



RESEARCH and ACTIVITY REPORT 2021-22

REGIONAL PLANT RESOURCE CENTRE BHUBANESWAR

RESEARCH AND ACTIVITY REPORT 2021-22



Research & Activity Report 2021-22

© Regional Plant Resource Centre

Published by

Chief Executive

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Printed: January 2023

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Design and Print:

Ketaki Enterprises Pvt. Ltd.

Unit-Third Eye Communications

Bhubaneswar

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CONTENTS

MESSAGES	5
FROM CHIEF EXECUTIVE'S DESK	9
INTRODUCTION	11
MANDATE	12
EXECUTIVE SUMMARY	13
RESEARCH ACHIEVEMENTS	
Morphotaxonomic characterization and documentation of fungi of Odisha	16
Development of bioinoculant for growth and development of <i>Dalbergia latifolia</i> and <i>Desmodium oogeinense</i> by using native microflora.	17
Screening of fungi for Glutaminase free L-asparaginase	20
Production, purification and evaluation of anticancer properties of extracellular secondary metabolite from <i>Colletotrichum</i> sp.	20
Harnessing the potential of endophytes against root knot nematode, <i>Meloidogyne incognita</i> in banana	21
Establishment of Mass Propagation and Breeding Facility for Orchids	22
Mass Production of Selected Medicinal Plants of Odisha through Tissue Culture	24
Developing micropropagation methods for <i>Pterocarpus santalinus</i> , <i>Anogeissus latifolia</i> <i>Santalum album</i> , and <i>Desmodium oojeinense</i> , some endangered forest trees species of Odisha	26
Omics-approach to regulate ripening and enhance fruit shelf-life in banana: an important fruit crop for food security	29
Therapeutic validation of <i>Pterocarpus marsupium</i> and <i>Piper trioicum</i> as a cholinesterase inhibitor for the treatment of Alzheimer's disease	35
Immunity boosting natural fruits : determination of Vitamin-C (Ascorbic Acid) for selection of potent species to promote domestication	39

Standardization of various macro-propagation methods of useful wild edible fruits of Odisha.	43
Conservation of salt-sensitive back-mangroves <i>Heritiera fomes</i> and <i>H. littoralis</i> through re-introduction in protected area: application of vegetative propagation technique.	46
Phytochemical, antioxidant and cytotoxic activity of ornamental plant <i>Clerodendrum siphonanthus</i>	49
Assessment of antifungal activity of <i>Vallisneria spiralis</i> and <i>Vernonia anthelmintica</i> solvent extracts against <i>Aspergillus flavus</i>	53
Propagation and reintroduction of selected endangered species of Odisha.	59
Standardization of in vitro regeneration techniques in red banana and establishment of red banana in Odisha climate condition.	63
RESEARCH PROJECTS (LIST)	67
PUBLICATIONS	69
TRAINING AND EDUCATION	71
LIBRARY	74
HERBARIUM	74
EX-SITU CONSERVATION & GERMPLASM COLLECTION	74
GARDEN COMPETITION : PRIZE DISTRIBUTION CEREMONY 2022	79
RELEASE OF BOOKS AND OTHER PUBLICATIONS	80
NEW INITIATIVES DURING 2021-22	82
NEW GERMPLASM IN RPRC	82
SEMINAR/TALK BY SUBJECT EXPERTS & RESEARCH SCHOLARS	97
EXPOSURE VISITS OF VARIOUS INSTITUTIONS TO RPRC	99
BALANCE SHEET	104



Shri Pradip Kumar Amat

Minister

Forest, Environment & Climate Change Department

Govt. of Odisha



I am pleased to learn that RPRC, a reputed Research & Development Center, has been implementing various basic as well as applied research projects in the thrust area of plant taxonomy and conservation, biotechnology, biochemistry, microbiology, medicinal and aromatic plants and horticulture too. In addition to core research on plant biodiversity assessment, microbial applications, wild edible fruits, mangroves, orchids and phyto-chemicals of selected medicinal plants, few other aspects like production of economically important crops including tissue culture of banana, orchids are noteworthy as important thrust and frontier areas of plant sciences. It has consistently maintained and added to its unique 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 conservation. 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 (2021-22) published by the center would be useful for students, teachers, researchers and conservationists.

