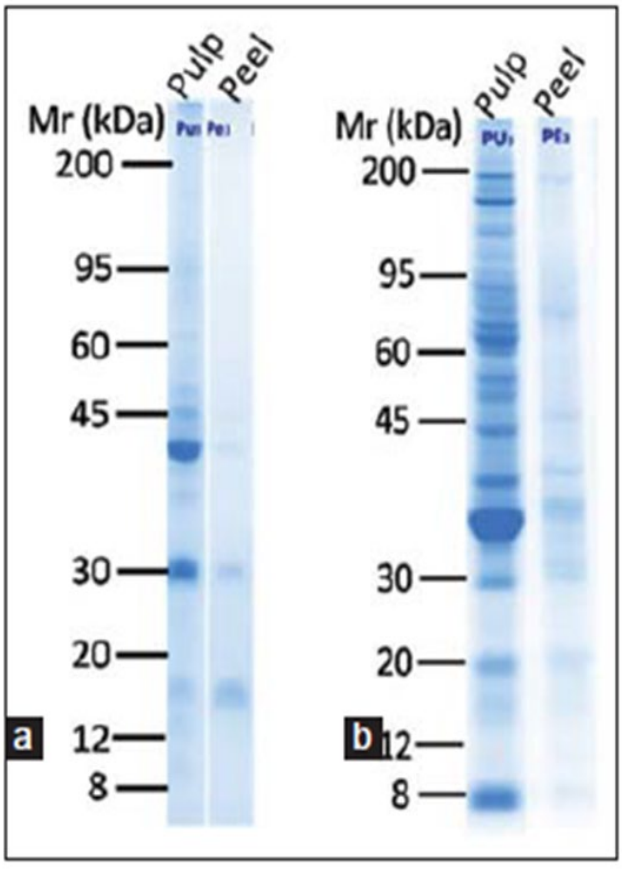


Fig. 2: Sodium dodecyl sulfate-polyacrylamide gel electrophoresis profiling of protein samples extracted from banana pulp and peel tissues using trichloroacetic acid-acetone (a) and phenol extraction (b) methods, and proteins were resolved on 12% gel.

observed in the number and resolution of protein spots (Figure 3), with no visible horizontal or vertical streaking.

Figure 3: Two-dimensional gel of protein extracts from banana pulp tissue obtained by the phenol extraction method. 150 µg proteins were separated on 13 cm immobilized pH gradient strips over a nonlinear pH range of 3-10 and then separated in the second dimension using 12% polyacrylamide gel. Gels was stained with GelCode blue stain reagent.

Separation of protein samples and comparison of 2D gels from pre-climacteric (Figure 4a-d) and climacteric (Figure 4e-h) stages were clearly demonstrated the differential expression of different sets of proteins in these two stages, due to alterations in different biochemical pathways involved in the ripening process. After subjecting 2D gel images to the software, on average 380 protein spots could be detected on a typical 2D gel. Images were subjected to 2D image analysis software (ImageMaster 2D platinum, vession-7.1, Wipro GE Healthcare), to identify differentially expressed protein spots.

Although banana fruit and pulp considered a recalcitrant tissue for protein extraction and gel analysis, we succeeded in establishing protein isolation and 2D gel preparation for the first time for different ripening stages of banana fruit. Protein extraction using two different methods from peel and pulp tissues of banana fruit were optimized. Irrespective of the tissue (peel and pulp) used for protein extraction, protocol based on phenol extraction gave optimal yield compared with

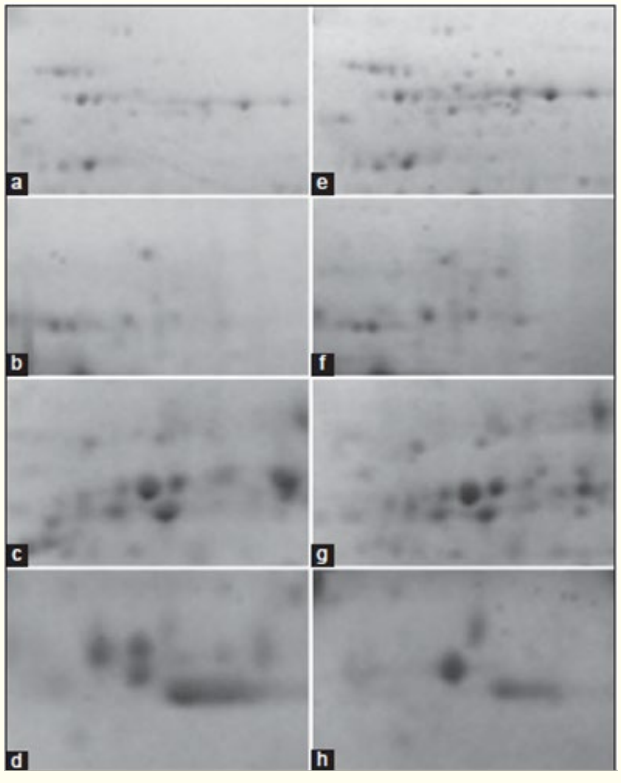


Figure 4: Portion of two-dimensional gel zoomed to visualizedifferentially accumulated proteins at pre-climacteric (a-d) and climacteric (e-h) stages of banana.

TCA-acetone method. Established high-quality protein extraction protocols in this study would be highly useful in conducting in-depth gel-based proteomic analysis in banana. Further, differentially expressed protein spots are subjected for mass spectrometry analysis (MALDI-TOF/MS or LC-MS/MS (Q-TOF) for peptide mass fingerprinting and sequence analysis.

RESEARCH PROJECTS

EXTERNALLY FUNDED PROJECTS

Sl. No	Title	PI	Funding	Period	Status
1	Qualitative and quantitative assessment of biological diversity and distribution pattern of macrophytes (angiospermic plants) of chilika lagoon and its adjoining regions.	Dr. P. C. Panda	ICZMP, CDA, Odisha	2012-2016	Completed
2	Qualitative and quantitative assessment of Plant biodiversity (angiosperms and pteridophytes) of Bhubaneswar Municipal Corporation area with emphasis on identification of important species and habitats of conservation concern.	Dr. P. C. Panda	OBB, Odisha	2014-2015	Completed
3	Preventing extinction and improving conservation status of the threatened plants through application of Biotechnological tools	Dr. P. C. Panda	DBT, GOI	2012-2018	Completed
4.	Qualitative and quantitative assessment of plant diversity of Chandka-Dampara sanctuary with special emphasis on identification of keystone, rare and useful species and their habitats.	Dr. P.C.Panda	PCCF (Wildlife), Odisha	2014-2016	Completed
5	Harnessing the potential of endopytes against root knot nematode Meloidogyne icognita in banana	Dr. N.Gupta	DBT, MS&T,	2018-2021	On going
6	Optimization of submerged culture requirements for the production of mycelial growth and exopolysaccharide by some selected Fungi	Dr. N.Gupta	GOI	2018-2021	On-going
7	Standardization of nursery technology by application of PGPF (Plant growth promoting fungi) under different soil compositions and its impact on quality of Piper longum: A RET medicinal plant of Odisha	Dr. N.Gupta	NMPB, Dept.of AYUSH, GOI	2016-2019	On going
8	Fungal diversity in Subarnarekha mangrove ecosystem of Odisha.	Dr. N.Gupta	OBB, GoO	2014-2016	Completed
9	Inventory and study of wild edible and poisonous mushrooms in the forest ecosystem of Odisha	Dr. N.Gupta	MEF&CC, GOI	2013-2016	Completed

Sl. No	Title	PI	Funding	Period	Status
10	Assessment of antioxidant and hepatoprotective potential of *Homalium* species found in Eastern Ghats, India	Dr. A. K.Sahoo	NMPB, GOI	2014-2019	Ongoing
11	Antinflammatory effects of *Homalium zeylanicum* in type 2 diabetic rats	Dr. A. K.Sahoo	S&TDept., GoO	2014-2018	Completed
12	Evaluation bioactive polysaccharides for its anticancer and immunomodulatory activity from wild edible mushrooms found in Odisha	Dr. A. K.Sahoo	DBT, GOI	2015-2018	Completed
13	Marker profiling of Geophila repens as a potential socrce for drug development against Alzheimer diesease	Dr. A. K.Sahoo	DST, GOI	2015-2016	Completed
14	Establishment of mass propagation and breeding facility for orchids	Dr. N. R. Nayak	RKVY	2017-2020	On going
15	Establishment of tissue culture based mass propagation facility of banana and plantains	Dr. N. R. Nayak	RKVY	2016-2020	On going
16	Mass propagation and reintroduction of *Eria meghasaniensis* an endemic and threatened orchid of Similipal Biosphere Reserve	Dr. N. R. Nayak	PCCF (WL), GoO	2014-2016	Completed
17	Cloning and characterization of cellulose synthase genes of sugarcane	Dr. N. R. Nayak	DBT, GoO	2014-2016	Completed
18	Omics'- approach to regulate ripening and enhance fruit shelf life in	Dr. G.K.Surabhi	RKVY, ICAR, GOI	2017-2020	On going
	Cloning and functional validation of key ripening process genes and enhancement of fruit shelf life in banana	Dr. G.K.Surabhi	S&T Dept., GoO	2016-2019	On going
19	Evaluation of unexplored Ardisia solanacea and Aegiceras corniculatum plants of Myrsinaceae family as embelin and other related compounds producing substitutes for overexploited RET medicinal species Embelia ribes & E. tsjeriam-cottam	Dr. U.C. Basak	NMPB, Dept of AYUSH, GOI	2016-19	Ongoing
20	Standardisation of nursery technology by application of PGPF (Plant Growth Promoting Fungi) under different soil composition and its impact on quality of *Piper longum*, a RET medicinal plant of Odisha	Dr. U.C. Basak (Co-PI)	NMPB, Dept of AYUSH, GOI	2016-19	ongoing
21	Evaluation of nutrients and antinutrients in two unexplored wild edible fruits of Odisha	Dr. U.C. Basak	S &T Dept., GoO	2014-17	Completed
22	Centralized Nursery for Bamboo	Dr. U.C. Basak	OBDA, GOO,	2014-16	Completed

Sl. No	Title	PI	Funding	Period	Status
23	Mass Propagation of Local *Musa* Varieties of Odisha, Commercialization using Tissue Culture Techniques.	Dr. B. Deo	RKVY, GOI	2017-2020	On going

STATE PLAN FUNDED PROJECTS

Sl. No	Title	PI	Funding	Period	Status
1	Bio-prospecting, propagation and reintroduction of some selected threatened plants of Odisha	Dr. P.C.Panda	F&E Dept., GoO	2018-2019	On going
2	Study of the structure and composition of tree vegetation in representative forest types and compilation of the pictorial guide to forest trees of Odisha	Dr. P.C.Panda	F&E Dept., GoO	2018-2019	On going
3	Study of the diversity, distribution and phenology of forest trees of Odisha and development of a pictorial guide and easy identification key based on macro morphological characters.	Dr. P.C.Panda	F&E Dept., GoO	2017-2018	Completed
4	Identification of plus trees and elite clones standardization of propagation methods and production of quality planting materials of some rare timber trees of Orissa.	Dr. P.C.Panda	F&E Dept., GoO	2017-2018	Completed
5	Floristic studies in sanghagra area for biodiversity conservation and climate change impacts.	Dr. P.C.Panda	F&E Dept., GoO	2016-2017	Completed
6	Study of the diversity, distribution and phenology of forest trees of Odisha and development of a pictorial guide and easy identification key based on macro morphological characters.	Dr. P.C.Panda	F&E Dept., GoO	2015-2017	Completed
7	Inventory of wild population, refinement, standardization of propagation methods and reintroduction of some threatened Plant species of Odisha.	Dr. P.C.Panda	F&E Dept., GoO	2014-2017	Completed
8	Quantitative ecological study and phytosociology of sal (*Shorea robusta*) in different sal-dominated forest type of Orissa	Dr. P.C.Panda	F&E Dept., GoO	2014-2015	Completed
9	Qualitative and quantitative assessment of Plant biodiversity (angiosperms and pteridophytes) of Bhubaneswar Municipal Corporation area with emphasis on identification of important species and habitats of conservation concern.	Dr. P.C.Panda	F&E Dept., GoO	2014-2015	Completed
10	Extraction, purification and characterization of L –asparaginase from Fusarium sp.	Dr. N.Gupta	F&E Dept., GoO	2018-2019	On going
11	Process optimization of enhanced recovery of antifungal lead molecule from mangrove fungi	Dr. N.Gupta	F&E Dept., GoO	2018-2019	On going

Sl. No	Title	PI	Funding	Period	Status
12	Bioprospecting mangrove fungi for phosphate solubising and antifungal potential	Dr. N.Gupta	F&E Dept., GoO	2017-2018	Completed
13	Screening for bio control agents against fungal pathogens causing Panama wilt and Anthracnose diseases on banana varieties cultivated in Odisha	Dr. N.Gupta	F&E Dept., GoO	2016-2017	Completed
14	Impact of microbial applications on growth and development of *Madhuca latifolia* (Mahua) and *Pongamia pinnata* (Karanja) under nursery conditions	Dr. N.Gupta	F&E Dept., GoO	2016-2017	Completed
15	Diversity of mushrooms from urban environment of Bhubaneswar and its suburban areas	Dr. N.Gupta	F&E Dept., GoO	2016-2017	Completed
16	Designing of nursery technology through novel bioinoculant for better growth and development of some important plantation tree species of Odisha	Dr. N.Gupta	F&E Dept., GoO	2015-2016	Completed
17	Development of time cutback and low cost technology for biodegradation of green wastes used in Vermicomposting	Dr. N.Gupta	F&E Dept., GoO	2015-2016	Completed
18	Studies on fungal associations of two RET Orchids (*Eria meghasaniensis* and *Pomatocalpa decipiens*) of Odisha and its evaluation for growth, development and establishment	Dr. N.Gupta	F&E Dept., GoO	2014-2015	Completed
19	Formulation of bioagent by using native plant growth promoting microbes and evaluation of their usefulness for agriculture productivity	Dr. N.Gupta	F&E Dept., GoO	2014-2015	Completed
20	Extraction of secondary metabolites from some mushrooms of odisha and evaluation of their bioactivity as antimicrobial and anticancer agent	Dr. N.Gupta	F&E Dept., GoO	2012-2014	Completed
21	Taxonomic and functional characterization of fungal flora of some Orchids	Dr. N.Gupta	F&E Dept., GoO	2012-2014	Completed
22	*In Vitro* Propagation of *Tainia penangiana* Hook.f , *Phaius tankervilleae* (Banks) Blume and *Pomatocalpa decipiens* (Lindl.) J.J.Sm. for Introduction into the Natural Habitats.	Dr. N. R. Nayak	F&E Dept., GoO	2018-2019	On going
23	Elucidation of Genetic Network for Cell Wall Maturation of Sugarcane towards Biofuel Production	Dr. N. R. Nayak	F&E Dept., GoO	2018-2019	On going
24	Evaluation of drought and salt tolerance potential of one of the wildly growing species of saccharum genus (*Saccharum bengalense* Retz.)	Dr. N. R. Nayak	F&E Dept., GoO	2017-2018	Completed
25	Population analysis of *Dendrobium regium* prain: one of the extremely rare and endemic orchids of India.	Dr. N. R. Nayak	F&E Dept., GoO	2016-2017	Completed

Sl. No	Title	PI	Funding	Period	Status
26	Production of healthy, genetically uniform, virus free planting materials of ornamentals *Dendrobiums* through tissue culture.	Dr. N. R. Nayak	F&E Dept., GoO	2016-2017	Completed
27	Conservation of *Dendrobium regium* and *Cymbidium bicolor* through introduction of *in vitro* raised seedlings	Dr. N. R. Nayak	F&E Dept., GoO	2016-2017	Completed
28	Restoration of orchids population through reintroduction of *in vitro* raised seedlings	Dr. N. R. Nayak	F&E Dept., GoO	2015-2016	Completed
29	Enzymatic saccharification of different lignocellulosic biomass produced in Odisha towards production of bioethanol	Dr. N. R. Nayak	F&E Dept., GoO	2015-2016	Completed
30	Production of quality plantlets of ornamental orchids	Dr. N. R. Nayak	F&E Dept., GoO	2015-2016	Completed
31	Conservation of orchids of Odisha through reintroduction of *in vitro* raised seedlings to their natural habitats	Dr. N. R. Nayak	F&E Dept., GoO	2014-2015	Completed
32	Mass propagation, standardisation of cultivation practices and development of molecular markers of ornamental orchids	Dr. N. R. Nayak	F&E Dept., GoO	2014-2015	Completed
33	Neuroprotective effect of *Geophila repens* in Alzheimer disease-A pivotal role for modulating oxidative stress.	Dr. A.K.Sahoo	F&E Dept., GoO	2018-2019	On going
34	*Hydrolea zeylanica* ameliorates type-II diabetic induced neurodegenerative disorders.	Dr. A.K.Sahoo	F&E Dept., GoO	2018-2019	On going
35	Phytochemical investigation and biological screening of *Homalium* sp. Wall (Benth) for antioxidant and hepatoprotective activity	Dr. A.K.Sahoo	F&E Dept., GoO	2013-2014	Completed
36	Evaluation of *Geophila repens* as a potential source for drug against Alzheimer disease	Dr. A.K.Sahoo	F&E Dept., GoO	2014-2015	Completed
37	Antidiabetic potential of *Homalium zeylanicum* in streptozotocin induced diabetic rats	Dr. A.K.Sahoo	F&E Dept., GoO	2014-2015	Completed
38	Phytochemical investigation and biological evaluation of *Hydrolea zeylanica*	Dr. A.K.Sahoo	F&E Dept., GoO	2015-2016	Completed
39	Phytochemical screening and Toxicity profiling of G*eophila repens*-An Endangered species	Dr. A.K.Sahoo	F&E Dept., GoO	2015-2016	Completed
40	Phytochemical screening and Toxicity profiling of *Geophila repens*-An Endangered species	Dr. A.K.Sahoo	F&E Dept., GoO	2016-2017	Completed
41	Anti-diabetic and anti-inflammatory studies of *Hydrolea zeylanica*	Dr. A.K.Sahoo	F&E Dept., GoO	2016-2017	Completed
42	Pharmacology and toxicological studies of *Geophila repens*	Dr. A.K.Sahoo	F&E Dept., GoO	2017-2018	Completed

Sl. No	Title	PI	Funding	Period	Status
43	Chemical profiling and pharmacological validation of *Hydrolea zeylanica*	Dr. A.K.Sahoo	F&E Dept., GoO	2017-2018	Completed
44	Standardization on micro-propagation methods for large-scale production of *Anogeissus latifolia/ Santalum album/ Desmodium ogeinense*	Dr. G.K.Surabhi	F&E Dept., GoO	2018-2019	On going
45	Developing multiplex PCR-based genetic fidelity testing protocols for tissue culture raised banana plantlets at RPRC	Dr. G.K.Surabhi	F&E Dept., GoO	2017-2018	On going
46	Molecular characterization and assessment genetic variability in *Shorea robusta* Gaertn. tree population in Odisha	Dr. G.K.Surabhi	F&E Dept., GoO	2017-2018	On going
47	Identification of key ripening proteins in banana through proteomic approach.	Dr. G.K.Surabhi	F&E Dept., GoO	2016-2017	Completed
48	Molecular characterization and assessment of genetic variability in *Shorea robusta* Gaertn. tree populations in Odisha	Dr. G.K.Surabhi	F&E Dept., GoO	2015-2016	Completed
49	Cloning and functional validation of salinity tolerant genes from mangrove plants of Odisha.	Dr. G.K.Surabhi	F&E Dept., GoO	2014-2015	Completed
50	Proteomic analysis of banana fruit to identify fruit ripening process related key proteins.	Dr. G.K.Surabhi	F&E Dept., GoO	2014-2015	Completed
51	Molecular characterization and assessment of genetic variability in *Shorea robusta* Gaertn. populations in Odisha.	Dr. G.K.Surabhi	F&E Dept., GoO	2014-2015	Completed
52	Genetic fidelity testing for tissue culture raised banana at RPRC by using PCR based molecular tools.	Dr. G.K.Surabhi	F&E Dept., GoO	2013-2014	Completed
53	Isolation and functional validation of salt tolerant genes from mangrove plants of Odisha.	Dr. G.K.Surabhi	F&E Dept., GoO	2013-2014	Completed
54	Proteomic studies on banana and other wild edible fruit plants of Odisha.	Dr. G.K.Surabhi	F&E Dept., GoO	2013-2014	Completed
55	Assessment of pectins and essential amino acids (EAA) in some unexplored wild edible fruits of Odisha	Dr. U.C. Basak	F&E Dept., GoO	2018-19	ongoing
56	Evaluation of vegetatively propagated re-introduced mangrove plant Heritiera littoralis for their adaptability in Bhitarkanika National Park.	Dr. U.C. Basak	F&E Dept., GoO	2018-19	ongoing
57	Re-Introduction of vegetatively propagated mangroves in Bhitarkanika National Park and Balasore Wildlife Division and evaluation of their field performance.	Dr. U.C. Basak	F&E Dept., GoO	2017-18	Completed

Sl. No	Title	PI	Funding	Period	Status
58	Exploration and screening of wild edible fruits for pectins, Amino acids and other nutrients	Dr. U.C. Basak	F&E Dept., GoO	2017-18	Completed
59	Screening of essential aminoacids (EAA) in some wild edible fruits used by tribals of Odisha	Dr. U.C. Basak	F&E Dept., GoO	2016-17	completed
60	Re-introduction of *Heritiera littoralis* (dhala sundari), a back mangrove species of Odisha coast.	Dr. U.C. Basak	F&E Dept., GoO	2016-17	completed
61	Analysis of some unexplored wild edible fruits of Odisha for their nutritional properties	Dr. U.C. Basak	F&E Dept., GoO	2016-17	completed
62	Ex-situ conservation and evaluation of Embelia tsjeriam-cottam for embelin content	Dr. U.C. Basak	F&E Dept., GoO	2015-16	completed
63	Propagation & Re-introduction of RET and other important back mangrove species of Odisha Coast.	Dr. U.C. Basak	F&E Dept., GoO	2015-16	completed
64	Nutritional, antinutritional & antioxidant analysis of 10 wild edible fruits of Odisha	Dr. U.C. Basak	F&E Dept., GoO	2015-16	completed
65	Comparative analysis of nutritional, antinutritional and antioxidant properties in some wild edible fruits of Odisha with their cultivated counter parts	Dr. U.C. Basak	F&E Dept., GoO	2014-15	completed
66	Conservation of RET mangroves : propagation and reintroduction in the wild	Dr. U.C. Basak	F&E Dept., GoO	2014-15	completed
67	Production of QPM of Embelia tsjeriam-cottam (baibidanga) : Propagation, Conservation and estimation of 'embelin' content	Dr. U.C. Basak	F&E Dept., GoO	2014-15	completed
68	Biomolecular characterization and conservation of wild *Saraca asoca* populations in Odisha	Dr. U.C. Basak	F&E Dept., GoO	2013-2014	Completed
69	Conservation, biochemical characterization and testing of the efficacy of some selected medicinal plants of Odisha	Dr. U.C. Basak	F&E Dept., GoO	2013-2014	Completed
70	Propagation, conservation and re-introduction of mangroves and related research on wetland plants	Dr. U.C. Basak	F&E Dept., GoO	2013-2014	Completed
71	Evaluation of selected medicinal Plants against aflatoxin producing fungus *Aspergillus flavus*	Dr. S.Bhatnagar	F&E Dept., GoO	2017-2019	Ongoing

Sl. No	Title	PI	Funding	Period	Status
72	A study on seed viability of important medicinal plant *Withania somnifera.*	Dr. S.Bhatnagar	F&E Dept., GoO	2018-2019	Ongoing
73	Selection of suitable protocols for propagation of the vulnerable medicinal plant *Celastrus paniculatus*	Dr. S.Bhatnagar	F&E Dept., GoO	2017-2018	Completed
74	Bioassay guided isolation of antifilarial principles from *Terminalia arjuna* and *Rouvolfia tetraphylla.*	Dr. S.Bhatnagar	F&E Dept., GoO	2017-2018	Completed
75	Phytochemical, antioxidant and Cytotoxic activity of leaf extracts of *Pancratium verecundum* and *Crinum defixum*	Dr. S.Bhatnagar	F&E Dept., GoO	2016-2017	Completed
76	Bioassay guided isolation of antifilarial principles from selected medicinal plants using Setaria cervi as target parasite	Dr. S.Bhatnagar	F&E Dept., GoO	2016-2017	Completed
77	Isolation of alkaloids from medicinal plant *Rauvolfia tetraphylla*	Dr. S.Bhatnagar	F&E Dept., GoO	2015-2016	Completed
78	Comparative evaluation of cultivated and wild variety of vulnerable medicinal plant *Paedaria foetida*	Dr. S.Bhatnagar	F&E Dept., GoO	2015-2016	Completed
79	Phytochemical characterization and testing of cytotoxic and antioxidant potential of medicinal plants *Rauvolfia tetraphylla* and *Barleria cristata*	Dr. S.Bhatnagar	F&E Dept., GoO	2014-2015	Completed
80	In vitro propagation of Banana (var. Champa and Yangambi) and Assessment of Genetic Fidelity in the Regenerated Plantlets through RAPD and ISSR markers.	Dr. B.Deo	F&E Dept., GoO	2018-2019	On going
81	Study of the effects of different phyto-hormones on in vitro mass propagation of *Musa* spp.	Dr. B.Deo	F&E Dept., GoO	2017-2018	Completed
82	Effects of growth regulators on proliferation of shoot and root of Banana through *in vitro*.	Dr. B.Deo	F&E Dept., GoO	2016-2017	Completed
83	To Introduce new *Musa* variety, Yangambi in Odisha, Commercialize Using Tissue Culture Techniques.	Dr. B.Deo	F&E Dept., GoO	2015-2017	Completed
84	Standardization of Protocol for Mass Propagation of Banana through Tissue Culture.	Dr. B.Deo	F&E Dept., GoO	2015-2016	Completed
85	Standardisation of efficient, safer and cost effective protocols for mass propagation of different banana through tissue culture.	Dr. B.Deo	F&E Dept., GoO	2014-2015	Completed

Sl. No	Title	PI	Funding	Period	Status
86	Studies on systematic, morphology, taxonomy and bioprospecting of Solanaceae in Eastern Ghats, India	DR. C.Kalidass	F&E Dept., GoO	2018-2019	On going
87	Mass production of micro-tubers of potato through tissue culture.	Dr. C. Kalidass	F&E Dept., GoO	2018-2019	On going
88	Conservation and production of synthetic seeds for selected endangered species of Odisha	Dr. C. Kalidass	F&E Dept., GoO	2016-2017	Completed
89	A systematic study of the genus *Solanum* L. (Solanaceae) in Eastern Ghats of India	Dr. C. Kalidass	F&E Dept., GoO	2016-2017	Completed
90	A systematic study of the genus *Solanum* L. (Solanaceae) in Eastern Ghats of India	Dr. C. Kalidass	F&E Dept., GoO	2015-2016	Completed
91	Mass multiplication and restoration of selected endangered plant species in Odisha	Dr. C. Kalidass	F&E Dept., GoO	2015-2016	Completed
92	Vegetative propagation of Lodha (*Symplocos racemosa* Roxb.)	Dr. C. Kalidass	F&E Dept., GoO	2014-2015	Completed
93	Micropropagation of selected endangered medicinal plants using biotechnological tools	Dr. C. Kalidass	F&E Dept., GoO	2014-2015	Completed
94	Study on distribution, phytogeography and reproductive biology of *Symplocos racemosa* Roxb. in Odisha	Dr. C. Kalidass	F&E Dept., GoO	2013-2014	Completed
95	*Ex situ* conservation of selected endangered medicinal plants using Biotechnological tools (*Cordia macleodii* Hook.f. & Thoms and *Blepharispermum subsessile* DC)	Dr. C. Kalidass	F&E Dept., GoO	2013-2014	Completed

PUBLICATIONS

Research Papers

2018

1 Panda, P.C., Kumar, S., Singh, J. P., P. Kamila, P.K. Kashung, S. Kulloli, R.N.Singh, P.P.Adhikari and Barik, .K. (2018). Improving macro-propagation and seed germination techniques for conservation of threatened species. Current Science. 114(3): 562-566, (IF: 0.843)

2 Haridasan, K., Mao, A.A., Janarthanam, M.K., Pandey, A.K., Barik, S.K., Srivastava, S.K., Panda, P.C., Suresh, Geeta, Borthakur, S.K., Datta, B.K. and Rao, B. Ravi Prasad (2018). Contributions of plant taxonomy, herbarium and field germplasm bank to conservation of threatened plants: case studies from Himalayas and Eastern and Western Ghats. Current Science. 114(3): 512-518. (IF: 0.843)

3 Behera, B., Sinha, P., Gouda, S., Rath, S.K., Barik, D.P., Jena, P.K., Panda, P.C., and Naik, S.K. (2018). In vitro propagation by axillary shoot proliferation, assessment of antioxidant activity and genetic fidelity of micropropagated Paederia foetida L. J. App. Biol. Biotech. 6(2): 41-49.

4 Asit Ray, Jena, S., Dash, B., Kar, B., Halder, T., Chatterjee, T., Ghosh, B., Panda, P.C., Nayak, S. and Mahapatra, N. (2018). Chemical diversity, antioxidant and antimicrobial activities of the essential oils from Indian population of Hedychium coronarium Koen. Industrial Crops and Products (Elsevier). 112: 353-362. (IF: 3.85)

5 Sahoo H. R. and N.Gupta (2018) .Diversity of endophytic phosphate solubilising fungi associated with Pomatocalpa decipiens (Lindl.) J.J. Smith - an endangered orchid in Barbara forest of Odisha, India Studies in fungi , 3(1):84-89

6 Mishra S, S.Pany and N.Gupta (2018). Phosphate solubilization potential of Native rhizospheric microfolra and their impact on growth of Madhuca latifolia (Mahua): an oil yielding medicinal plant of India . Studies in fungi 3(1);59-72.

7 Sahoo H.R. and N.Gupta (2018). Evaluation of Phosphate Solubilisation Potential of Eight Isolate of Aspergillus niger and their Utility in Enhancing the Growth of Piper longum under Field Condition Int J curr Micro and applied science 7(4): 2881-2889 (NAAS 5.38)

8 Pany Swatishree, Swagatika Mishra, Nibha Gupta (2018) Evaluation of native rhizospheric and phosphate solubilising microbes for growth and development of Pongamia pinnata under nursery condition" ADVANCES IN BIORESEARCH. Vol. 9 [1] :92-101 2018. (NAAS-4.77)

9 Panigrahi Manas Ranjan, Soumya Ranjan Nayak and Nibha Gupta (2018). Beneficial impact of fungal inoculation on growth and development of Terminalia arjuna and Terminalia bellirica ADVANCES IN BIORESEARCH. Vol. 9 [1]:140-144 2018 (NAAS-4.77)

10 Sahoo, A.K., Dandapat, Jagneshswar, Dash, Umesh Chandra and Kanhar, Satish (2018). Features and outcomes of drugs for combination of therapy as multi-targeteds strategy to combat Alzheimer's disease. Journal of Ethnopharmacology. (Elsevier).215: 42-73. (IF: 3.49)

11 Kanhar, Satish, Sahoo, Atish Kumar and Mahapatra, Ajay Kumar (2018). The ameliorative effect of Homalium nepalense on carbon tetrachloride-induced hepatocellular injury in rats. Biomedicine & Pharmacotheraphy. (Elsevier). 103: 903-914. (IF: 3.39)

12 Surabhi, G.K. (2018). Update in root proteomics with special reference to abiotic stresses: achievements and challenges. Journal of Protein & Proteomics (Springer). 9(1): 31-55. (IF: 1.00).

13 Behera, D.R. and Bhatnagar, S. (2018). Assessment of macrofilaricidal activity of leaf extract of Terminalia sp. Against bovine filarial parasite Setaria cervi. Journal of Infection and Public Health. https://doi.org/10.1016/j.jiph.2018.01.006 (IF: 1.439).

14 Vishwakarma, R. and Bhatnagar, S. (2018). Comparative analysis of leaf extracts of Phyllanthus niruri and Phyllanthus reticulatus. World Journal of Pharmacy and Pharmaceutical Sciences. 7(4): 1004-1014.

15 Behera, D.R. and Bhatnagar, S. (2018). Filariasis: role of medicinal plants in lymphatic filariasis. International Journal of Herbal Medicine. 6(1): 40-46. (IF: 2.47)

16 Deo B. and Chhatoi N. (2018). Influence of NaCl Treatments on Micropropagation of Musa spp. cv. Gaja Bantala. International Journal of Agriculture & Environmental Science. 5 (2) : 59-61.

17 Kalidass C. (2018). A New Combination in Steirachne Ekman (Poaceae: Eragrostidineae). Journal of Biological Records 3(1): 190-192.

2017

18 Dash, P.K., Panda, P.C. and Upadhyay, H.S. (2017). Endemic vascular plants of Odisha: A reappraisal. Plant Science Research. 39(1&2): 84-88. (NAAS: 3.63)

19 Mallick, S.N., Naik, S.K. and Panda, P.C. (2017). Diversity of wild edible food plants and their contribution to livelihood of tribal people in Nabarangpur district , Odisha. Plant Science Research. 39(1&2): 64-75. (NAAS: 3.63)

20 Murugan, P., Kalidass, C. and Panda, P.C. (2017). Andrographis longipedunculata (Sreem.) L.H. Cramer (Acanthaceae) – an addition to the flora of Odisha. Plant Science Research. 39(1&2): 82-83. (NAAS: 3.63)

21 Murugan, P., Kalidass, C. and Panda, P.C. (2017). Pityrogramma Link. (Pteridaceae) – A new generic record for Odisha, India. Plant Science Research. 39(1&2): 79-81. (NAAS: 3.63)

22 Ray, A., Jena, S., kar, B., Pattnaik, J., Panda, P.C. and Nayak, S. (2017). Chemical composition and antioxidant activities of essential oil of Hedychium greenii and Hedychium gracile from India. Natural Product Research (Taylor & Francis), DOI: 10.1080/14786419.2017.1416384. (IF: 1.828)

23 Kar, S.K., Tripathy, P.K., Mohanty, S.K., Achary, P.K. and Panda, P.C. (2017). Additions to the flora of Chilika lake and its immediate neighbourhood. J. Econ. Taxon. Bot. 40(3-4): 134-150.

24 Kamila, P.K., Ray, A., Sahoo, A., Nayak, S., Mohapatra, P.K. and Panda, P.C. (2017). Physicochemical charcterisation of the Lasicocca comberii Haines Seeds. Natural Product Research (Taylor & Francis). 32(6): 739-742. (DOI:10.1080/14786419.2017.1408091) (IF: 1.828)

25 Biswal, A.K. and Panda , P.C. (2017). Searsia paniculata (Wall. Ex G.Don) C.Y. Wu & T.L. Ming (Anacardiaceae) – an additional tree species for the flora of Odisha, India. NeBio. 8 (1): 63-65.

26 Murugan, P., Kalidass, C. and Panda, P.C. (2017). Solanum villosum Mill. (Solanaceae): A new plant record for Eastern Ghats of India. Ind. J. Forestry. 40(1): 73-75.

27 Kamila, P.K., Ray, Asit, Jena, S., Mohapatra, P.K. and Panda, P.C. (2017). Chemical composition and antioxidant activities of the essential oil of Hypericum gaitii Haines_ an endemic species of Eastern India. Natural Product Research (Taylor & Francis). 32(6): 739-742. (DOI:10.1080/14786419.2017.1338283) (IF: 1.828)

28 Sinha, P., Nanda, S.P., Joshi, R.K. and Panda, P.C. (2017). Development of a Sequence Tagged Site (STS) marker for sex identification in dioecious rattan speies Calamus guruba Buch.-Ham. Molecular Breeding (Springer). 37(3): 22. (DOI: 10.1007/s11032-017-00630-z). (IF: 2.077).

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BOOKS/ BOOKLETS/BOOK CHAPTERS

Books and Book chapters

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TRAINING AND EDUCATION

Short term Training to the students of M.Sc. / B.Tech. / M/Tech. and other courses are provided every year from January to June for a duration of 6 months. Training is imparted on the "Advance Plant Biotechnology". The students have to submit their CV along with the forwarding letter from their Institutes head or the Project head. The applications are to be received by end of November every year. Students enroll themselves by end of December and the training starts from January (6 months). Students are allotted to various Scientists and have to work under them for completing their Thesis. At the end of the course they are issued a course completion certificate. During 2012 a total of 22 students were imparted training. Where as in 2013, 21 numbers of students were given training on plant biotechnology. But in the year 2014 the number of students was restricted and only 13 students were enrolled for the 6 months training course.

Summer training is imparted to the NIT, Rourkela students every year in the month of May. Forwarding letter from the NIT, authority along with the ID nos. of the students is received at this end. On the basis of it the students are asked to deposit the course fee so that the course – "Summer-Internship in Biotechnology" could commence at the right time. A separate programme and course content is prepared for it. At the end they are issued the internship completion certificate.

Year of Training: 2012

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
1	Sonali Sarkar	Molecular Characterisation of wild and cultivated species of *Amaranthus* using RAPD & ISSR markers.	Dr. P.C.Panda Pr. Scientist	2012
2	Sarmila Roulo	Assessment of genetic diversity of *Cordia* spp. (Boraginaceae) with special emphasis on *Cordia oblique- Cordia dichotoma* complex.	Dr. P.C.Panda Pr. Scientist	2012
3	Saswati Nanda	Phylogenetic relationship among the species of *Cycas* (Cycadaceae) as inferred from ISSR & RAPD markers.	Dr. P.C.Panda Pr. Scientist	2012
4	Swayamsiddha Manaswini Samal	Evaluation of intra-specific genetic variability in *Cycas sphaerica* with the application of molecular markers.	Dr. P.C.Panda Pr. Scientist	2012
5	Asit Kumar Behera	Impact of soil compositions on growth and antioxidant activity of *Trigonella* and *Coriander* under pot culture conditions.	Dr. N.Gupta Sr. Scientist	2012
6	Priyambada Pati	Characterization of endophytic fungi for extracellular amylase production.	Dr. N.Gupta Sr. Scientist	2012
7	Sashikanta Satapathy	Effect of microbial inoculants and inorganic fertilizers on growth and antioxidant properties of *Coriander* under greenhouse conditions.	Dr. N.Gupta Sr. Scientist	2012
8	Jayashree Panda	Antioxidant properties of some fungi under different nutritional conditions.	Dr. N.Gupta Sr. Scientist	2012
9	Suchismita Behera	Accacia auriculiformis A. cunn ex Benth: A potential plant for biofuels production in Odisha.	Dr. N.R.Nayak Sr. Scientist	2012

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
10	Swatishree Shradhanjali	Studies on *Cymbidium aloifolium* (L.) sw and *Cymbidium bicolor* (Lindl.): Two Epiphytic wild orchids of Odisha.	Dr. N.R.Nayak Sr. Scientist	2012
11	Monika Kumari	Comparative study on evaluation of nutritive value of some commonly used wild edible fruits of Odisha.	Dr. U.C.Basak Scientist	2012
12	Pallavi Suman Mishra	Evaluation of total antioxidant activity of some selected wild edible fruits of Odisha.	Dr. U.C.Basak Scientist	2012
13	Keholeon Kennao	Phytochemical evaluation of spikes of *Piper longum* from various agro-climatic zones of Odisha.	Dr. U.C.Basak Scientist	2012
14	Alaka Pradhan	Salt induced alternation of protein, phenol and antioxidative enzymes during seedling growth of *Xylocarpus grantum*.	Dr. U.C.Basak Scientist	2012
15	Usharani Nanda	Effect of hormones on shoot and root growth of *Musa acuminate* cv. Bantala grown *in vitro*.	Dr. B.Deo Scientist	2012
16	Namita Tudu	Effect of different hormones on micropropagation of *Musa acuminate* cv. Grand naine.	Dr. B.Deo Scientist	2012
17	Supriya Tripathy	Stiudies on morphological, biochemical and enzymatical activities of different varieties of *Vigna radiate* through pot culture experiment.	Dr. B.Deo Scientist	2012
18	Monalisa Nath	Evaluation of antioxidant activity of *Ocumum tenuiflorum*.	Dr. B.Deo Scientist	2012
19	Minakshi Ganjir	Comparative analysis of *Ipomoea pes-caprae* and *Merremia umbellate* leaf extracts using phytochemical analysis and bioevaluation.	Dr. S.Bhatnagar Scientist	2012
20	Rituparna Panigrahi	Phytochemical analysis and bio-evaluation of medicinal plant *Enhydra fluctuans*.	Dr. S.Bhatnagar Scientist	2012
21	Swati Patnaik	Phytochjemical analysis and bio-evaluation of medicinal plant *Vernonia anthclementica*.	Dr. S.Bhatnagar Scientist	2012
22	Tanvi Sharma	Phytochjemical analysis and bio-evaluation of medicinal plant *Barleria cristata*.	Dr. S.Bhatnagar Scientist	2012