(Pradip Kumar Amat)





Dr. Mona Sharma, IAS
Additional Chief Secretary
Forest, Environment & Climate Change Department
Govt. of Odisha



The Regional Plant Resource Centre (RPRC), a Research & Development organization, under the Forest, Environment and Climate Change Department, Govt. of Odisha has been implementing several unique fundamental and applied research projects for wider use for conserving, propagating, and documenting the rich biological wealth of the region. Production of quality planting materials on commercial scale, germplasm conservation & analysis of wild edible fruits and re-introduction of rare and endangered plants including mangroves & orchids are some of the significant activities of the centre.

Recent initiative on development of Breeding & Tissue Culture facilities, Re-introduction of RET plants into field for conservation, is highly appreciable. I am glad to learn that RPRC has achieved Accreditation for Certification of T.C. Banana plantlets. I hope the Institute would continue to endeavor to find solutions to meet new challenges in conserving the biological diversity of the State.

I hope that the findings of various research activities being undertaken by RPRC, highlighted in this Research & Activity Report (2021-22), would be of great help to various academicians, students & researchers.

Best Wishes.

(Dr. Mona Sharma)





Smt. Pusazhule Mekro, IFS
PCCF & Chief Executive



It is my pleasure to bring out this Research & Activity Report 2021-22 which appraises implementation of various research programmes prioritized to address issues pertaining to conservation and bio-resource utilization 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 research activities focusing the prioritized areas such as germplasm conservation and re-introduction of RET and other important special group of plants including mangroves and orchids, screening of wild edible fruits and medicinal plants for active bio-molecules, nutraceuticals, antioxidants, microbial applications (bioinoculant) for benefiting forest species and micro-propagation of plantation crops and endangered plants.

Research funds have been made available to the Scientists of RPRC from state Forest, Environment & Climate Change Department under state plan budget after rigorous evaluation by the Research Advisory Committee (RAC) headed by the PCCF & HoFF in the Government. The centre has implemented several such research projects covering various thrust areas of research relevant to the state as per recommendation of the RAC.

RPRC has been encouraging and nurturing academic intellect by guiding Ph.D. and M.Sc. students. A six month Project training programme for M.Sc. (Biotech) students from various organizations is being organized to provide hands on training to fulfill the requirement of their M.Sc. degree. Several research papers in national and international journals have been brought out by the Centre and new processes and technologies have been developed.

All the research group, administrative group and supporting staff of RPRC made sustained effort and contributed to growth of the institute, and I extend my sincere thanks to all of them for their endeavour. Financial support received from various of Govt. of India and Odisha is gratefully acknowledged. We are grateful to Additional Chief Secretary, Forest, Environment and Climate Change Department, Government of Odisha for providing the research grant under state plan budget and support provided by Director, (Environment)-cum-Special Secretary is thankfully acknowledged.

(Pusazhule Mekro)



INTRODUCTION

Regional Plant Resource Centre (RPRC), Bhubaneswar, an autonomous R&D Institute of Forest, Environment and Climate Change Department, Govt. of Odisha, has been taking all efforts to showcase its various R&D activities primarily through implementation of various research projects relevant to the state and establishment of different State of the Art facilities to produce and conserve plant genetic resources such as Modern Tissue Culture Laboratory, Orchidarium, Threatened Plants (RET) Garden: Wild Edible Fruits Garden, Medicinal Plants Garden, Cacti and other Succulents, Jagannath Vatika, Fragrant Flower Garden, Morning Health Walk etc. RPRC has implemented various research programmes under financial support from Forest, Environment & Climate Change Dept., Government of Odisha, RKVY, Science & Technology Dept., Govt. of Odisha, other apex central funding agency like DBT, NMPB, Govt. of India, which were prioritized to address issues pertaining to conservation and bio-resource utilization relevant to Odisha state.