Year of Training: 2013

Sl.no.	Name of the student	Title of the dissertation	Guide	Year
1	Hare Krushna Swain Coll.BS&H,OUAT	Assessment of genetic diversity and molecular phylogeny of six species of *Calamus* (Arecaceae) from Eastern ghats.	Dr. P.C.Panda Pr. Scientist	2013
2	Mangesh Prabhakarrao Pande Nagpur University	Left after 3 months.	Dr. N.Gupta Sr. Scientist	2013
3	Manish A. Pachkawade Nagpur University	Left after 3 months.	Dr. N.Gupta Sr. Scientist	2013
4	Bijay Kumar Bagh Sambalpur University	Evaluation of the genetic fidelity of tissue culture raised Banana cv. Grand naine using DNA based marker.	Dr. G.K.Surabhi Sr. Scientist	2013
5	Nihar Ranjan Rout Sambalpur University	Inter-sample sequence repeats (ISSR) primer screening and preliminary evaluation of genetic variation in *Saraca asoca* population.	Dr. G.K.Surabhi Sr. Scientist	2013
6	Neha TACT, BBSR	Evaluation of the genetic fidelity of Banana var. Bantala using PCR based molecular markers.	Dr. G.K.Surabhi Sr. Scientist	2013
7	Richa TACT, BBSR	Phytochemical and invitro antioxidant activity of leaves of *Homalium nepalense*.	Dr. A.K.Sahoo Sr. Scientist	2013
8	Ritesh Ranjan TACT, BBSR	Phytochemical and pharcological investigation of bark of *Homalium nepalense*.	Dr. A.K.Sahoo Sr. Scientist	2013
9	Priyanbada Shetty TACT, BBSR	UV-Spectrophotometric determination of Acetaminophen content of different brands of paracetamol tablet of 500mg.	Dr. A.K.Sahoo Sr. Scientist	2013
10	Mainak Sinha TACT, BBSR	Mass propagation of Gaja Bantala (A plantain variety) through tissue culture.	Dr. N.R.Nayak Sr. Scientist	2013
11	Sambedana Biswal TACT, BBSR	Effect of different growth hormones on micropropagation of *Musa acuminate* cv. 'Grand naine'.	Dr. B.Deo Scientist	2013
12	Megha Choudhuri TACT, BBSR	Study of biochemical and antioxidant activity of *Catharanthus roseus* L. 'Alba'.	Dr. B.Deo Scientist	2013
13	Priyanka Priyadarshini TACT, BBSR	Isolation and estimation of vital secondary metabolites present in the roots of *Piper longum* collected from various agro-climatic zones of Odisha.	Dr. U.C.Basak Scientist	2013
14	Bishnupriya Mohanty TACT, BBSR	Antioxidant properties of some sour and sweet wild edible fruits of Odisha.	Dr. U.C.Basak Scientist	2013
15	Reetu Viswakarma TACT, BBSR	Comparative analysis of leaf extracts of *Phyllanthus nirisi* and *Phyllanthus reticulatus*.	Dr. S.Bhatnagar Scientist	2013

Sl.no.	Name of the student	Title of the dissertation	Guide	Year
16	Saba Parween TACT, BBSR	Comparative analysis of leaf and tuber extracts of *Alpinia culcarata*.	Dr. S.Bhatnagar Scientist	2013
17	Sasmita Jena TACT, BBSR	Isolation and molecular characterization of symbiotic bacteria from mild legumes.	Dr. B.K.Babu Scientist	2013
18	Pragya Paramita Sahoo TACT, BBSR	Isolation and detection of viral DNA from the tissue cultured banana plants.	Dr. B.K.Babu Scientist	2013
19	Gyana Ranjan Behuria TACT, BBSR	Isolation and molecular characterization of obligate fungi causing Downy mildew disease on bitter gourd (*Momordica charantia*).	Dr. B.K.Babu Scientist	2013
20	Gyana Ranjan Jenamani Sambalpur University	*In vitro* propagation of *Spathoglottis plicata Blume*: an ornamental terrestrial orchid.	Dr. C.Kalidass Scientist	2013
21	Jyotiranjan Dalabehera MITS, BBSR	*In vitro* conservation of *Stemona tuberosa* Lour. An endangered medicinal plant.	Dr. C.Kalidass Scientist	2013

Year of Training: 2014

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
1	Subrat Kumar Kisku OUAT, Bhubaneswar	Assessment of genetic diversity of three species of *Saraca* (*Caesal piniaceae*) using RAPD and ISSR marker.	Dr. P.C.Panda Pr. Scientist	2014
2	Priyanka Sahoo SOA, Bhubaneswar	Isolation and characterization of fungi from medicinal plant.	Dr. N.Gupta Sr. Scientist	2014
3	Anuradha Panda MITS, Bhubaneswar	Studies on growth pattern and extracellular enzymatic activity of some fungi.	Dr. N.Gupta Sr. Scientist	2014
4	Debabrata Dash MITS, Bhubaneawar	Saccharification of two potential legume trees [*Cassiea siamea* Lann. and *Sesbania grandiflora* (L.) Poir.] for biofuel production by Lignocellulose Fractionation followed by Enzymatic Hydrolysis.	Dr. N.R.Nayak Sr. Scientist	2014
5	Meghali Biswas AMIT, Bhubaneswar	Pharmacological evaluation of antioxidant and antidiabetic activity of a potential extract from *Azadirachta indica*.	Dr. A.K.Sahoo Sr. Scientist	2014
6	Protsahana Satapathy AMIT, Bhubaneswar	Anti-inflammatory and free radical scavenging activity of *Terminalia arjuna*.	Dr. A.K.Sahoo Sr. Scientist	2014
7	Anita Ojha MITS, Bhubaneswar	Decophering the genetic identity and fidelity of mico-propagated banana through ISSR fingerprinting.	Dr. G.K.Surabhi Sr. Scientist	2014
8	Nikhil Kumar MITS, Bhubaneswar	Analysis of nutritional, anti-nutritional and antioxidant properties of some edible fruits of Mangroves.	Dr. U.C. Basak Scientist	2014

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
9	Saraswati Maharana SOA, Bhubaneswar	Phytochemical, cytotoxic and antioxidant activities of leaf extracts of *Aristolchia indica* (Linn.).	Dr. S. Bhatnagar Scientist	2014
10	Padmalaya Behera TACT, Bhubaneswar	Effect of growth hormones on morphological and biochemical changes in *Musa acuminate* cv. Bantal grown *invitro*.	Dr. B. Deo Scientist	2014
11	Priyanka Barik MITS, Bhubaneswar	Isolation and molecular detection of RNA viruses infecting banana crop.	Dr. B.K. Babu Scientist	2014
12	Mousumee Behura SOA, Bhubaneswar	Isolation and molecular detection of Banana Bract Mosaic Virus (BBrMV) in cultivated banana plants.	Dr. B.K. Babu Scientist	2014
13	Sambit Ranjan Biswal MITS, Bhubaneswar	High frequency multiple shoot induction and *invitro* regeneration of *Dendrocalamuis strictus* (Raxb.) Nees.	Dr. C. Kalidass Scientist	2014

Year of Training: 2015

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
1	Ms. Snita Dash SOA Univ., BBSR	Effect of nutritional media and culture conditions on growth and development of myceloid fungi.	Dr. N. Gupta, Sr. Scientist	2015
2	Ms. Madhumita Behera SOA Univ., BBSR	Enzymatic saccharification of *Saccharum bengalense* Rebi: a potential bioenergy crop.	Dr. N. R. Nayak, Sr. Scientist	2015
3	Ms. Deepshika MITS, BBSR	Phytochemical investigation and biological evaluation of wild orchid "*Cymbidium aloifolium*".	Dr. A. K. Sahoo, Sr. Scientist	2015
4	Ms. Pankhuri MITS, BBSR	Establishing ISSR fingerprinting profiles and evaluation of intra genetic variability in *Shorea robusta* Gaertn. population.	Dr. G. K. Surabhi, Sr. Scientist	2015
5	Ms. Rojesh Stella Kujur Ravenshaw Univ, CTC	Proteome analysis of banana fruit key ripening proteins.	Dr. G. K. Surabhi, Sr. Scientist	2015
6	Ms. Shovna Singh Ravenshaw Univ, CTC	Assessment of some nutritional parameters of six edible fruit of mangrove species.	Dr. U. C. Basak, Scientist	2015
7	Ms. Saswoti Patra SOA Univ., BBSR	Phytochemical, antioxidant and cytotoxic activity of leaf extracts of *Turnera ulmifolia*.	Dr. S. Bhatnagar, Scientist	2015
8	Ms. Lopamudra Pradhan AMIT, Khurda	Exploration of cytotoxic and antioxidant potential of *Antigonon leptopus* (Family: Polygonaceae).	Dr. S. Bhatnagar, Scientist	2015
9	Mr. Bikram Pradhan AMIT, Khurda	Cost effective protocol for mass propagation of *Musa paradisiaca* (a Plantain variety) through tissue culture.	Dr. B. Deo, Scientist	2015

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
10	Ms. Chinmayee Behera AMIT, Khurda	Morphological and Molecular characterization of powdery mildew pathogen infecting on pumpkin crop.	Dr. B. K. Babu, Scientist	2015
11	Ms. Lasky Das BU, Berhampur	Collection and establishment of pumpkin powdery mildew pathogen under glass house and determination of its spore germination time.	Dr. B. K. Babu, Scientist	2015
12	Ms. Snigdhamayee Nayak AMIT, Khurda	Effect of plant growth regulators and explant types on micropropagation of *Blepharispermum subsessile* DC. – An endangered medicinal plants.	Dr. C. Kalidass, Scientist	2015

Year of Training: 2016

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
1	Ms. Sukanya Mishra MITS, BBSR	Assessment of genetic variability in sal (*Shorea robusta* Gaertn.) tree populations of Odisha by ISSR markers.	Dr. G. K. Surabhi, Sr. Scientist	2016
2	Ms. Smrutika Mishra MITS, BBSR	A comparative proteomic analysis of banana fruit during pre-climacteric and climacteric stages of ripening.	Dr. G. K. Surabhi, Sr. Scientist	2016
3	Ms. Nibedita Chhatoi MITS, BBSR	Induction of roots in *Musa paradiciaca* cv. Gaja Bantala grown invitro under saline condition.	Dr. B. Deo, Scientist	2016
4	Ms. Lizaranee Behuria SOA, BBSR	Analysis of Nutritional, Antinutritional and Antioxidant properties of Five Wild Edible Fruits of Odisha.	Dr. U. C. Basak, Scientist	2016
5	Ms. Pusparani Garabadu SOA, BBSR	Comparative analysis of biological properties of *Saraca asoca* and *Saraca declineta*.	Dr. S. Bhatnagar, Scientist	2016
6	Ms. Dipsikha Samantaray MITS, BBSR	Evaluation of Phytochemical, Antioxidant and Cytotoxic activites of leaf extracts *Vallaris solanacea* (Roth) Kuntze.	Dr. S. Bhatnagar, Scientist	2016
7	Ms. Rashmi Das MITS, BBSR	Antioxidant, Cytotoxic and Phytochemical assessment of lef extracts of Golden Trumpet (*Allamanda cathartica* L.)	Dr. S. Bhatnagar, Scientist	2016
8	Ms. Dipika Badajena UU, BBSR	Isolation and characterization of fungi from Botanic garden (Ekamrakanan) of Bhubaneswar.	Dr. N. Gupta, Sr. Scientist	2016
9	Ms. Priyadarshini Mallia UU, BBSR	Studies on rhizospheric microflora and evaluation of their extracellular beneficial activity.	Dr. N. Gupta, Sr. Scientist	2016

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
10	Ms. Aiswarya Ghadei SOA, BBSR	Evaluation of glucose release potential of different *Agave* biomass towards bioethanol production.	Dr. N. R. Nayak, Sr. Scientist	2016
11	Ms. Sangeeta Mahato SOA, BBSR	*Invitro* Biological Assessment of some Indian Medicinal Plants of Zingiberaceae family.	Dr. A. K. Sahoo, Sr. Scientist	2016

Year of Training: 2017

Sl.no.	Name of the student	Title of the dissertation	Guide	Year
1	Mr. Abhijit Tripathy SOA, BBSR	Assessment of genetic diversity of some important sea grasses of Odisha coast usig ISSR markers.	Dr. P. C. Panda, Pr. Scientist	2017
2	Mr. Kalpataru Mallick SOA, BBSR	Study of genetic diversity of *Cycas spharica* (Cycadaceae) – an endangered species of Eastyern ghats using ISSR makers.	Dr. P. C. Panda, Pr. Scientist	2017
3	Ms. Trupty Pragyan Nayak UU, BBSR	Antimicrobial properties of some edible and non-edible mushrooms.	Dr. N. Gupta, Sr. Scientist	2017
4	Ms. Pragyan Dash UU, BBSR	Bioactive potential of Termitomyces, Ganoderma and Phallus: Wild mushrooms of Odisha.	Dr. N. Gupta, Sr. Scientist	2017
5	Ms. Shibani Sahu MITS, BBSR	Evaluation of different cultivars of *Agave* grown in Odisha for Gucose release from leaf biomass towards bioethanol production.	Dr. N. R. Nayak, Sr. Scientist	2017
6	Ms. Nishi Padma Samal MITS, BBSR	Evaluation of Glucosse release from the biomass of *Saccharum bendalense* Retz. Towards second generation bioethanol production.	Dr. N. R. Nayak, Sr. Scientist	2017
7	Ms. Rashmi Naik MITS, BBSR	Studies of Inter Simple Sequence Repeat molecular marker profile of different cutivars of *Spathoglottis* (Orchidaceae).	Dr. N. R. Nayak, Sr. Scientist	2017
8	Ms. Bhaswatimayee Mahakur MITS, BBSR	Two-dimentional gel electrophoresis based proteomic analysis of banana during fruit ripening.	Dr. G. K. Surabhi, Sr. Scientist	2017
9	Ms. Sushree Subhasmati Mohanty MITS, BBSR	Two-dimentional gel electrophoresis based proteomic analysis of banana during fruit development.	Dr. G. K. Surabhi, Sr. Scientist	2017
10	Ms. Supriya Sahoo MITS, BBSR	Assessment of genetic variability in *Saraca asoca* tree populations of Oisha by ISSR markers.	Dr. G. K. Surabhi, Sr. Scientist	2017
11	Ms. Aiswariya Rath PGDBiosci, CPS, Berhampur	Spectroscopic method of qualitative evaluation of some of the paracetamol formulated tablets and their therapeutic validation for anti-inflamatory activities.	Dr. A. K. Sahoo, Sr. Scientist	2017

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
12	Ms. Kalyani Barik PGDBiosci, CPS, Berhampur	Anti-oxidant and anti-diabetic properties of some Indian spices.	Dr. A. K. Sahoo, Sr. Scientist	2017
13	Mr. Bedadyuti Mohanty SRM Univ., TN	Pharmacological validation of some Indian spices for cholinesterase inhibitory activities.	Dr. A. K. Sahoo, Sr. Scientist	2017
14	Ms. Bharati Mishra SOA, BBSR	Nutritional and antinutritional evaluation of some lesser known wild edible fruits.	Dr. U. C. Basak, Scientist	2017
15	Ms. Narmada Beura TACT, BBSR	Comparative analysis of antioxidant potential of selected wild edible fruits od Odisha.	Dr. U. C. Basak, Scientist	2017
16	Ms. Suchideepa Das TACT, BBSR	Screening of pectin content in 15 wild edible fruits of Odisha.	Dr. U. C. Basak, Scientist	2017
17	Ms. Jayashree Sahoo MITS, BBSR	Biological evaluation of leaf extracts of Indian wormwood (*Artemisia nilagirica* L.)	Dr. S. Bhatnagar, Scientist	2017
18	Ms. Rojalini Jena PGDBiosci, CPS, Berhampur	Bioevaluation of rhizomes of Mango ginger (*Curcuma amada*).	Dr. S. Bhatnagar, Scientist	2017
19	Ms. Saswati Nayak PGDBiosci, CPS, Berhampur	Antioxidant, cytotoxic and phytochemical assessment of rhizomes of Black Turmeric (*Curcuma caesia*).	Dr. S. Bhatnagar, Scientist	2017
20	Ms. Sarojini Kar AMIT, BBSR	Micropropagation of Yagambi (*Musa* species) through invitro meristem culture.	Dr. B. Deo, Scientist	2017
21	Mr. Smruti Ranjan Mohanty PGDBiosci, CPS, Berhampur	Effects of phytohormones on micropropagation of *Musa* spp. FHIA-03 through tissue culture.	Dr. B. Deo, Scientist	2017
22	Ms. Anima Priyadarshini Jena MITS, BBSR	Effect of Thidiazuron (TDZ) on regeneration from existing meristem and induced meristem of *Blepharispermum subsessile* DC – An endangered medicinal plant.	Dr. C. Kalidass, Scientist	2017
23	Ms. A. K. P. Akshita MITS, BBSR	Effect of growth regulators on regeneration from exiting and induced meristems of *Blepharispermum subsessile* DC – An endangered medicinal plant.	Dr. C. Kalidass, Scientist	2017
24	Ms. Subhra Pallabee Nanda MITS, BBSR	Effect of different concentration of Thidiazuron (TDZ) on in vitro proliferation of culinary type *Banana* var. *Bantal*.	Dr. C. Kalidass, Scientist	2017

Year of Training: 2018

Sl. No.	Name of the student	Title of the dissertation	Guide	Year
1	Ms. Rupali Priyadarshini Paria UU, BBSR	Studies on antifungal properties of *Penicillium* sp. against *Fusarium* sp.	Dr. N. Gupta, Pr. Scientist	2018
2	Mr. Amit Kumar Swain MITS, BBSR	Exploration of cytotoxic and antioxidant potential of *Pongamia pinnata* (Family: Fabaceae).	Dr. S. Bhatnagar, Sr. Scientist	2018
3	Ms. Namrata Priyadarshini MITS, BBSR	Exploration of cytotoxic and antioxidant potential of *Plumbago capensis* (Family: Plumbaginaceae).	Dr. S. Bhatnagar, Sr. Scientist	2018

Ph.D. Awarded (Period 2012-2018)

Sl. No.	Name of the Supervisor / candidate	Title of the Doctoral program	University registered/ Year
1	**Dr. P.C. Panda, Principal Scientist**		
	Dr. Pradosh Ku. Acharya	Phylogenetic relationships in the sub-tribe Phaseolinae (Leguminosae: Papilionoideae) as inferred from molecular marker.	Utkal University, Vani Vihar, Bhubaneswar.
	Dr. Akhil Ku. Debata	Molecular characterization and analysis of genetic relationships among the members of the sub-tribe Cajaninae (Leguminosae: Papilionoideae).	Utkal University, Vani Vihar, Bhubaneswar
	Dr. Sanjay Ku. Pattanaik	Quantitative assessment of mangrove vegetation of the Bhitarkanika wildlife sanctuary, Orissa.	Utkal University, Vani Vihar, Bhubaneswar
	Dr. (Mrs.) Pankajini Bal	Study of molecular systematic and phylogenetic relationships among the members of the tribe Dalbergieae (Leguminosae: Papilionoideae).	North Orissa University, Baripada, Mayurbhanj

Sl. No.	Name of the Supervisor / candidate	Title of the Doctoral program	University registered/ Year
2	**Dr. Nibha Gupta, Pr. Scientist**		
	Dr. Sujata Dash	Characterization and evaluation of biofertilization potential of phosphate and iron solubilising fungi and rhizobia for tree legumes. (Reg. No.: 22-Biotech2007-08)	Dept. of Biotechnology, Utkal University, Bhubaneswar
	Dr. Krishna Raju Patro	Studies on cultural biochemical and nutritional factors affecting L-asparaginase production by some fungi. (Reg. No.: 14- Biotech 2008-09)	Dept. of Biotechnology, Utkal University, Bhubaneswar
	Dr. Sushree Shant Tripathy	Inventorization and evaluation of biochemical and antioxidant properties of some wild mushrooms of Odisha. (Reg. No.: 03- Micro 2012-13)	Dept. of Microbiology, Utkal University, Bhubaneswar
	Dr. Ashutosh Rajoriya	Studies on cultural, nutritional and biochemical characterization of some wild edible mushrooms of Odisha. (Reg. No.: 02-Micro 2012-13)	Dept. of Microbiology, Utkal University, Bhubaneswar
3	**Dr. Nihar Ranjan Nayak, Sr. Scientist**		
	Dr. Nitesh Ku. Mund	Studies on the life cycle assessment for bio-ethanol production from different biomass and cloning and characterization of cellulose synthase genes of the members of *Saccharum* genus	Dept. of Botany Utkal University, Bhubaneswar 2014-Present
4	**Dr. B. Deo, Sr. Scientist**		
	Dr. Yogamaya Dhal	Antioxidant profile of ethno-medicinal plants of Koraput district, Orissa. (Reg. No. 05-Life Sc. 2009-2010)	Dept. of Life Science, Utkal University, Bhubaneswar.
	Dr (Mrs.) Kalyani Singh	Studies on antioxidative and antidiabetic properties of *in vitro* culture of *Gymnema sylvestre* (Retz.) R. Br. Ex. Schult. (Reg. No. 11-Life Sc. 2009-2010)	Dept. of Life Science, Utkal University, Bhubaneswar.
5	**Dr. U. C. Basak, Sr. Scientist**		
	Dr. (Ms.) Pramodini Rout	Screening of biomolecular markers expressed during *ex-vitro* multiple shoot regeneration in hypocotyls of four Rhizophoraceae mangroves under salinity stress. (Reg. No.: 13PH-BT-010)	Ravenshaw University
	Dr. (Ms.) Manisha Mohapatra	Assessment of Embelin content and its antioxidant activity of two less-explored plant species of the family Myrsinaceae. (Reg. No.: 01-Botany-2014-2015)	Utkal University

Orchids

Mangrove

Ardisia solanacea

EX-SITU CONSERVATION & GERMPLASM COLLECTION

RPRC has rich living collections of different plant groups. Till date, cacti and other succulents, wild and exotic orchids, species with fragrant flowers, endangered and threatened plants, medicinal plants, mangroves, palms, bamboos, wild edible fruit plants, cultivars of *Hibiscus* and Rose have been introduced to the living collection division and are being studied. Following are some of the *ex-situ* collections available in RPRC.

Wild Edible Fruits Garden

Wild edible fruits are the rich source of nutrition for thousands of years. Even after significant developments in agriculture still a sizable population of modern world depends on these gifts of nature to meet their nutritional requirements. In view of the importance of these species RPRC has developed a "Wild Edible Fruits Garden" in its premises with an aim of ex-situ conservation of these species. This garden has good collection of 106 species which include *Zizyphus mauritiana, Syzigium cumini,* ***Cordia dichotoma****, Ficus spp etc.*

Cacti and other Succulents

RPRC has one of the best and rich collections of cacti and other succulents. The Centre houses more than 1000 species and cultivars. Part of the collections is displayed in a beautiful Cactus House which is open to the visitors. *Gymnocalycium spp, Mammalaria spp, Cereus spp, Cleistocactus spp, Coryphantha spp, Echinopsis spp, Opuntia spp, Prodia* spp form the part of this collection.

Orchids

More than 137 species of orchids are reported so far from Odisha. Most of the species are under threatened categories and some like *Eria meghasaniensis, Tainia hookeriana* have reached critical levels. Keeping in view the declining population of orchids and role played in the field of floriculture, RPRC has taken up the responsibility of conservation of these rare and unique plants. Research on various aspects

Tainia hookeriana growing at Similipal Biosphere Reserve

Flower of *Tainia hookeriana*

of orchids including developing of hybrids and reintroduction of tissue cultured seedlings into wild is going on. To support this programme and also to conserve the germplasm of these species of orchids RPRC has a collection of nearly 100 species of orchids. Besides this many hybrids are also available.

Steps have been taken to preserve the germplasm of orchids of Odisha under *in vitro* condition. In this regard, seeds have been made on the plants by pollination and cultured on nutrient medium to produce seedlings. Factors influencing the seed germination and subsequent development have been analysed. Seedlings of 25 wild orchids have been made and being maintained at the culture room. Orchids are mostly important for their ornamental value, thus new varieties are being collected from different places in order to strengthen the germplasm collection of the institute. During 2012 to 2015 the following varieties were collected and successfully grown at the orchid house viz. *Dendrobium* Miniature**,** *Spathoglottis* sp.

Species with Fragrant Flowers

As a part of conservation programme RPRC has also established a "Garden of Species with Fragrant Flowers". In this garden 74 species have been planted. Among them *Cananga odorata, Gardenia jasminoides, Magnolia coco, Murraya paniculata* etc. are worth mentioning.

Endangered and Threatened Species

In any conservation programme of plant resources the first priority is RET (Rare/Endangered/Threatened) species. Ideally all Rare, Endangered and Threatened (RET) plant species should be conserved as evolving populations in the natural habitat and should also be conserved *ex situ*. Collection and conservation of rare, endangered, threatened and endemic plants in a garden from is very much useful for the study of their reproductive biology, taxonomy aspects, maintenance of their germplasm for the purpose of propagation and multiplication studies, etc. According to the conservation role of botanic or RET gardens prepared by IUCN in 1987, these *ex situ* collections will act as sources for easily available plant materials for propagation, research and education purposes. In line with this principle RPRC has developed a RET garden. In this garden more than 30 RET species have been planted. These include the species like *Cycas sphaerica, Cordia maclleodii, Gnetum ula, Homalium tomentosum, Hypericum gaitti, Pomatocalpa decipiens* etc. Besides, *ex situ* germplasm also developed with some selected endangered species i.e., *Cordia macleodii* Hook.f. & Thoms, *Blepharispermum subsessile* DC and critically endangered *Symplocos racemosa* Roxb. for further multiplication.

A view of *Cordia macleodii* plantation in RPRC campus

A view of Sambarsinga / Baurlo / Bhoto / Sikari / Phanki (*Cordia macleodii*) plantation in RPRC campus

A view of Lodha (*Symplocos racemosa*) plantation in RPRC campus

Palmetum

Palms are very important and interesting group of plants. RPRC has a noticeable collection of different palm species. The palmetum is represented by nearly 60 species of palms. These include *Archontophoenix alexandrae, Calamus spp, Corypha umbraculifera, Dypsis lutescens, Livistonia chinensis, Ravenea rivularis* etc. Besides, authentic quality planting materials are being

produced from such mother palms from this financial year and being sold to the consumers, nursery personnel, private entrepreneurs at cheaper rate for which they were depending to the production and supply on A.P, W.B or Uttarakhand. Some of the important species of Palm presently developing from ex-situ conserved plant of RPRC are *Areca* palm, *Phoenix acaulis,Pritchardia pacifica*, Blue palm, Red palm- *Cyrtostachys renda*, *Dipsy* palm,*Washingtonia filifera*, *Ravenia rivularis*, *Livistona chinensis, Phoenix sylvestris*

Bambusetum

Bamboos are rightly referred as GREEN GOLD. They are put to different uses by various sections of society including commercial establishments. Large number of people depends on bamboos for their livelihood. Keeping in view the importance of bamboos RPRC has established a bambusetum as part of conservation efforts. This bambusetum has collections of nearly 30 species. Bamboos collected include *Arundinaria chino, Arundo donax, Bambusa balcooa, Dinochloa maclellandii, Melocanna baccifera, Phyllostachys nigra, Pseudosasa japonica* etc.

Medicinal Plants Garden

Importance of medicinal plants in traditional and modern healthcare is well established. To conserve the germplasm of medicinal plants RPRC has developed a Medicinal Plants Garden. Total of 237 plants of high medicinal value have been well preserved in this garden which include *Amaranthus spinosus, Aristolochia indica, Caesalpinia bonduc, Celosia argentea, Desmodium heterocarpon, Mirabilis jalapa, Phyllanthus amarus, Piper betle, Tylophora indica* etc.

Besides, two RET medicinal plants viz. *Embelia tsjeriam-cottam* (baibidanga) and *Operculina terpethum* (dudhalomo) are vegetatively propagated following various conventional methods, mass multiplied and being conserved in the experimental field nursery of RPRC. Though dudhalomo is a easy-to-root species, baibidanga is relatively hardy but can be propagated through root/stump-cuttings. Because of their vital medicinal, commercial as well as ecological importance, these RET species were collected from different agro-climatic habitats, propagated and being conserved for further use.

Ex-situEmbelia tsjeriam-cottam in RPRC

Hibiscus Garden

This garden houses the collection of 52 varieties of *Hibiscus* species.

Rose Garden

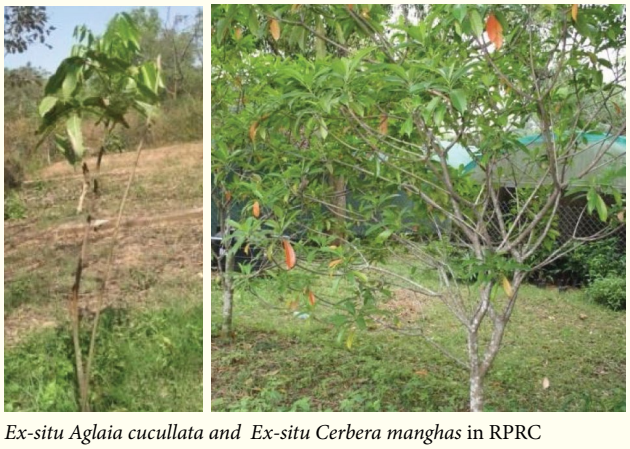
RPRC has rich collection of Rose varieties. Keeping in view the utility of roses in Odisha, very recently, RPRC has added 749 varieties to its existing cultivars totaling to 1084. Varieties like Lolita, Lord Luis, Mamy blue, Marria Callos, Milk ray, Monnalissa, Pearl, Pearl Beast, Rangoli, Rangastova are being added. This would be the highest collection of cultivars in the entire state and it has been proposed to stand RPRC as one of the few reputed collection centres in India by raising its present status of cultivars. Not only symbol of adoration, innocence and love, at present roses commercial exploitation like cut flowers, potted plants (poly pot and earthen pots) are the other possibilities to provide employment to unemployed youth. At present RPRC earns lakhs of rupees by selling rose plantlets to cultivators and city dwellers by producing more than 10,000 budded rose plants annually. In future rose water, rose oil, *Gulkhand* i.e. equal proportion of rose petal pounded with sugar and *Pankkuri*, i.e. sweetened cold drinks can also be exploited independently or in collaboration with interested parties.

ABSTRACTS OF ROSES AT RPRC

Item	Hybrid Tea	Floribundas	Miniatures	Climbers	Polyantha	Total
Existing	212	73	42	8	--	335
Plantation during 2014-15	637	73	36	--	3	749
	833	**146**	**78**	**8**	**3**	**1084**

Ex-situ Mangroves

As an unique attempt, several salt-sensitive tree mangrove species like *Aglaia cucullata* (uanra), *Intsia bijuga* (mahasweta), *Cerbera manghas, Heritiera littoralis* were vegetatively propagated, hardened and established in the experimental field of RPRC. Though most of these plants are difficult-to-root species, yet, can be vegetatively propagated, mass multiplied and thus be made available as and when required to augment plantation, re-introduction as well as species recovery programme.



Ex-situ Aglaia cucullata and Ex-situ Cerbera manghas in RPRC

REINTRODUCTION OF RET & OTHER IMPORTANT PLANTS

Plant reintroduction play a number of important roles in species conservation : to reinstate the original biological diversity of a degraded area as part of a restoration programme, the plant used may be part of a general planting matrix to aid in the re-establishment of a community, or they may be single species with a particular value. The re-ntroduction of a rare species can be used to secure or improve the status of a protected area. The reintroduction of a high valued species can play a important role as a symbol for conservation projects and provide an avenue for training and research at a variety of levels. The reintroduction may create opportunities for economic return in the form of limited harvesting or ecotourism.

Re-introduction of Mangrove species

Excoecaria agallocha (guan) is of the salt-sensitive landward mangrove species which contributes a considerable population density and thus play a major role in formation of total mangrove vegetation systems of Odisha coast. As a compensatory measure against its gradual depletion owing to habitat loss and natural regeneration, RPRC has initiated re-introduction trial of this species with around 2000 vegetatively propagated saplings in an experimental plot in the wild at Khadibil area under Balasore Wild Life Division with financial support from state plan budget. The re-introduced saplings were vegetatively propagated and hardened against suitable NaCl-induced salinity stress to evaluate salt tolerance for successful re-establishment in the wild.

Reintroduction of Orchids

Reintroductions of four orchid seedlings were carried out at different natural habitat of the state. Seedling were produced through *in vitro* culture of seeds and thoroughly acclimatized at the green house. Seedlings of *Dendrobium regium*, *Dendrobium moschatum, Rhyncostylis retusa* and *Phaius tankervilleae* were reintroduced. The details of the reintroduction are mentioned below. At each site of reintroduction fertilizer 'Polyfeed' that contains N: P: K (19:19:19) and essential micronutrients were applied at 1gm/l on the plants weekly. To prevent any fungal infection bavistin at 2gm/l applied to the plants biweekly. Growth and development of the plants were monitored at different times.

Re-introduction of *Excoecaria agallocha* (Khadibil, Balasore Wildlife Division)

Orchids reintroduced on 2014-15

Name of the Species	Site of Reintroduction	No of Plants Reintroduced
Dendrobium regium	Sanaghagara, Keonjhar	100
	Gudugudia	100
	Ransa range office	200
Phaius trankervilleae	Sarkanda Reserve Forest, Sundargarh	75
Dendrobium moschatum	Gudugudia	100
Rhyncostylis retusa	Tamana Reserve Forest, Khordha	100

a, &b: Reintroduction of *Phaius tankervilleae* at Sarkanda reserve forest of Sundargarh

c. Reintroduction of *Dendrobium regium* at Koenjhar

d. Reintroduction of *Dendrobium regium* at *Gudgudia*, Similipal Biosphere Reserve

e. Reintroduction of *Rhyncostylis retusa* at Tamana Reserve Forest, Khordha

SEMINAR/CONFERENCE/WORKSHOP/ EXHIBITION/MEETING

1. Events organized by RPRC

1.1. Meetings of Advisory Committees

19th Scientific Advisory Committee (SAC) Meeting, 2013

The 19th Scientific Advisory Committee (SAC) Meeting of Regional Plant Resource Centre (RPRC), Bhubaneswar was held on 28th November, 2013 at 3-00 PM in the PK Parija Hall of the Centre. The SAC meeting was attended by Dr. Paramjit Singh, Director, Botanical Survey of India, Kolkata as Chairman, Dr. A.K. Mahapatra, Chief Executive, RPRC, as Member-Secretary, Shri S.B. Samant, Director-cum-Spl. Secretary to Govt., Dr. Trilochan Mohapatra, Director, CRRI, Professor P.K. Chand, Utkal University and Dr. Kishore CS Panigrahi, Reader, NISER, as Member of the SAC. The committee reviewed the presentations made by the scientists on their ongoing work and also future research programmes for various lines of research. The SAC concurred to the institutional projects implemented by the centre.

20th Scientific Advisory Committee (SAC) Meeting, 2014

The 20th Scientific Advisory Committee (SAC) Meeting of Regional Plant Resource Centre (RPRC), Bhubaneswar was held on 15th November, 2014 at 3-00 PM in the PK Parija Hall of the Centre. The SAC meeting was attended by Dr. Paramjit Singh, Director, Botanical Survey of India, Kolkata as Chairman, Shri Shashi Paul, Chief Executive, RPRC, as Member-Secretary, Shri S.B. Samant, Director-cum-Spl. Secretary to Govt, as Member, Professor P.K. Chand, Utkal University, as Member and Dr. Kishore CS Panigrahi, Reader, NISER, as Member of the SAC. All the Scientists of RPRC presented their research activities before the Committee. After careful evaluation of the completed and ongoing research projects, the Committee suggested and recommended various future aspects of fruitful research activities.

1.2. Research Advisory Committee (RAC) of Regional Plant Resource Centre, Bhubaneswar

The First Meeting of the Research Advisory Committee (RAC) of Regional Plant Resource Centre (RPRC), Bhubaneswar was held on 27th February, 2015 at 3-30 PM in the PCCF (HoFF) Office, Aranya Bhawan, Bhubaneswar. The RAC meeting was attended by Shri J.D. Sharma, PCCF,Odisha as Chairman, Shri S.B. Samant, Director, Environment-cum-Special Secretary to Government,Odisha, as member, Shri M. Mohan,

A view of the 20th SAC Meeting,2014 of RPRC

CCF (wildlife), Odisha as member, Shri O.P. Singh, CCF (Training and Development), Odisha as member, Dr. P.C. Panda, Principal Scientist,RPRC as member and Shri Shashi Paul,Chief Executive, RPRC as Member-Convener.

At the outset of the meeting, Shri Shashi Paul, Chief Executive, RPRC welcomed the dignitaries and offered a brief introductory presentation on the 1st RAC meeting of RPRC. He explained the status of the ongoing research projects being implemented in RPRC with the financial supports received from State Plan (institutional) as well as external agencies like DBT, MoEF and State DST etc. for the year 2014 and 2015.

In order to take up research projects relevant to the Odisha state, all the Scientists of RPRC presented their project proposals before the Committee for consideration of grant under State Plan budget for the financial year 2015-16. A total 29 project proposals submitted by 10 Scientists were evaluated. Finally, 21 projects were recommended for the financial year 2015-16.

1.3. National Conference on "Biodiversity Assessment, Monitoring and Conservation : Application of Biotechnological Tools & 39th Annual Conference of Orissa Botanical Society , 2015"

The Regional Plant Resource Centre in collaboration with Orissa Botanical Society organized a National Conference on "Biodiversity Assessment, Monitoring and Conservation: Application of Biotechnological Tools" and the 39th Annual Conference of Orissa Botanical Society on 22nd and 23rd February, 2015 to discuss and deliberate on issues relating to plant biodiversity inventory, assessment and conservation in the country. Besides, role of modern techniques of molecular biology, plant tissue culture, cryo-preservation, seed banking and policy and legal issues concerning conservation of biological diversity of plants was also dealt at length. More than 300 delegates and subject experts from Odisha and other parts of the country working in the field of plant biodiversity participatedduring two-day deliberations, shared their views and experiences and identified gaps for further research and management intervention.

To mark the occasion, a "Souvenir" was brought out containing articles on plant biodiversity of India and Odisha, important habitats, organizations involved in research on biological diversity, history of research and teaching botany in the state etc. contributed by learned academicians and researchers. An issue of "Plant Science Research"- the official journal of the Orissa Botanical Society, was released. A number of scientists/ teachers/ researchers and students of the state making significant contribution to teaching/ research/ popularization of botanical sciences in the state were awarded with different prizes instituted by the Orissa Botanical Society. Besides oral presentation of papers, there was a section on poster presentation by researchers and students.

The conference was inaugurated by Sri U. N. Behera, IAS, Development Commissioner and Additional Chief Secretary, Forest & Environment Department, Govt. of Odisha. Sri J. D. Sharma, IFS, PCCF, Odisha attended the inaugural session as the Guest of Honour. Dr. Paramjit Singh, Director, Botanical Survey of India, Kolkata delivered the keynote address on the topic "Plant diversity in India: Role in economic development". Prof. S. K. Barik, North Eastern Hill University, Shillong (Meghalaya) and Prof. B. Ravi Prasad Rao, Dept. of Botany, S. K. University, Anantapur, Andhra Pradesh were the lead speakers of the conference and they spoke on "An integrated approach to threatened plants conservation: Experiences from India" and "Plant resources of Eastern Ghats of India: Quantitative assessment and mapping - A retrospect and current status" respectively.

In the inaugural function, Sri Shashi Paul, IFS, Chief Executive, Regional Plant Resource Centre and Chairman of the Organizing Committee of the National Conference welcomed the guests. Dr. K. B. Satpathy, Secretary, Orissa Botanical Society read the activity report of the Society and Prof. H. K. Patra, President of Orissa Botanical Society presided over the function and delivered the presidential talk on "Phyto-remediation Technology: A Novel Approach for Management of Chromium Toxicity Stress". Dr. P. C. Panda, Principal Scientist, Regional Plant Resource Centre and the Organizing Secretary of the Conference proposed a formal vote of thanks. The National Conference was supported by the National Biodiversity Authority, Chennai; Science and Engineering Research Board, Department of Science & Technology, Government of India; Department of Forest & Environment, Government of Odisha and State Council on Science and Technology, Department of Science & Technology, Government of Odisha.

2. Participation of RPRC in various events

2.1. World Forestry Day 2014 in Jaydev Bhawan, BBSR

RPRC had participated in the World Forestry Day 2014 held at Jaydev Bhawan and displayed its various R&D activities . The major activities were highlighted through poster as well as live display on Conservation of Threatened (RET) Plants, propagation and improvement of Orchids, Ex situ Conservation/Re-introduction, Studies on Genetic Diversity, Conservation & Evaluation of wild fruits & other species, Commercial Production & Supply of TC banana & orchid plants and vermicompost etc.

RPRC Participation in World Forestry Day, 2014

2.2.Conference on 'Biodiversity Conservation and Sustainable Development in Odisha,2014"

In order to promote the cause of biodiversity conservation and create awareness among the public in general, 22nd May is being celebrated worldwide as the International Day for Biological Diversity. As a state level celebration of International Day for Biological Diversity in Odisha, Odisha Biodiversity Board in collaboration with Regional Plant Resource Centre had organised a conference on "Biodiversity Conservation and Sustainable Development in Odisha" at Hotel New Marrion, Convent Square, Bhubaneswar. The programme was fully supported by National Biodiversity Authority, Chennai.

The conference was inaugurated by Professor Manoranjan Kar, Vice-Chancellor, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar as the Chief Guest of the Inaugural Function. Sri S. S. Srivastava, IFS, Principal Chief Conservator of Forests (Wildlife), Odisha was the Guest of Honour. A booklet containing the abstracts of presentations and a book entitled "Biological Diversity of Regional Plant Resource Centre, Bhubaneswar" were released on this occasion. Sri Shashi Paul, IFS, Member Secretary, Odisha Biodiversity Board and Chief Executive, Regional Plant Resource Centre welcomed the guests and delegates at the Inaugural Session. Dr. P. C. Panda, Principal Scientist, RPRC conducted the meeting and proposed formal vote of thanks.

In the scientific sessions, some 40 invited resource persons and delegates presented their findings/ views under the following four selected themes.

i. Forest Biodiversity

ii. Coastal & Wetland Biodiversity

iii. Agricultural Biodiversity & Livestock

iv. Biodiversity Education, Role of Community, Legal and Policy Issues

Professor R. C. Mohanty, Scientist Emeritus, Department of Botany, Utkal University and Sri B. K. Pattnaik, Former PCCF (Wildlife), Odisha chaired the scientific sessions. the recommendations/ suggestions made out of the deliberations during this conference would be useful for formulation of strategies for conservation

For popularization of important medicinal plants, a brochure was designed giving the photographs and medicinal uses of 20 important medicinal plants. Same is distributed to the visitors of stall in the herbal fair.

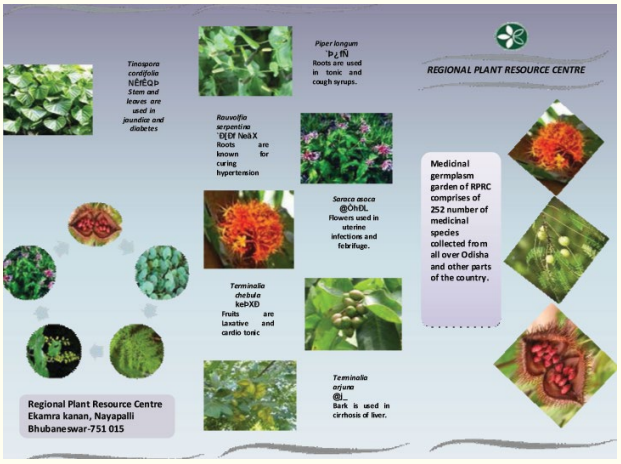
of the biological diversity of Odisha and also address livelihood and development issues.

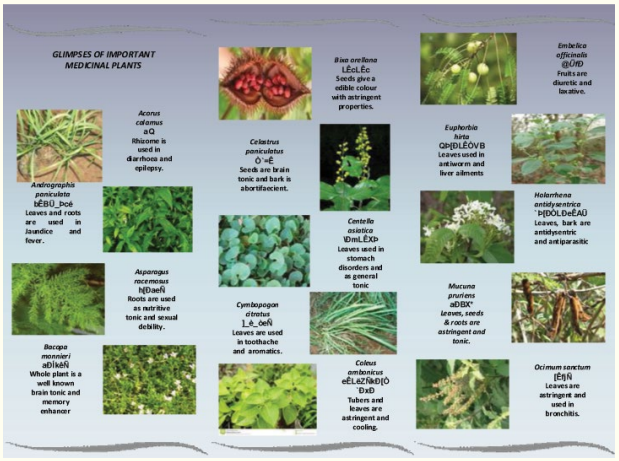
2.3. Kalinga Herbal Fair

Kalinga Herbal Fair organised by State Medicinal Plant Board (SMPB), Odisha at IDCO Exhibition ground from 24th to 28th-January, 2015. Many of the Government, private organisations were participated in the fair. Regional Plant Resource Centre (RPRC) also participates in the fair and exhibited some important of the medicinal plants and their uses in different diseases.

This event provides multi-faceted benefits to the Centre, which are as follows:

- State wide exposure to the centre in the field of medicinal plants.
- Interaction between the pharmacists, farmers and the scientific personnel of the organization.
- Provides an opportunity to serve the General Public by providing them information on medicinal plants and the provision of medicinal plants to the general public at a nominal cost.\





3. Participation by Scientists and Research Scholars of RPRC Year 2013

Dr.U.C. Basak: International Workshop on Mangrove Conservation in India, 25-26 July,2013, Jointly organized by Gujarat Ecology Commission, Mangrove Society of India, ISME, MoEF. Held at Mahatma Mandir, Gandhinagar, Gujarat. **Poster Presentation.**

Dr.U.C. Basak: Conference on Biodiversity Conservation & Sustainable Development in Odisha. Held on 22nd May,2014 in Hotel New Marrion, Bhubaneswar. Organized jointly by Odisha Biodiversity Board (OBB) and Regional Plant Resource Centre (RPRC), Bhubaneswar. **(Participation)**

Dr.U.C. Basak: Seminar-cum-workshop on "sustainable coastal zone protection through mangrove management in Odisha",Organized by Council of Cultural Growth and Cultural Relations, Cuttack (6th& 7th September, 2014 , venue: The Universe, Maitree Sarani, Cuttack) (**Resource Person).**

Jyotimayee Nayak and Dr.U.C. Basak: National Symposium on Underutilized and Wild Edible Plants of India – 'Future

Oral & Poster Presentations during National Conference

Crops' Held on Dec 10-11, 2014 , Organized by Dept. of Bot., University of Kerala, Kerala. (Oral Paper Presentation);Theme: Underutilized plants-improvement, and utilization potential).

National Conference on "Biodiversity Assessment, Monitoring and Conservation: Application of Biotechnological Tools", Held on 22-23 Feb, 2015. Organized by Regional Plant resource Centre & Odisha Botanical Society, Bhubaneswar. Oral & Poster presentation.

Dr. G.K. Surabhi has delivered an invited talk on "salinity tolerance in barley: a proteome approach" at UGC (DRS-SAP-III) sponsored National Seminar on "Current Trends in Stress Biology", organized by post graduate Department of Botany, Utkal University on 26th March, 2014, ORAL PRESENTATION.

Mohanty S, Pattanaik S, Surabhi GK , Proteome analysis of banana fruit to identify key ipening proteins, presented at "National conference on biodiversity assessment, monitoring and conservation: application of biotechnological tools & 39th annual conference of Orissa Botanical Society", 23rd -24th February, 2015, Page no.77, POSTER.

Pattanayak S and Surabhi GK, Deciphering the genetic identity and fidelity of banana through ISSR fingerprinting, presented at "National conference on biodiversity assessment, monitoring and conservation: application of biotechnological tools & 39th annual conference of Orissa Botanical Society", 23rd -24th February, 2015, Page no.77, POSTER.

Sahu H, Molecular characterization and assessment of genetic variability in Shorea robusta Gaertn. tree populations in Odisha, presented at National conference on biodiversity assessment, monitoring and conservation: application of biotechnological tools & 39th annual conference of Orissa Botanical Society, 23rd -24th February, 2015, Page no.77, POSTER.

RENDERING SERVICES

Orchid propagation & Sale

Production of quality planting materials of orchids is highly important and requires the use of tissue culture techniques to produce. At our centre protocols of the mass propagation of 34 different hybrids belonging to *Dendrobium*, *Phalaenopsis*, *Cattleya*, *Vanda*, *Doritis,* Mokara, *Ascocenda, Spathoglottis* have been made successfully using tissue culture techniques. The names of the varieties for those the propagation techniques are standardized are listed below. Of these, 13 varieties are growing at orchid house and available for sale, the list mentioned below.

Technical details about how to grow orchids are being provided to different growers of the state.

Ornamental orchids of which mass propagation protocols have been standardized

Sl. No.	Name of The Hybrid Orchid
	Dendrobium Light Pink 1
	Dendrobium Light Pink 2
	Dendrobium Mountfuji
	Dendrobium Tosico Pink
	Dendrobium Charka red
	Dendrobium Golden Beauty
	Dendrobium Fairy White
	Dendrobium Burana White
	Dendrobium Burana Jade
	Dendrobium Dargon Red
	Dendrobium Rhynco Green White
	Dendrobium Beena Pearl
	Phalaenopsis Variety 1
	Phalaenopsis Variety 2
	Phalaenopsis Variety 3
	Phalaenopsis thu
	Cattleya Pink
	Cattleya Sandle Pink
	Cattleya Violet
	Cattleya Violet X *Cattleya* Pink
	Cattleya Pink X *Cattleya* Violet
	Cattleya - White
	Cattleya – White Pink
	Spathoglottis plicata
	Spathoglottis kimballiana
	*Vanda*Sansai Blue
	Vanda White
	Vanda 1
	Vanda 2
	Vanda Blue Magic
	Ascocenda
	Mokara
	Doritis varieties
	Doritis pulcherinia

Orchid plantlets available for sale

Sl. No.	Name of The Hybrid Orchid
	Dendrobium Light Pink 1
	Dendrobium Light Pink 2
	Dendrobium Mountfuji
	Dendrobium Tosico Pink
	Dendrobium Charka red
	Dendrobium Golden Beauty
	Phalaenopsis Variety 1
	Phalaenopsis Variety 2
	Cattleya Pink
	Cattleya Sandle Pink
	Spathoglottis plicata
	Vanda Sansai Blue

Production & Sale of QPM of various garden plants

Authentic quality planting materials to the tune of 3.25 lakhs have been produced during the financial year 2014-15. These planting materials are grown from seeds, suckers, stem cutting, root cutting, leaf cuttings etc. 70 species of flowering and foliage plants are produced from seeds, where as 135 species are propagated from soft wood, cuttings, hard wood cuttings, leaf cuttings, root cutting, budding, air layering and grafting technique. These quality planting materials are sold to all consumers at productive reasonable rates. As such year after year there is growing demand of such authentic quality planting materials. This is reflected from generation of revenue in each year. The year-wise quality planning material since 2010-11 to 2014-25 is the index of such growing demand and sale.

Sl. No.	Year	Revenue receipt from sale of Nursery products
1.	2010-11	9,61,765.00
2.	2011-12	12,94,741.00
3.	2012-13	16,12,578.00
4.	2013-14	20,05,425.00
5.	2014-15	20,18,403.00

Besides above, steps are being taken to poplularise cultivation of *Gerbera* , Carnation and Dahlia, so that along with revenue generation cultivators could get authentic quality planting materials.

Production and Sale of Bamboo spp. during 2014-15

Apart from its' rich collection and conservation of Bamboo species in the Bambusetum, RPRC has started commercial production of economically important bamboo species viz. *Dendrocalamus strictus* (salia) & *Bambusa arundinacea* (kanta) under Odisha Bamboo Development Agency-funded project to benefit the progressive growers and farmers. The above bamboo seedlings were made available for sale (@Rs.7.50 per seedling in polybag) in the RPRC during 2014-15 .

Bamboo QPM in RPRC (2014-15)

Production of QPM of Tissue Culture Banana

Banana is an important food crop and the second most important fruit crop. Despite the significant commercial value of the crop, the main production constrain is the availability of reliable and safe planting material. The planting materials obtained through conventional methods (suckers) do not meet the increasing demand for planting and they are poor quality. These suckers had been collected from valuable banana clones, which were often growing in remote field sites under poor agronomic conditions before being placed into culture. The poor condition of the suckers when they arrived at the tissue culture laboratory contributed to the high contamination rate in culture. Therefore, it was imperative to have an initiation techniques that minimised contamination, enhanced survival and was time effective.

Tissue culture is the approach which can solve these problems. Micropropagation of the crop is also faced with challenges which need to be addressed in order to improve its production.

Banana Tissue culture lab has established in 1995 at Regional Plant Resource Centre to supply elite disease free plantlets to the farmers of the state according to the requirement. Different varieties like Robusta, Dwarf Cavendish,Grand naine, Bantal, Patakpura, Champa have been produced in lakhs till date. During 2012 all total 98,850 nos. of banana plantlets were produced out of which G-9 var. were 62,250 and Banta lvar. 36,600. During that period more than 700 nos. of suckers were collected from different places of Odisha like

Balipatna , Garia, and Rajas and used for initial culture .A mother block of different varieties of banana was also developed in our centre to get the explants for initial culture in time. In 2013 all total 29,540 banana plantlets were produced out of which Bantal 28,450 and G-9 1,090. The explants were collected from RPRC Banana Mother Block plantation site.

During 2014 more than 21,000 nos. of banana plantlets were produced. 157 nos. of suckers of different varieties like patakpura, Bantal and G9 were collected from different areas, Pipili , Satasankha, Rajas, Garia, and Balipatna. During 2015 our target is to produce 1.5 lacks bantal plantlets for this financial year. All the suckers which were utilized for initial culture were sent to NRCB, Trichi for Virus indexing testing purposes. From the test result it was indicated that almost all plantlets are free from virus. We were also conducting genetic fidelity testing. The plantlets produced from Tissue Culture Banana Lab of RPRC are free of any viral diseases and have good yielding capacity and also identical to the mother plant type.

a. Banana mother block at RPRC. Suckers collected from different parts of Odisha, from Balipatna, Nimapara, Satsankha, Sakhigopal, Pipili, Garia and Rajas. Varities: G-9, Bantal, Patakpura and Champa.
b. Processing of Sucker, c. Laminar Air Flow for inoculation work, d. Culture rooms with different stages., e. Primary hardening chamber
f. Secondary hardening chamber

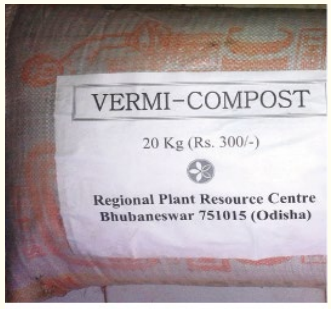
Vermicompost production and sale Unit

The green wastes from garden, local plantations and household kitchen wastes are very difficult to manage as it requires manpower and functional machinery. In view of fact that the mechanical

management of green wastes are time consuming , an alternative process is considered necessary to save energy and place into another productive use. In this perspective, vermi composting is an eco-friendly technology by using earthworms as a tool for rapid conversion of any organic wastes to value added manure. Vermicompost, or castings, is worm manure and are considered as best soil amendment available. It is fact that by establishing vermicompost units we can recycle the wastes from our own resources and create an effective fertiliser in the process. With this views , a minor unit for vermicompsoting has been developed at the botanic garden of Regional Plant Resource Centre, Bhubaneswar . The base materials used for the vermicompost development are green biomass waste seasonally developed in campus of our centre. The process involves the primary decomposition of raw materials by using cow dung slurry in layers. The 21 day old primary decomposed material are then dumped into vermin tank along with verms (*Eudrilus eugineae*, the night crawler). Regular watering through sprinkler is required to create moist and cool environment for the functional activity and survival of earthwarms. Through this process the unit is able to produce 1500 -2000 kg per month. Currently, Vermicompost technology is very well established at the centre and demonstrated in order to generate public awareness, strengthening of own vermicompost set-up and research, utilization and management of green wastes and rearing of night crawling worms *Eudrilus eugineae* most suitable for Bhubaneswar environment. It is an asset for revenue generation and gradually step towards higher scale.

Primary decomposed material (Green waste)

Vermicompost collection and drying



Vermicompost packaging and sale

Success Story of Cultivation of Tissue Culture Banana

Development of banana certification system

The Regional Plant Resource Centre is producing tissue culture raised banana and supporting the thousands of farmers in the state by supplying quality planting materials from the past 15-years onwards. In connection with this, the following services were proposed to implement at the centre in order to supply certified banana. Since the plantlets production is not season dependent, banana cultivation can be conducted any time of the year, if proper irrigation is available.

Banana success story by the farmers of Bhubaneswar : These are some photographs that are taken from a banana field at Shampur near Sum Hospital. The bunch shown has been developed from tissue culture raised pnaltlets of RPRC

Mass propagation of elite cultivars like Grand Naine, Bantala has been thoroughly standardized. With existing protocols, from single source explants thousands of plantlets can be produced. Genetic fidelity testing protocols were developed for cv. Grand Naine and cv. Bantala at RPRC laboratories by utilizing PCR based molecular tools (ISSR/SSR markers). Four viruses known to infect naturally bananas have been characterized as banana bunchy top virus (BBTV), Banana streak virus (BSMysV), banana bract mosaic virus (BBrMV) and cucumber mosaic virus (CMV). RPRC aimed to develop and evaluate an integrated multiplex reverse transcription-PCR (RT-PCR) assay for simultaneous detection of all four characterized viruses of banana. It is proposed that, a DBT accredited banana tissue culture, genetic fidelity and virus indexing certification system will be established at RPRC through National Certification System (NCS-TCP) in order to provide certified disease free and true-to-type quality planting material to the farmers of the state, Odisha.

MAJOR ATTRACTIONS

The Botanic Garden developed and maintained by the institute at Bhubaneswar and Keonjhar with its panoramic views attract visitors from far and wide. The RPRC Campus has a beautiful lake of about 40 acres and a very rich and diverse flora of more than 2000 species both natural and introduced. From the rare and threatened plants of the state to the marvellous rose garden, the garden areas show the diverse beauty of nature and special features include:

a) Children's Corner
b) Morning walk
c) Boating
d) Cacti Collection
e) Rose Garden
f) Fountain
g) Migratory birds in lake

Besides this, with an aim to provide facility to citizens of Bhubaneswar morning walk facility is also provided through picturesque gardens, lawns and patches of natural vegetation. For this purpose a track of around 3.5 Km is earmarked alongside the periphery of lake.

Morning Walkers

Boating in RPRC Lake

Awareness through Wall Magazine

Plant of the week

It is required to know the importance of all plants as these are fulfilling the majority of the needs of human beings. Beside the crops there are good numbers of plants those are contributing enormously to the human society. In order to highlight the uses of many

Children's Corner

Cacti Collection

of the plants the program 'Plant of The Week' has been made in which on each week information about a plant provided. This has highlighted the common name, scientific name, habit, habitat, distribution as well as the uses of the plants. The name of the plants for which information prepared are listed below.

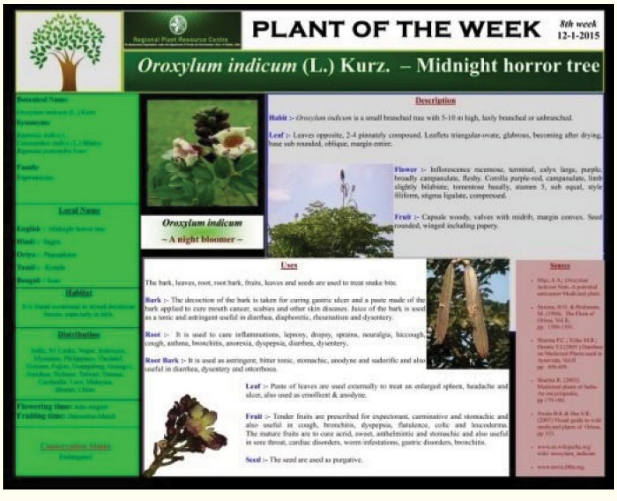
Plant species included in the plant of week

Sl No.	Botanical Name of the Plant
	Saraca asoca (Roxb.) De Wilde
	Ficus religiosa L.
	Azadirachta indica A Juss.
	*Mesua ferrea*L.
	Pterocarpus marsupium Roxb.
	Helminthostachys zeylanica (L.) Hook.
	Cycas sphaerica Roxb.
	Oroxylum indicum (L.) Kurz.
	Rauvolfia serpentina (L) Benth. exKurz.
	Rhynchostylis retusa (L.) Blume
	Cyathea spinulosa Wall.ex Hook
	*Lasiococca conberi*Hanes.
	Symplocos racemosa Roxb.
	Litsea glutinosa (Lour.) C.B.Rob.
	Gnetum ula Brongi.
	Stemona tuberosa Lour.

Wall Magazine

In order to develop awareness about the recent happenings in science, the program 'Wall Magazine' has been made. Twoissues have been made. The first issue provided the information about all the Nobel Prize winners of the year 2014. The name of the winners, brief background and their contribution for which they won the award were provided. In the second issue, information about the Botanical Gardens those have played a major role for the conservation of the plant of the world provided. Since there are many Botanical Gardens around the world, the information of the most important gardens provided. The major contribution of the gardens towards conservation of the plants particularly in maintaining the rare plants in the gardens and research contribution were highlighted. The name of the botanical gardens of which information provided are mentioned below.

Migratory & resident Birds in RPRC Lake



Information of the following Botanical Gardens provided

Sl. No.	Botanic Garden
	Nong Nooch Tropical Botanic Garden, Thailand
	The Singapore Botanic Garden
	Denver Botanic Garden
	Berlin-Dahlem Botanic Garden
	The Montreal Botanic Garden, USA
	Kristen Bosch National Botanic Garden, South Africa
	Jardin Botanico -De -Rio-de Janeiro , Brazil
	Royal Botanic Garde, Kew, London
	Brooklyn Botanic Garden, New York, Usa
	Acharya Jagdish Chandra Bose, Indian Botanical Garden, Howarh, India

LIBRARY

At present the library of the centre has a collection of 2670 books on the thrust areas of Taxonomy, Biotechnology, Medicinal and Aromatic Plants, Tissue Culture, Microbiology, Physiology and Biochemistry, Forestry and Ecology, Molecular Biology, Horticulture and Floriculture, Ornamental Plants, Orchids and many other areas. Number of periodicals and journals of leading institutions and firms on related areas of importance are subscribed by the library. About 22 Indian Journals of repute are included as annual subscription. Library holdings also include non-book materials such as transparencies, cassettes, floppies, audio-visuals, CD's, DVD's and number of Topo sheets of Odisha. Internet facility is provided to its users. Reprography service at nominal payment is available to the research personnel. The Library's collection is referred by the research fellows of various institutions such as OUAT, IMMT, CRRI, CTCRI, Utkal University, Berhampur University, Sambalpur University, North Orissa University, IGIPS, Andhra University, Kalyani University, Jadavpur University and many other research institutions.

HERBARIUM

The Centre has a modern Herbarium with a collection of 14,000 accessions belonging to 1600 species. The herbarium specimens have been digitized and made available to researchers as well as scientific communities through a web-based application.

FLOWER SHOW

To promote interest and elicit public awareness towards floriculture crops, the centre has been organizing annual flower show in the month of January in its excellent recreational botanical garden spreading over 110 acres with sprawling lawns, trees and flower beds, fountains, children park and boating facility in the lake. The special attractions of the flower show are being competition, display and sales of roses, cacti, orchids, succulents, herbal plants and the agri-horticultural tools and products etc. enjoyed by huge gatherings of plant lovers and visitors from local, far & wide.

Annual Flower Show at RPRC

Annual Flower Show, 2018

The Regional Plant Resource Centre (RPRC) and Plant Lovers' Association (PLA), Bhubaneswar have been organising State Level Annual Flower Show in the premises of the Botanic Garden of RPRC (Ekamrakanan) on second Saturday and Sunday of January since 2005. This year, the Annual Flower Show has been organised on 13th and 14th January, 2018 in the premises of Ekamrakanan. The event is sponsored by National Aluminium Company Ltd. (NALCO) and the Directorate of Horticulture, Odisha.

Sri Bijayshree Routray, Hon'ble Minister, Forest & Environment, Odisha inaugurated the Show as Chief Guest and visited the flower displays, cut flower and flower arrangement section, Rangoli, Plant Bazar, Nurseries and exhibition stalls of RPRC and Directorate of Horticulture etc. Sri Suresh Chandra Mohapatra IAS, Additional Chief Secretary, Forest & Environment Department, Government of Odisha also attended the inaugural function as Guest of Honour. The guests were accompanied by Dr. H. S. Upadhyay IFS, Chief Executive and other scientists of Regional Plant Resource Centre (RPRC), Sri Khirod Pattnaik, President and members of Plant Lovers Association and other dignitaries.

A "Plant Bazar" has been organised at the venue of the show and 40 nurseries and firms have put up their stalls. Here, ornamental plants, seeds, seedlings, garden tools and implements, fertilisers, pesticides etc. are being made available to public on sale. Besides nurseries and seed firms, stalls have been opened by the Regional Plant Resource Centre (RPRC), Directorate of Horticulture, Odisha, Ekamravan Medicinal Plant Garden and Odisha Biodiversity Board to showcase their activities. From last year, "Rangoli"- art of decoration with flowers and petals and "Vegetable Carving" have been introduced and specially designed stalls have been erected for the purpose.

The Plant Lovers' Association and RPRC also organised "Garden Competition" in the Capital city of Bhubaneswar to encourage the institutions and individuals to grow flowers and develop Gardens to add to the beauty of the City and to contribute to environment. This year 90 entries for Garden competitions in different categories were received and more than 50 prizes will be awarded at the valedictory function to be held on 14th January, 2018. PLA also organised Painting and Poster Competitions among school children on 3rd December, 2017 at Indira Gandhi Park to educate them about plants and environment. Some 700 children from different schools of Bhubaneswar participated in the competition and 36 of them will be awarded with prizes on 13th January, 2018.

In this year's Flower Show, more than 300 entries were received in Potted Flowering, Foliage, Cut Flower, Flower Arrangement and Group Display categories, vegetable carving, Rangoli etc. An beautiful "Floral Gate" has been erected by RPRC at the entry point, which has been the main attraction for the visitors.

The winners of Garden Competitions under different categories, Painting/ Drawing competitions will be awarded trophies in the prize distribution ceremony scheduled at 4.00 PM on 13th January, 2018. Dr. Sandeep Tripathy IFS, Principal Chief Conservator of Forests (Wildlife), Odisha will be the Chief Guest of the function.

The Flower Show will conclude with award of prizes and trophies for various floral exhibits and competitions in a special function to be held at 4.00 PM on 14th January, 2018. Dr. Tapan Kumar Chand, Chairman-cum-Managing Director, NALCO and Mrs. Priti Roy Chand, President of NALCO Mahila Samiti will give away the prizes as Chief Guest and Guest of Honour. Sri M. Muthukumar IAS, Director of Horticulture, Odisha will also attend the function as the Guest of Honour. Dr. H. S. Upadhyay IFS, Chief Executive, RPRC and Sri Khirod Pattnaik, President, PLA will also be on the dais.

As in previous years, about 1,00,000 visitors are expected to visit the Show during these 2-days. They need not have to pay entry fees to visit the garden on 13th and 14th January, 2018 and free parking inside the garden has been provided for convenience of people. The visitors will certainly like the ambience with beautiful landscape, colourful flower beds, sprawling lawns, greenery, picturesque lake with migratory birds and enjoy the childrens' corner and boating in Ekamrakanan Lake.

The scientists, students and staff of RPRC; the office bearers and members of PLA have put their best efforts to make this State Level Flower Show, 2018 a success. The financial assistance from NALCO and Directorate of Horticulture, Odisha is thankfully acknowledged.

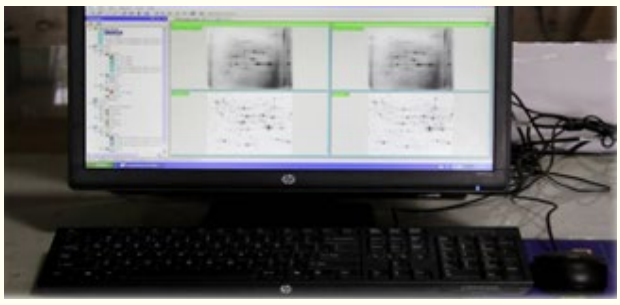
NEW INFRASTRUCTURE

1. Equipment

- Multi Plate Reader
- UV-Vis Spectrophotometer
- Digital Melting point apparatus
- Cooling Centrifuge
- IPG Phore3Protein IEF System
- Protein Gel Electrophoresis Unit
- IMP7 2D Gel Imaging System Software
- Chemi Doc MP Gel Imaging System
- HPLC Dionex Ultimate 3000 (Quartenary Pump)

U.V. Visible Spectrophotometer (SPEKOL 2000)

Digital Melting Point Apparatus



HPLC Dionex Ultimate 3000 (Quartenary Pump)

Cooling Centrifuge 5430 R

U.V. Visible Spectrophotometer (SPEKOL 2000)

Animal House, RPRC

2. Facility

Animal House Keeping Facility

Modern Tisuue Culture Laboratory

The lab is designed to produce 5 lakhs of quality planting materials of banana and plantains. In the facility, there is a mass production lab that will produce 5lakhs of plantlets using tissue culture technology. The lab is equipped with all modern equipment and facilities. To ensure the uniformity in the planting materials, a facility developed to test genetic uniformity using cutting age technology. Virus indexing facility also developed in the lab, certifying the pathogen free plants.

ORCHIDARIUM

Orchids are popular for their high ornamental value. The orchidarium is the house of major orchids like Phalaenopsis, Vanda, Dendrobium, Cattleya, Spathoglottis and other orchids of ornamental value. Also in the facility, rare orchids of the Odisha state are growing for their *ex situ* conservation purpose. Information regarding their growth, maintenance and propagation are also provided for the visitor of the facility.

Orchid Mass Propagation Laboratory

Poly-house for growing orchids

Orchidarium

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1	Mrs. Rebecca Nayar, IFS	PCCF & Chief Executive	rebeccanayar@rediffmail.com 9937055138
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43	Sri Hitansu Moharana	Field Assistant	hitansumoharana@gmail.com 7077618019
44	Ms. Chinmayee Behera	Field Assistant	sweetchinmayee1@gmail.com 8457067039
45	Sri Tinku T.Routray	Field Assistant	tinkuroutray@gmail.com 9040355535
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5	Sri. Rabindra K.Routray	Junior Asst.-cum-Typist	9040558661
6	Sri. Ghanashyam Behera	Junior Asst.-cum-Typist	8917564755
7	Sri. Damodar Jena	Junior Clerk	8480612824
8	Sri. Chanchal Ray	Junior Clerk	9776151607
9	Sri. Hemendra K. Dalai	Junior Clerk-cum-Typist	9439793050
10	Sri. Nilamani Sahoo	Junior Clerk-cum-Typist	8908204427
11	Sri. Ranjan K.Mohanty	Junior Clerk-cum-Typist	9776046750
12	Mrs. Jayashree Mohanty	Junior Clerk-cum-Typist	9861044529
13	Mrs. Prabina Pattanaik	Junior Clerk-cum-Typist	9861122254
14	Sri. Kabibar Samal	Garden Assistant	9090714724
15	Sri. Debendra Mohapatra	Garden Assistant	9861125132
16	Sri. Panchu Bhoi	Garden Assistant	9777306288
17	Sri. Narahari Mahanta	Garden Assistant	9937984514
18	Sri. Banamali Nayak	Garden Assistant	7681045445
19	Sri. S. C. Nayak	Field Assistant	9178086589
20	Sri. J. N. Choudhury	Field Assistant	9861292752
21	Sri. Nirakar Mallik	Driver	8596809327
22	Sri. Bhagawan Swain	Driver	9040570850
23	Sri. Laxman Majhi	Driver	9178719590
24	Sri. Bhubana N. Naik	Driver	9556655330
25	Sri. Kishore C. Gouda	Driver	9556672742
26	Sri. A. T. Pradhan	Pump Operator	7873323064
27	Sri. Gangadhar Pradhan	Lawn Mower Driver	9853324047

Sl. No.	Name	Designation	Email/ Phone no.
28	Sri. S. N. Patra	Lawn Mower Driver	7894209986
29	Sri. R. C. Kisku	Lawn Mower Driver	9938779532
30	Sri. Narahari Nayak	Lawn Mower Driver	9937260290
31	Sri. N. C. Swain	Gardener	9938496239
32	Sri. Tukuna Sethi	Gardener	9938317193
33	Sri. Mahendra Jena	Gardener	9861888276
34	Sri. Bimbadhar Dakua	Gardener	8114793924
35	Sri. K. C. Das	Gardener	9040212052
36	Sri. Ramesh C. Barik	Gardener	9556145580
37	Sri. Ratha Kisku	Gardener	9178141193
38	Sri. Jogi N. Harichandan	Gardener	9437089289
39	Sri. Purna C. Dakhinray	Gardener	9437196058
40	Sri. H. K. Naik	Gardener	9937410311
41	Sri. S. N. Das	Gardener	9777184529
42	Sri. Sarat C. Jena	Gardener	8658056910
43	Sri. S. K. Swain	Gardener	9937286198
44	Sri.Purusottam Sethi	Gardener	9178430799
45	Sri. A. Samantaray	Peon	9338301818
46	Sri. N. Mohanty	Peon	9437406318
47	Sri. D. Kandi	Peon	7655053469
48	Sri. Narahari Naik	Peon	9668446947
49	Sri. Aruna K. Rout	Landscape Attendant	9937411742
50	Sri. Birabara Naik	Watchman	9776561637
51	Sri. Chita R. Mohapatra	Laboratory Attendant	9668000978
52	Sri. Kailash C. Naik	Laboratory Attendant	7682833957
Other Laboratory support staff (Consolidated)			
1	Sri Kunja B.Mahakud	Contractual	9938607035
2	Sri Bagyadhar Barik	Contractual	9776836239
3	Ms. Bandini Pattnaik	Contractual	7008535119
4	Ms. Sandhya Das	Contractual	8763191914
5	Ms. Mandakini Nayak	Contractual	9439490027
6	Ms. Namita Sahu	Contractual	9124457030

PLANTS GROWN & MAINTAINED IN RPRC

Trees

Sl. No.	Name of the plant	Local name	Price per plant					
			Polybags	6"/7x8"	8"x10"	9"x11"	12"x13"	21"
1	*Acacia polycantha*	Sami			60			
2	*Adenanthera pavonina*	Manda Kaincha	20					
3	*All Spices plants*	Sarba masala		100				
4	*Alstonia scholaris*	Chatiana	20					
5	*Araucaria bidwillii*		50	80	150			
6	*Araucaria cookii*	Araucaria	60	100	250			
7	*Aurocaria*					250		
8	*Azadirachta indica*	Neem, Nima	20					
9	*Bambusa vulgaris*	Baunsa	20				100	
10	*Barringtonia racemosa*		30					
11	*Bauhinia blakeana*	Kanchan	30		100			
12	*Bauhinia purpurea*	Kanchan	30		100			
13	*Bauhinia variegata*	Kanchan	30/ 100					
14	*Bixa orellana*	Kumkum	30					
15	*Brassaia actiniphylla*		50					
16	*Brownea ariza*		50	80	120			
17	*Brownea grandiceps*		50	80	120			
18	*Brya ebenus*		40					
19	*Butea monosperma*	Palas	20					
20	*Caesalpinia coriaria*		20	40	60		100	
21	*Callistemon lanceolatus*	Bottle Brush	30					
22	*Calophyllum inophyllum*	Polang	20		60		80	
23	*Cascabela thevetia*	Kaniar	10					
24	*Cassia fistula*	Sunari	20					
25	*Cassia grandis*		30					
26	*Cassia nodosa*		30					
27	*Chrysophyllum cainito*		30					
28	*Cinnamomum camphora*	Karpura	40				100	
29	*Cinnamomum tamala*	Telpatra	40		80			
30	*Cinnamomum verum*	Dalchini	40					
31	*Citharexylum spinosum*		30					
32	*Clitoria fairchildiana*		50					
33	*Clusia rosea*		50	80	120			

Sl. No.	Name of the plant	Local name	Price per plant					
			Polybags	6"/7x8"	8"x10"	9"x11"	12"x13"	21"
34	*Coccoloba uvifera*		30					
35	*Colvillea racemosa*		30					
36	*Cordia dichotoma*	Gual	30					
37	*Cordia sebestena*		50		100			
38	*Couroupita guianensis*	Naga Linga	30					
39	*Cryptomeria japonica*		60	100	150			
40	*Cupressus*	Juniper golden		300				
41	*Cupressus juniper golden*			350				
42	*Cupressus sempervirens*		60	100	150			
43	*Cupressus Thai*						200	
44	*Cycas revoluta*		100	150	300			
45	*Delonix regia*	Krushnachuda	20					
46	*Elaeocarpus garinatus*	Rudrakshya	30					
47	*Ficus benghalensis*	Bara, Banyan	30					
48	*Ficus benjamina*		30				200	
49	*Ficus black*						200	
50	*Ficus black*							500
51	*Ficus elastica*	Rubber(2 var.)	50	100	200			
52	*Ficus religiosa*	Aswatha, Peepul	30					
53	*Ficus tinctoria*		40					
54	*Ficus triangularis*	Variegated					200	
55	*Filicium decipiens*		30	50	80		100	
56	*Gmelina arborea*	Gamhari	20					
57	*Grevillea excelsior*		20					
58	*Grevillea robusta*	Swetachandrika	20					
59	*Guaiacum officinale*		50					
60	*Gustavia augusta L.*		100					
61	*Ixora arborea*	Tel Koruan	20					
62	*Juniper new*						500	
63	*Juniperus chinensis*	Juniper	40	70	100			
64	*Kigelia africana*		20					
65	*Lagerstroemia flos-reginae*	Patali	15					
66	*Lagerstroemia indica*	Sidha/ red	20	40	60		300	
67	*Lagerstroemia thorelii*		15					
68	*Lagesroemia lancestrii*						250	
69	*Lassiococa comberi*	Kukrihari	50					
70	*Lawsonia inermis*	Manjuati	20					

Sl. No.	Name of the plant	Local name	Price per plant					
			Polybags	6″/7x8″	8″x10″	9″x11″	12″x13″	21″
71	*Litsea glutinosa*	Medha	20					
72	*Melaleuca sp.*				50			
73	*Melia azedarach*	Mahalimba	20					
74	*Mesua ferrea*	Nageswar	30					
75	*Michelia champaca*	Champa	30					
76	*Millingtonia hortensis*	Akasmalli	20					
77	*Mimusops elengi*	Baula	20					
78	*Muntingia calabura*		20					
79	*Murraya exotica*		30	60	80		100	
80	*Murraya koenigii*	Bhrusanga	20					
81	*Murraya paniculata*	Kamini	20	50	80		100	
82	*Myristica fragrans- Jaiphala*				150			
83	*Neolamarckia cadamba*	Kadamba	10				50	
84	*Nyctanthes arbortristis*				50			
85	*Oncoba spinosa*		30					
86	*Peltophorum pterocarpum*	Radhachuda	20				60	
87	*Pencil pine*		200					
88	*Plumeria alba*	Kathachampa	30		80		100	
89	*Polyalthia longifolia*	Debadaru	20				30	
90	*Psidium guajava*	Pijuli			60			
91	*Pterocarpus santalinus- Rakta chandan*	Rakta chandan			150			
92	*Pterosppermum acerifolium*	Kanakchampa			60			
93	*Putranjiva roxburghii*	Poichandia	10					
94	*Santalum album*	Chandan	50				100	
95	*Saraca asoca*	Asoka	20					
96	*Saraca declinata*		30					
97	*Saraca thaipingensis*		30				60	
98	*Sesbania grandiflora*	Agasthi	20					
99	*Shorea robusta*	Sal	20					
100	*Simarouba glauca*	Mahatila	20					
101	*Spathodea campanulata*	Turi	20					
102	*Syzygium aromaticum – Labang*	labanga			80			
103	*Syzygium cumini*	Jamu	20					
104	*Syzygium sp. Red leave*						300	
105	*Tabebuia argentea*		20					

Sl. No.	Name of the plant	Local name	Price per plant					
			Polybags	6"/7x8"	8"x10"	9"x11"	12"x13"	21"
106	*Tabebuia avellanedae*		20					
107	*Tabebuia rosea*		20					
108	*Tabeubia dwarf*						380	
109	*Tectona grandis*	Saguan, Teak	10					
110	*Terminalia catappa*	Kathabadam	20					
111	*Terminalia variegated*						300	
112	*Thuja*	golden					500	
113	*Thuja orientalis*	Thuja	50	70	200			
114	*Xylia xylocarpa*	Kangada	20					

Shrubs

Sl. No.	Name of the plants	Local names	Price per plant				
			Polybags	6"/ 7"x8"	10"	12"	21"
1	*Acalypha*	Red/deep maroon		25			
2	*Acalypha (Hanging)*		30	50	80		
3	*Acalypha godseffiana*		20				
4	*Acalypha hispida*		20				
5	*Acalypha wilkesiana*		20				
6	*Allamanda neriifolia*		20				
7	*Allamanda schottii*		20				
8	*Angelonia grandiflora*	Blue flower (varigated)	10	30			
9	*Asclepias curassavica*		10				
10	*Barleria cristata*		20				
11	*Barringtonia racemosa*		30				
12	*Bauhinia acuminata*		20				
13	*Bauhinia galpinii*		20				
14	*Bauhinia tomentosa*		20				
15	*Beloperone guttata*		20				
16	*Belopeurone sp.*			60			
17	*Bougainvillea*		30	50			
18	*Brunfelsia americana*		20				
19	*Brunfelsia calycina*		20				
20	*Caesalpinia pulcherrima*		20				
21	*Calliandra brevipes*		20				
22	*Calliandra haematocephala*		20				
23	*Calliandra tweedii*		20		60	100	

Sl. No.	Name of the plants	Local names	Price per plant				
			Polybags	6"/ 7"x8"	10"	12"	21"
24	*Cananga kirkii*		40				
25	*Canna sp.*		20				
26	*Carissa carandas*	Karanda	30				
27	*Cassia glauca/ biflora*		20	50			
28	*Catesbaea spinosa*		20				
29	*Cerbera fruticosa*		20	50			
30	*Cestrum diurnum*		20				
31	*Cestrum nocturnum*		20	40			
32	*Clerodendrum fragrans*		20				
33	*Clerodendrum inerme*		10				
34	*Clerodendrum macrosiphon*		20				
35	*Codiaeum variegatum*	Croton, Baksa	30				
36	*Coleus blumei*		20	50	80	110	
37	*Crinum sp. Miniature/Green*				75		
38	*Crossandra infundibuliformis*		20				
39	*Croton*		30	50	70	100	
40	*Croton sp.*	All varieties		40			
41	*Croton sp.*	Pitra broad leaf		100	100		
42	*Croton sp. Golden dust*			60			
43	*Croton sp. Indian yellow*			60			
44	*Croton sp. Lillypot*			50			
45	*Croton sp. Multicolor*			50			
46	*Croton sp. Multicolor yellow*			60			
47	*Croton sp. Multicolour*			40			
48	*Croton sp. Narrow leaf*			50			
49	*Croton sp. Others*			50			
50	*Croton sp. Pink apple*			50			
51	*Croton sp. Pitra broad leaf*				100		
52	*Croton sp. Pride of Japan*			50			
53	*Croton sp. Screw red*			50			
54	*Croton sp. Shiv Shankar*			80			
55	*Croton sp. Trishul*			50			
56	*Croton sp. Yellow apple*			50			
57	*Cuphea hyssopifolia*		20				
58	*Daedalacanthus nervosus*		20				
59	*Dioon cycas*						3500
60	*Dombeya wallichii*		30				

Sl. No.	Name of the plants	Local names	Price per plant				
			Polybags	6"/ 7"x8"	10"	12"	21"
61	*Duranta repens*		20				
62	*Duranta repens"Goldiana"*		10				
63	*Elettaria cardamum -Elaichi*		200				
64	*Eranthemum albo-marginatum*		20				
65	*Eranthemum bicolor*		20				
66	*Eranthemum nigrum*		20				
67	*Eranthemum sp.*	Dark (2 vars)	20				
68	*Ervatamia (Large)*		20	50			
69	*Ervatamia (Mini)*		20	50			
70	*Euphorbia cotinifolia*		30				
71	*Euphorbia leucocephala*		30			100	
72	*Euphorbia pulcherrima*		30				
73	*Excoecaria bicolor*		30				
74	*Gardenia jasminoides*		30	50	70	100	
75	*Gardenia sp. scented*			50			
76	*Graptophyllum pictum*		20	50	70	100	
77	*Gustavia insignis*		100				
78	*Hamelia patens*		20				
79	*Hibiscus (hybrid)*			100			
80	*Hibiscus double*	3 Varieties		80			
81	*Hibiscus mutabilis*		20				
82	*Hibiscus rosa-sinensis*	Hybrid Mandar	40	70	100	120	
83	*Hibiscus rosa-sinensis*	Desi Mandar	20	50	80		
84	*Hibiscus schizopetalus*	Khili Mandar	20	50	80	100	
85	*Hibiscus sp.*	Rose play, red		50			
86	*Hibiscus sp.*	Viceroy			100		
87	*Hibiscus sp.*	White single		50			
88	*Hibiscus sp. Hawai vars,*	Hawai vars		50			
89	*Houlana sellowina*		15				
90	*Iresine herbstii*		10				
91	*Ixora chinensis*		30	60	80	100	
92	*Ixora coccinea*	4 colors		30			
93	*Ixora coccinea*		30		60	80	
94	*Ixora coccinea 4 colors*			50			
95	*Ixora lutea*		30	50	80	100	
96	*Ixora singaporensis*		30	50	80	100	
97	*Ixora sp.*	Narrow leaf		50			

Sl. No.	Name of the plants	Local names	Price per plant				
			Polybags	6"/ 7"x8"	10"	12"	21"
98	*Ixora sp. Double- Thai*			150			
99	*Ixora sp. narrow leaf*			75			
100	*Ixora superba*		100	150	200	250	
101	*Jacobinia*	Pink		75			
102	*Jacobinia carnea*		30	60			
103	*Jacquinia ruscifolia*		30				
104	*Jasminum pubescens*		20				
105	*Jasminum sambac*		20		60	80	
106	*Jasminum sp. Thai species (Juai, Chameli)*	Juai, chameli		75			
107	*Jasminum spp. Mogra*	Mogra		40			
108	*Jatropha panduraefolia*	Dwarf red	30				
109	*Kopsia fruticosa*		20	50	80		
110	*Lagestroemia indica*		20				
111	*Lantana camara (red white, yellow, pink)*			30			
112	*Lantana camara Hybrid*		20				
113	*Lantana sellowiana*		30				
114	*Lemon fruit*		20				
115	*Leucophylum leucocephala*	Variegated	20				
116	*Ligustrum robustum*		20				
117	*Lilium (Big)*		120				
118	*Lilly (Small)*		20				
119	*Limonia accidissima –variegated*	variegated		100			
120	*Limonia spectabilis*		20				
121	*Magnolia mutabilis*		50				
122	*Magnolia pumila*		50				
123	*Malpighia coccigera*		30	100			
124	*Malpighia coccigera- Green*	green		50			
125	*Malpighia coccigera-Golden dust*	Golden dust		100			
126	*Malpighia glabra*		20				
127	*Malvaviscus arboreus*		20				
128	*Manihot esculenta*		30				
129	*Marigold (poly potted)-Baramasi*		10				
130	*Melastoma malabathricum*		20				
131	*Melastoma white*	Plerome (white)			80		
132	*Muehlenbeckia platyclada*		20				
133	*Mussaenda erythrophylla*	Red Mussaenda	100	130	150	170	

Sl. No.	Name of the plants	Local names	Price per plant				
			Polybags	6"/ 7"x8"	10"	12"	21"
134	*Mussaenda erythrophylla*	Pink Mussaenda	50				
135	*Mussaenda frondosa*	Yellow Mussaenda	30				
136	*Mussaenda philippica*	White Mussaenda	50				
137	*Nandina dornestica*		50				
138	*Nerium dwarf*	Red, pink	20				
139	*Nerium oleander*		30				
140	*Nolina roxburghii*		250	300	350	400	
141	*Ochna squarrosa*		30				
142	*Oncoba spinosa*		30				
143	*Pachystachys lutea*		20				
144	*Pedilanthus tithymaloides*	Hedge plant	15	45			
145	*Pentas lanceolata*		30				
146	*Pentas sp. Dwarf all colours*	Five colours		200			
147	*Phyllanthus nivosus*		30	100			
148	*Pisonea alba*					140	
149	*Pisonia alba*					200	
150	*Plumbago capensis*	Blue flower	12				
151	*Plumbago capensis- blue flower*			50			
152	*Plumbago indica*		20				
153	*Polata Tree var.*	Polata (diff. colours)		80			
154	*Polyscias balfouriana*		20				
155	*Polyscias filicifolia*		20				
156	*Polyscias fruticosa*		20				
157	*Polyscias guilfoylei*		20				
158	*Pritchardia grandis*		60	100	150		
159	*Pseuderanthemum atropurpureum*		30				
160	*Quassia amara*		30				
161	*Randia macrantha*		30				
162	*Randia maculata*		30				
163	*Raphis palm*		50		100		
164	*Ravenia spectabilis*		20				
165	*Rondeletia odorata*		20				
166	*Russelia juncea*		20				
167	*Russelia sarmentosa*		20				
168	*Sanchezia nobilis*		20				
169	*Serissa foetida*		20				

Sl. No.	Name of the plant	Local name	Price per plant				
			Polybags	6"	7"x 8"	9"x 11"	12"
170	*Spider lilly variegated*				100		
171	*Stachytarpheta indica*		10				
172	*Tabernaemontana coronaria*		30	60	90	120	
173	*Tecoma gaudichaudi*		20				
174	*Tecoma stans*		20				
175	*Tecomaria capensis*		30				
176	*Thryallis glauca*		20				
177	*Thunbergia erecta*		20				
178	*Turnera ulmifolia*		10				
179	*Vinca rosea*		10				
180	*Wedelia trilobata*		10				
181	*Wormia burbidgii*		50				
182	*Yucca silver*					300	

Climbers

Sl. No.	Name of the plant	Local name	Price per plant				
			Polybags	6"	7"x 8"	9"x 11"	12"
1	*Adenocalyma aliaceum*		20				
2	*Allamanda cathartica*		20				
3	*Allamanda sp. 4 species*				50/ 100		
4	*Allamanda violacea*		20				
5	*Antigonon leptopus*		10				
6	*Argyreia nervosa*		50				
7	*Artabotrys odoratissimus*		50				
8	*Asparagus densiflorus*					70	
9	*Asparagus racemosa*		30			80	
10	*Bignonia venusta*				70		
11	*Bougainvillea glabra*		30				
12	*Bougainvillea peruviana*		30			80	
13	*Bougainvillea spectabilis*		30			80	
14	*Campsis grandiflora*		30				
15	*Chonemorpha macrophylla*		50				
16	*Clematis gouriana*		30				
17	*Clerodendrum inerme*	Hedge plant	10				
18	*Clerodendrum splendens*		30				
19	*Clerodendrum thompsonae*		30				

Sl. No.	Name of the plant	Local name	Price per plant				
			Polybags	6"	7"x 8"	9"x 11"	12"
20	*Clitoria ternatea*		30				
21	*Combretum coccineum*		30				
22	*Ficus pumila*		30				
23	*Gmelina hystrix*		30				
24	*Holmskioldia sanguinea*		30				
25	*Jasminum auriculatum*		30				
26	*Jasminum grandiflorum*		20				
27	*Jasminum nitidum*		20				
28	*Lonicera japonica*		20				
29	*Money plant*		20	50		80	
30	*Passiflora coccinea*		30				
31	*Passiflora quadrangularis*		30				
32	*Passiflora sp.red, blue*				50		
33	*Petrea volubilis*		30				
34	*Piper nigrum*	golmirch	30		100		
35	*Pseudocalymma alliaceum*		20				
36	*Pyrostegia venusta*		30				
37	*Quisqualis indica*	miniature	20		50		
38	*Singonium mini*	mini			100		
39	*Stigmaphyllon periplocifolium*		20				
40	*Strophanthus gratus*		30				
41	*Syngonium sp.*	red	pot	200			
42	*Tetracera sarmentosa*		30				
43	*Thunbergia grandiflora*		20				
44	*Vallaris solanacea*		30				
45	*Vernonia elaeagnifolia*		30				

Ferns

Sl. No.	Name of the plant	Local name	Revised price per plant				
			Polybags	6"	7"x8"	10"	12"
1	*Adiantum pedatum*		40	60		120	
2	*Adiantum raddianum*		40	60		120	
3	*Adiantum trapeziforme*		40	60		120	
4	*Asplenium nidus*	Bird's Nest Fern	100	150			
5	*Doryopteris ludens*		50	70			
6	*Irsine horstii*		10				

Sl. No.	Name of the plant	Local name	Price per plant				
			Polybags	6"	7"x 8"	9"x 11"	12"
7	*Nephrolepis biserrata*		20	40			
8	*Nephrolepis exaltata*		20	40			
9	*Nephrolepis sp.*	Golden fern			50		
10	*Nephrolepis sp. golden fern*	Golden fern			80		
11	*Platycerium bifurcatum*		50	70			
12	*Polypodium punctatum*		30	50			
13	*Pteris cretica*		20	40			

Palms

Sl. No.	Name of the plant	Local name	Price per plant					
			7"x 8"	8"x10"	9"x 11"	12"x13"	15"x18"	21"x25"
1	*Areca lutescens (Areca palm)*	Areca palm	200					
2	*Areca sp.*	Palm				300		
3	*Bismarckia nobilis*	Bismarck Palm			100			
4	*Calamus guruba*	Cane			50			
5	*Caryota mitis*	Clustered Fishtail Palm			200		400	600
6	*Caryota urens*	Fishtail Palm/ Toddy Palm			100		300	400
7	*Chamaedorea elegans*	Parlour Palm			200	350		
8	*Champion palm*	champion					600	
9	*Chemaedorea metallica -palm*				350			
10	*Chrysalidocarpus lutescens*	Areca Palm			50-100		200	300
11	*Chrysostachys renga (red palm)*				500	400		
12	*Cocothrinax argentea*	Hispaniolan Silver Thatch			100		200	400
13	*Howea belmoreana*	Kentia/ Sentry Palm			100		200	400
14	*Hyophorbe lagenicaulis*	Champion Palm/ Bottle Palm	100		800		1200	1500
15	*Kentia belmoreana-Palm*					250		
16	*Latania lontaroides*	Red Latan Palm			300		400	600
17	*Latania verschaffeltii*	Yellow Latan Palm			300		400	600
18	*Licuala grandis*	Vanuatu Fan Palm		300	150		300	600
19	*Licuala peltata*	-	100		300	300	600	
20	*Licuala spinosa- palm*	Spiny palm				300		
21	*Livistona chinensis*	Chinese Fan Palm			100		200	300
22	*Neodypsis decaryi*	Triangular palm	300		200		400	600

Sl. No.	Name of the plant	Local name	Price per plant					
			7"x 8"	8"x10"	9"x 11"	12"x13"	15"x18"	21"x25"
23	*Neodypsis leptocheilos*	Red Neck Palm			500			
24	*Phoenicophorium borsigianum*	Stolen Palm			600		1000	
25	*Phoenix canarensis*							2500
26	*Phoenix canarensis*							2500
27	*Phoenix dactyilifera*	Khajur						2000
28	*Phoenix roebelenii*	Dwarf Date Palm	200		100	700	300	
29	*Phoenix rubileni*					700		
30	*Phoenix rupicola*							2000
31	*Phoenix rupicola*	-			100		300	2000
32	*Pritchardia grandiflora*					300		
33	*Pritchardia pacifica*	Pritchardia/ Fiji Fan Palm	100		100	300	450	600
34	*Ptychosperma macarthurii*	Mac Arthur Palm			100		300	
35	*Ravanella sp. Traveller palm*	Traveller palm		150				
36	*Ravenia rivularis*	Majestic Palm			300		600	
37	*Rhaphis humilis- Palm*							1000
38	*Rhapis excelsa*	Lady Palm			200		400	600
39	*Roystonia regia*	Cuban Royal Palm			100		200	500
40	*Syagrus romanzoffiana*	Queen Palm			100		300	500
41	*Syagruss palm*			200				
42	*Thrinax radiata*	Florida Thatch Palm			60			
43	*Veitchi variegata Palm*							4000
44	*Washingtonia filifera*	American Cotton Palm			100		300	600
45	*Washingtonia pacifica palm*	Pacific palm				200		
46	*Wodyetia bifurcata*	Foxtail palm					350	

Tissue Culture Banana

Sl. No.	Name of the plant	Price per plant		
		Polybags	10" pot	12" pot
1	G-9 variety	30		
2	Bantala variety	30		
3	Patakapura	30		
	Champa	23		

Orchids

Sl. No.	Name of the plant	Size	Price per plant		
			Coir pith/ Soil	4" plastic pot	6" plastic pot
1	*Dendrobium hybrids*	2"-4"	50		
		4.1"-6"	75		
		6.1"-10"		100	
		More than 10" (veg.)			125
		More than 10" (Flowering)			150
2	*Cattleya hybrids*	2"-4"	75		
		4.1"-6"	125		
		6.1"-10"		200	
		More than 10" (veg.)			250
		More than 10" (Flowering)			300
3	*Spathoglottis plicata (in soil)*	2"-4"	30		
		4.1"-6"	40		
		6.1"-10"		60	
		More than 10" (veg.)			75
		More than 10" (Flowering)			100
4	*Phalaenopsis spp./ hybrid*	2"-4"	75		
		4.1"-6"	125		
		6.1"-10"			200
		More than 10" (veg.)			250
		More than 10" (Flowering)			300

Cacti

Sl. No.	Name of the plant	Size	Bare rooted	4" Plastic	6/ 5/ 10"
1	Grafted cacti on Hylocereus stock*	1.0-1.5 inch dia/long scion	100	130	
2	Grafted cacti on Hylocereus stock*	1.5-2.5 inch dia long scion	150	200	
3	Grafted cacti on Hylocereus stock*	2.5-3.5 inch dia/long scion	250	300	
4	Grafted cacti on Hylocereus stock*	3.5-5.0 inch dia/long scion	350	400	
5	Grafted cacti on Myrtilicactus stock*	1.5-2.5 inch dia/long scion	150	200	
6	Grafted cacti on Myrtilicactus stock*	2.5-3.5 inch dia/long scion	200	250	
7	Grafted cacti on Myrtilicactus stock*	3.5-5.0 inch dia/long scion	300	350	
8	Grafted cacti on Pereskia stock*	Less than 1 inch dia/long scion	30	60	
9	Grafted Gymnocalycium	1.0-1.5 inch dia/long scion	150	200	
10	Grafted Gymnocalycium	1.5-2.5 inch dia/long scion	200	250	
11	Grafted Gymnocalycium	2.5-3.5 inch dia/long scion	300	350	
12	Grafted Astrophytum/Ariocarpus	1.0-1.5 inch dia/long scion	200	250	
13	Grafted Astrophytum/Ariocarpus	1.5-2.5 inch dia/long scion	250	300	

Sl. No.	Name of the plant	Size	Bare rooted	4" Plastic	6/ 5/ 10"
14	Grafted Astrophytum/Ariocarpus	2.5-3.5 inch dia/long scion	350	400	
15	Rooted Ferocactus, Melocactus, Hamatocactus, Notocactus etc	1.0-2.0 inch dia	50	70	
16	Rooted Ferocactus, Melocactus, Hamatocactus, Notocactus etc	2.0-3.0 inch dia	100	120	
17	Rooted Ferocactus, Melocactus, Hamatocactus, Notocactus etc	3..0-5.0 inch dia	250		350
18	Rooted Ferocactus, Melocactus, Hamatocactus, Notocactus etc	5.0-7.0 inch dia	400		500
19	Rooted Ferocactus, Melocactus, Hamatocactus, Notocactus etc.	8.0-10.00 inch dia	600		700
20	Rooted Ferocactus, Melocactus, Hamatocactus, Notocactus etc.	12.0-15.0 inch dia	1000-1500		
21	Rooted Echinocactus grussonii	2.0-3.0 inch dia	500	600	
22	Rooted Echinocactus grussonii	3.0-5.0 inch dia	1500		1600
23	Rooted Echinocactus grussonii	6.0-8.0 inch dia	2000		2200
24	Rooted Echinocactus grussonii	More than 10.0 inch dia	3000-20,000		
25	Rooted Echinocactus grussonii	Multi-headed	30,000-50,000		
26	Hylocereus root stock	6 inch long	15		
27	Myrtilocactus root stock	6 inch long	30		

Roses

Sl. No.	Name of the plant	Price per plant				
		Polybags	7"x8" pot	10" pot	12" pot	15" pot
1	Hybrid Tea Roses (budded)	50		100	120	150
2	Floribunda budded roses	50		100	120	150
3	Miniature budded roses	50		100	120	150
4	Rose (white) Summer snow Rose		100			

Foliage plants

Sl. No.	Name of the plant	Local name	Price per plant				
			Polybags	6″	7″x 8″	8″x10″	11″x 12″
1	*Agave sp.*		20	50	60		
2	*Agave sp. Variegated*				300		
3	*Aglaonema commutatum*		30	50	90		
4	*Aglaonema costatum*		30	50	90		
5	*Aglaonema crispum*		30	50	90		
6	*Aglaonema narrow leaf*				175		
7	*Aglaonema pseudobracteatum*		30	50	90		
8	*Aglaonema sp.*	Narrow leaf					300
9	*Aglaonema sp.*	Grey leaf				150	
10	*Aglaonema.marantifolium*		30	50	90		
11	*Aloe vera*		20	50	60		
12	*Alpinia sanderae*		30	50	90		
13	*Alpinia zirumbet*		30	50	90		
14	*Alternanthera philoxeroides*		20	40	60		
15	*Alternanthera sp.*	hybrid	30				
16	*Ananas bracteatus*		30	50	90		
17	*Ananas comosus*		30	50	90		
18	*Anthurium*	Leafy Anthurium					400
19	*Anthurium andreanum*		30	50	90		
20	*Anthurium Leafy*				250		
21	*Aralia sp.*		30	50	80		
22	*Arallia sp.*	New gold			100		
23	*Arallia sp. snow pin mini*	snow pin mini			60/ 50		
24	*Asparagus densiflorus*		20	40			
25	*Asparagus plumosus*		20	40			
26	*Begonia rex*		30	50			
27	*Begonia semperflorens*		30	50			
28	*Billbergia seidelii*		50	100			
29	*Caladium bicolor*		30	50			
30	*Caladium hortulanum*		30	50			
31	*Caladium picturatum*		30	50			
32	*Calamus guruba*		15	30	60		
33	*Calathea bella*		30	50	90		
34	*Calathea insignis*		30	50	90		
35	*Calathea leonii*		30	50	90		
36	*Calathea lutea*						700
37	*Calathea ornata*		30	50	90		

Sl. No.	Name of the plant	Local name	Price per plant				
			Polybags	6"	7"x 8"	8"x10"	11"x 12"
38	*Calathea picturata*		30	50	90		
39	*Calathea roseo-picta*		30	50	90		
40	*Calathea rufibarba*		30	50	90		
41	*Calathea undulata*		30	50	90		
42	*Calathea zebrina*		30	50	90		
43	*Callisia repens*		20	50			
44	*Chlorophytum comosum*		20	40	90		
45	*Chlorophytum laxum*		20	30			
46	*Cordyline terminalis*		30	50	90		
47	*Costus melartifolius*		30	60	90		
48	*Costus sp.*	red		60			
49	*Costus speciosus*		20	30			
50	*Cuphea miniata*		30	40	60		
51	*Curculigo capitulata*		30	50			
52	*Dianella tasmanica*		20	40			
53	*Dieffenbachia amoena*		30	50	90		
54	*Dieffenbachia hoffmannii*		30	50	90		
55	*Dieffenbachia maculata*		30	50	90		
56	*Diffenbachea starlight*				100		
57	*Diffenbachia- starlight*	starlight				200	
58	*Dizygotheca elegantissima*		30	50	90		
59	*Dracaena deremensis*		30	50	90		
60	*Dracaena fragrans*		30	50	90		
61	*Dracaena marginata '*		30	50	90		
62	*Dracaena sanderiana*		30	50	90		
63	*Dracaena sp.*	Song of India			40		
64	*Dracaena sp.*	Red				100	
65	*Dracaena victorea*						50
66	*Dracena godseffiana*		30	50	90		
67	*Dracena gold*					150	
68	*Dracena milkywhite*			300			
69	*Eranthemum sp.*		10				
70	*Ficus lyrata*		20	40			
71	*Ficus triangularis*		20	40			250
72	*Furcaria foetida*		40	60	90		
73	*Heliconia illustris*		30	50	90		
74	*Heliconia psittacorum*		30	50	90		
75	*Heliconia rostrata*		30	50	90		

Sl. No.	Name of the plant	Local name	Price per plant				
			Polybags	6″	7″x 8″	8″x10″	11″x 12″
76	*Heliconia sp.*	4 varieties			75		
77	*Helicornia sp. metallica*				100		
78	*Hemigraphis colorata*		30	50			
79	*Kaempferia pulchra*		30	50			
80	*Kaempferia roscoeana*		30	50			
81	*Lawsonia inermis*		20				
82	*Leea coccinea*		30	50			
83	*Liriope muscari*		10	30			
84	*Livistonia rotundifolia*		50	80	100		
85	*Maranta arundinacea*		20	40			
86	*Monstera deliciosa*		30	60			
87	*Ophiopogon jaburan*		20	50			
88	*Ophiopogon japonicus*		20	50			
89	*Opuntia (rooted)*		20				
90	*Oreodoxa regia*		50	80			
91	*Pachypodium (potted)*		100				
92	*Pandanus baptistii*		30	50			
93	*Pandanus dwarf*				50		
94	*Pandanus sanderi*		30	50			
95	*Pellionia daveauana*		20	50			
96	*Pellionia pulchra*		20	50			
97	*Pentas lanceolata*		20	40	70		
98	*Peperomia obtusifolia*		20	40			
99	*Philodendron bipinnatifidum*		50	80	130		
100	*Philodendron domesticum*		50	80	130		
101	*Philodendron erubescens*		50	80	130		
102	*Philodendron williamsii*		50	80	130		
103	*Pilea cadierei*		20	40			
104	*Pilea depressa*		10	30			
105	*Pilea serpyllacea*		10	30			
106	*Pilea sp.*				50		
107	*Pilea sp.*				50		
108	*Pleomele reflexa*		30	50			
109	*Rauvolfia tetraphylla*		20				
110	*Rhoeo discolor*	Mini Rhoea	35				
111	*Rhoeo spathacea (red)*		20	40			
112	*Rhoeo spathacea (yellow)*		30	60			
113	*Rundelia odorata*		20				
114	*Sansevieria cylindrica*		30	300			
115	*Sansevieria trifasciata*		20	40			

Sl. No.	Name of the plant	Local name	Price per plant				
			Polybags	6"	7"x 8"	8"x10"	11"x 12"
116	*Schefflera arboricola*		30	50			
117	*Scindapsus aureus*		30	50			
118	*Selaginella candida*		20	50			
119	*Serissa foetida*		20				
120	*Setcreasea purpurea*		10	30			
121	*Song of India*		30	60			
122	*Spathyphyllum clevelandii*		30	50			
123	*Syngonium macrophyllum*		30	50			
124	*Syngonium mini*				150		
125	*Syngonium podophyllum*		20	40			
126	*Variegated grass*				40		
127	*Wedellia chinensis*		10	30	60		
128	*Zebrina pendula*		20	40			

Succulents (other than Cactus)

Sl. No.	Name of the plant	Local name	Price per plant			
			Polybags/ Bare rooted	4"	6"	10"
1	*Adenium obesum- Double*		150	200		
2	*Adenium obesum-single*		50	100	200	
3	*Agave americana*		50	100		
4	*Agave angustifolia*		50	100		
5	*Agave filifera*		50	100		
6	*Agave potatorum*		50	100		
7	*Agave victoriae-reginae*		100	150		
8	*Alluaudia comosa*		100	150		
9	*Aloe abyssinica*		30	50		
10	*Beaucarnea recurvata*		200	300		
11	*Caralluma sarkarii*		50	100		
12	*Cissus quadrangularis*		20	40		
13	*Cotyledon orbiculata*		50	100		
14	*Dyckia brevifolia*		20	40		
15	*Echeveria peacockii*		30	50		
16	*Euphorbia bioensis*		20	40		
17	*Euphorbia clavigera*		20	40		
18	*Euphorbia decaryi*		20	40		
19	*Euphorbia grandicornis*		30	50		
20	*Euphorbia greenwayii*		30	50		

Sl. No.	Name of the plant	Local name	Price per plant			
			Polybags/ Bare rooted	4"	6"	10"
21	*Euphorbia lactea*		30	50		
22	*Euphorbia millii*		30	50		
23	*Euphorbia millii Hybrid*		50	70		
24	*Euphorbia obesa*		100	150		
25	*Euphorbia tirucalli*		20	40		
26	*Euphorbia trigona*		30	50		
27	*Furcraea gigantia*		50	100		
28	*Gasteria acinacifolia*		50	100		
29	*Gasteria disticha*		50	100		
30	*Gasteria liliputana*		50	100		
31	*Gibbaeum petrense*		20	40		
32	*Haworthia angustifolia*		20	40		
33	*Haworthia cuspidata*		20	40		
34	*Haworthia fasciata*		20	40		
35	*Haworthia limifolia*		20	40		
36	*Haworthia reinwardtii*		20	40		
37	*Jatropha podagrica*		30	50		
38	*Kalanchoe beharensis*		20	40		
39	*Kalanchoe blossfeldiana*		20	40		
40	*Kalanchoe orgyalis*		20	40		
41	*Lithops brornfieldii*		50	100		
42	*Monadeniurn ellenbeckii*		20	40		
43	*Orbea sernota*		30	50		
44	*Pachypodium geayi "cristate"*		200	250		
45	*Pachypodiurn geayi*		100	150		
46	*Pachypodiurn lamerei*		100	150		
47	*Pachypodiurn lealii*		100	150		
48	*Pachypodiurn rosulaturn*		100	150		
49	*Pachypodiurn rutenbergianurn*		100	150		
50	*Pedilanthus tithyrnaloides*		20	40		
51	*Portulacaria afra*		30	50		
52	*Sedum morganianum*		30	50		
53	*Senecio stapeliaeformis*		30	50		
54	*Stapelia gigantea*		20	40		
55	*Talinum paniculatum*		20	40		
56	*Yucca aloifolia*		50	100		
57	*Zamiacalcus zamifolia*		100		500	

Seasonals

Sl. No.	Name of the plant	Price per plant		
		Rate per barerooted seedling	Poly bags	Potted (6")
1	*African Marigold*	5/-		
2	*Ageratum (Blue)*	5/-		50/-
3	*Alyssum (Easter Bonnet Mix)*	5/-		50/-
4	*Antirrhinum Dwarf*	5/-		50/-
5	*Antirrhinum-Medium*			50/-
6	*Aster -Medium*	5/-		50/-
7	*Astilbe (Showstar)*	5/-		
8	*Begonia (Single-Dwarf)*	10/-		
9	*Calendula*	5/-		
10	*Candy top*	5/-		
11	*Carnation (Double)-Dwarf Lilypot*	10/-		50/-
12	*Carnation (Tall)*	5/-		
13	*Celosia (Dwarf)*	5/-		
14	*Celosia (Tall)*	5/-		
15	*Cineraria*	10/-		
16	*Clianthus*	5/-		
17	*Cosmos (Dwarf)*	5/-		
18	*Delphinium*	5/-		50/-
19	*Dianthus (Double F1 Hybrid)*			50/-
20	*Dianthus (Single F1 Hybrid)*	5/-		50/-
21	*French Marigold*	10/-		
22	*Gazzania-F1 Hybrid*	5/-		50/-
23	*Geranium-F2 hybrid*	10/-		
24	*Godetia*	10/-		
25	*Hollyhock -Dwarf*	10/-		
26	*Impatiens (Dwarf)*	5/-		
27	*Impatiens (New Guinea)*	10/-		
28	*Inca (Gold)*	7/-		
29	*Inca (Orange)*	7/-		
30	*Inca (White)*	10/-		
31	*Inca (Yellow)*	7/-		
32	*Lasianthus*	5/-		
33	*Linaria (Fantasy)*	10/-		
34	*Lobelia*	5/-		
35	*Mimulops*	5/-		
36	*Nasturtium*	5/-		
37	*Nicotiana (Double)*	5/-		

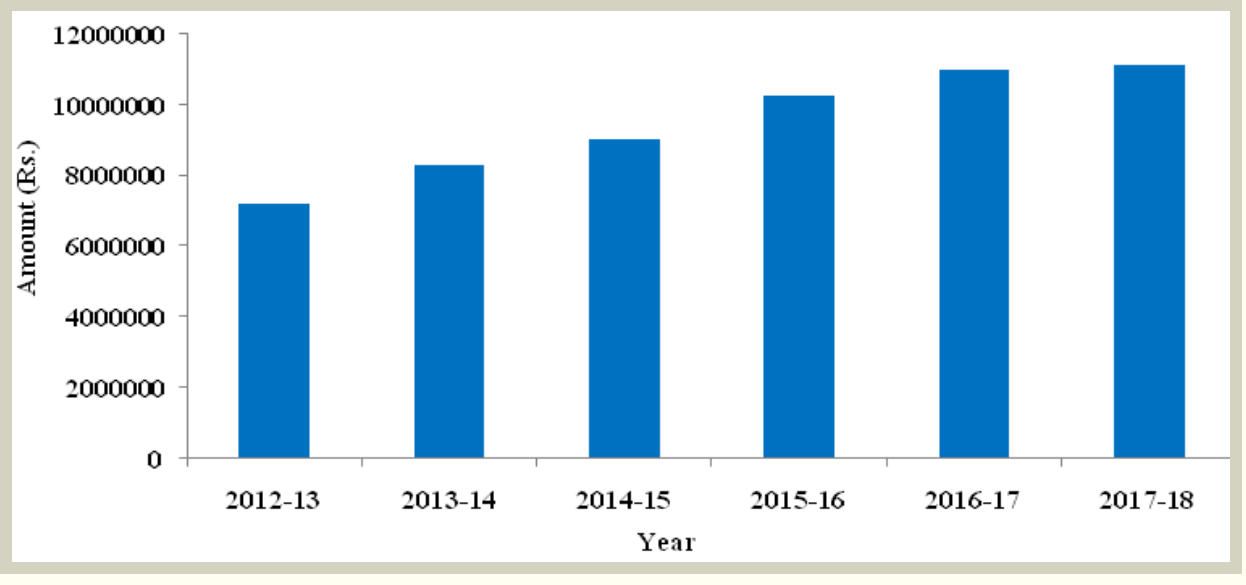
Sl. No.	Name of the plant	Price per plant		
		Rate per barerooted seedling	Poly bags	Potted (6")
38	*Pansy (Majestic Giant- F1 hybrid)*	10/-		
39	*Pentas (Dwarf)*	10/-		
40	*Petunia (Double)-grandiflora series (Plain colour/ bicolour)*	10/-		50/-
41	*Petunia (single)-grandiflora series (Super Cascade)*			50/-
42	*Petunia (single)-grandiflora series (Ultrastar)*	10/-		50/-
43	*Phlox- F1 Hybrid*	5/-		
44	*Salvia (Red & Mix)- Dwarf/ Medium/ Tall*	10/-		
45	*Seed Dahlia*	5/-		
46	*Starfire Marigold*	5/-		
47	*Stock (Vintage/Midget)*	5/-		
48	*Sweet William*	5/-		
49	*Torenia*	10/-		
50	*Verbena*	5/-		
51	*Zinnia (F1 hybrid)*	10/-		
52	All seasonal seedlings produced from OP seeds (Other than Sl. No. 1-45)	3/-		

REVENUE GENERATED

Revenue generation

(Entry fee, Sale of plants, Training, etc)

Year	Amount (Rs.)
2012-13	7202126
2013-14	8292974
2014-15	9041093
2015-16	10287929
2016-17	11011602
2017-18	11150726



REGIONAL PLANT RESOURCE CENTRE, BHUBANESWAR

BALANCE SHEET AS ON 31.03.2012

LIABILITIES	SCHEDULE	AMOUNT (Rs.)	ASSETS	SCHEDULE	AMOUNT (Rs.)
General Fund	1	26,006,731.36	Fixed Assets	5	96,534,866.26
Grant for Non-recurring Expenses	2	152,575,414.00	Work-in-progres	6	33,620,614.27
Advance Received for Contract work	3	7,220,370.00	Fund Transfer to opening new scheme account		4,565,034.00
Current Liabilities	4	6,027,918.14	**Current Assets**		
			Loans & Advances	7	54,820,365.26
			Cash at Bank Balance:		
			Cash in Hand		1,772.06
			Cash at Bank		2,287,781.65
TOTAL		191,830,433.50	TOTAL		191,830,433.50

SIGNIFICANT ACCOUNTING POLICIES & NOTES ON ACCOUNTS: SCHEDULE-8

Place : Bhubaneswar
Date : 11.02.2013

MKPS & ASSOCIATES Bhubaneswar Chartered Accountants

Chief Executive
Regional Plant Resource Centre

MKPS & Associates
Chartered Accountants

CA Anup Agrawal
Partner
M.No 058878

REGIONAL PLANT RESOURCE CENTRE, BHUBANESWAR

BALANCESHEET AS ON 31.03.2013

LIABILITIES	SCHEDULE	AMOUNT(RS.)	ASSETS	SCHEDULE	AMOUNT(RS.)
General Fund	1	31,174,309	Fixed Assets	5	91,951,539
Grant for Non-recurring Expenses	2	152,575,414	Work-in-Progress	6	33,620,614
			Fund Transfer to opening new scheme		4,565,034
Advance Received for Contract Work	3	7,220,370	account		
Current Liabilities	4	5,384,426	Current Assets		
			Loans & Advances	7	53,236,035
			Cash in Hand		2,577
			Cash at Bank Balance:		12,978,720
Total		196,354,519	Total		196,354,519

For AASA AND ASSOCIATES
Chartered Accountants
CA P S Mishra (FCA DISA
Partner M No 060108

Chief Executive
Regional Plant Resource Centre
Bhubaneswar

Place: Bhubaneswar
Date: 31/12/2014

REGIONAL PLANT RESOURCE CENTRE, BHUBANESWAR

BALANCESHEET AS ON 31.03.2014

LIABILITIES	SCHEDULE	AMOUNT(RS.)	ASSETS	SCHEDULE	AMOUNT(RS.)
General Fund	1	49,988,388	Fixed Assets	5	104,681,611
Grant for Non-recurring Expenses	2	152,575,414	Work-in-Progress	6	33,620,614
Advance Received for Contract Work	3	7,220,370	Fund Transfer to opening new scheme account		4,565,034
Current Liabilities	4	5,384,001	Current Assets		
			Loans & Advances	7	52,962,552
			Cash in Hand		2,814
			Cash at Bank		19,335,548
Total		215,168,173	Total		215,168,173

For AASA AND ASSOCIATES
Chartered Accountants

P S Mishra (FCA,DISA)
Partner
M.No.: 060108

Chief Executive
Regional Plant Resource Centre
Bhubaneswar

Place: Bhubaneswar
Date: 20/03/2015

REGIONAL PLANT RESOURCE CENTRE, BHUBANESWAR

BALANCESHEET AS ON 31.03.2015

LIABILITIES	SCHEDULE	AMOUNT(RS.)	ASSETS	SCHEDULE	AMOUNT RS.
General Fund	1	43,248,100	Fixed Assets	5	99,246,445
Grant for Non-recurring Expenses	2	152,575,414	Work-in-Progress	6	33,620,614
Advance Received for Contract Work	3	7,220,370	Fund Transfer to opening new scheme account		4,565,034
Current Liabilities	4	4,665,817	Current Assets		
			Loans & Advances	7	55,147,355
			Cash in Hand		1,998
			Cash at Bank		15,128,255
Total		207,709,701	Total		207,709,701

For PARTHA S. MISHRA & CO.
Chartered Accountants

P.S. Mishra (FCA) Partner
M.No.-60108

PARTHA S. MISHRA & CO. FRN 324487E Chartered Accountants

Place: Bhubaneswar
Date: 16/12/2015

Chief Executive
Regional Plant Resource Centre
Bhubaneswar

REGIONAL PLANT RESOURCE CENTRE, BHUBANESWAR

BALANCESHEET AS ON 31.03.2016

LIABILITIES	SCHEDULE	AMOUNT(RS.)	ASSETS	SCHEDULE	AMOUNT(RS.)
General Fund	1	64,907,056	Fixed Assets	5	103,839,482
Grant for Non-recurring Expenses	2	152,575,414	Work-in-Progress	6	36,986,813
Advance Received for Contract Work	3	7,220,370	Fund Transfer to opening new scheme account		4,565,034
Current Liabilities	4	4,860,650	Current Assets		
			Loans & Advances	7	58,267,392
			Cash in Hand		4,647
			Cash at Bank		25,900,122
Total		229,563,490	Total		229,563,490

For PARTHA S. MISHRA & CO.
Chartered Accountants
Sangaya kumar Patra
CA S.K. Patra (FCA, DISA)
Partner, M. No-301929

PARTHA S. MISHRA & CO. FRN 324467E Chartered Accountants

Place: Bhubaneswar
Date: 17/03/2018

REGIONAL PLANT RESOURCE CENTRE, BHUBANESWAR

BALANCESHEET AS ON 31.03.2017

LIABILITIES	SCHEDULE	AMOUNT(RS.)	ASSETS	SCHEDULE	AMOUNT(RS.)
General Fund	1	73,218,810	Fixed Assets	5	101,206,218
Grant for Non-recurring Expenses	2	152,575,414	Work-in-Progress	6	36,986,813
Advance Received for Contract Work	3	7,220,370	Fund Transfer to opening new scheme account		4,565,034
Current Liabilities	4	5,364,484	Current Assets		
			Loans & Advances	7	62,589,628
			Cash in Hand		1,575
			Cash at Bank		33,029,810
Total		238,379,078	Total		238,379,078

For PARTHA S. MISHRA & CO.
Chartered Accountants

Sanjaya Kumar Patra

CA S.K. Patra (FCA, DISA)
Partner, M. No-301929

Place: Bhubaneswar
Date: 20/03/2018

Carissa carandas

Regional Plant Resource Centre

Forest and Environment Department, Government of Odisha
Nayapalli, Bhubaneswar 751015, Odisha, India
Phone: +91 674 2552002, 2557925 Fax: +91 674 2550274
Email: rprcbbsr@gmail.com

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Cover : ***Dendrobium regium***
(Wild Endemic Orchid of India) reintroduced in Similipal Biosphere