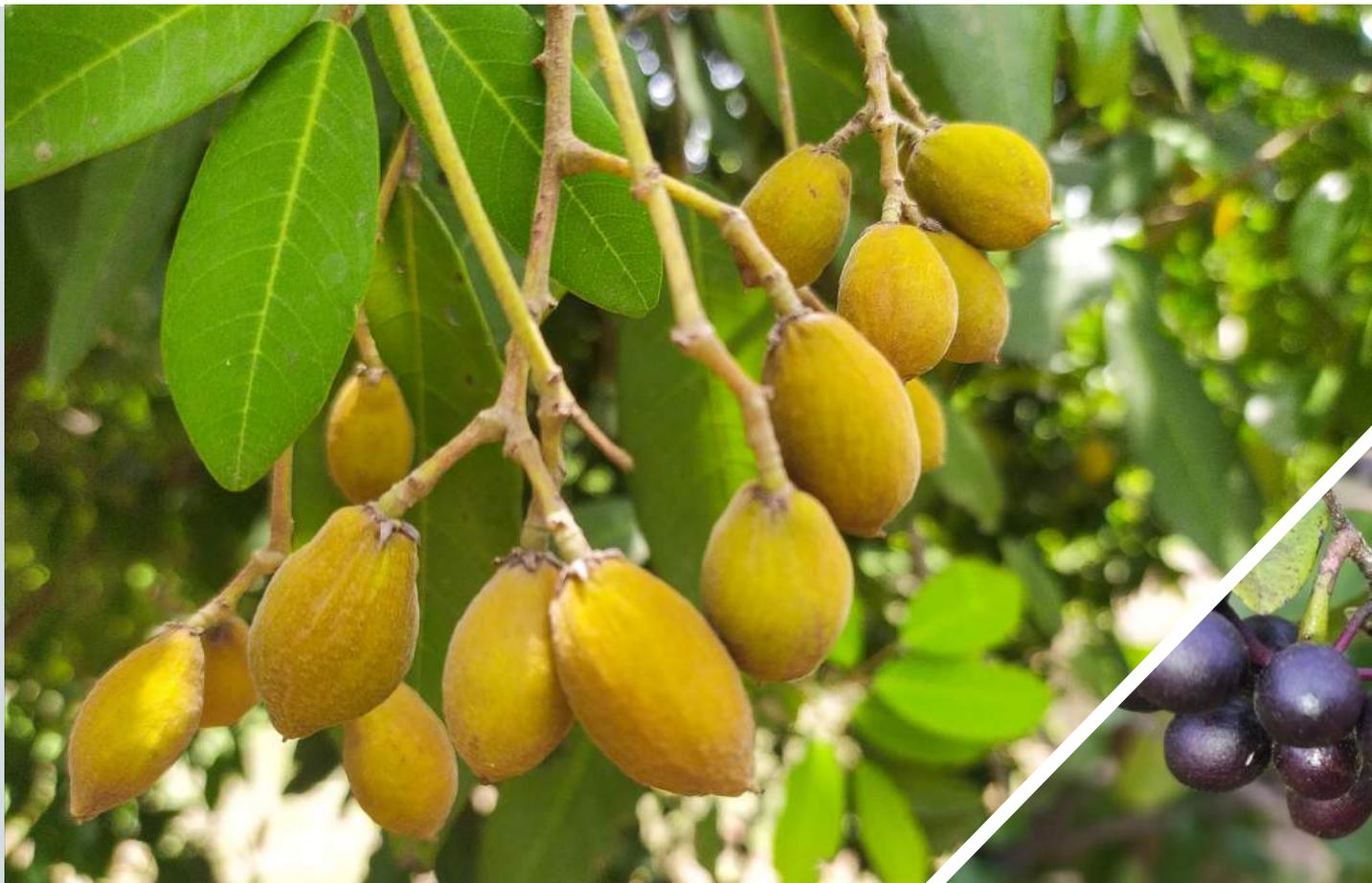
During the year 2021-22, the Center initiated and maintained its core research activities focusing the prioritized areas such as re-introduction of RET and other important special group of plants including mangroves and orchids, domestication and evaluation of wild edible fruits and medicinal plants for active bio-molecules, nutraceuticals, antioxidants, application of bioinoculant for forest species, useful secondary metabolites from fungi, micro-propagation of forest species, plantation crops and endangered plants. A total 6 external funded, 14 state plan funded projects have been implemented during the year 2021-22, engaged around 30 research fellows, 2 Ph.D awarded, published 18 research papers, 2 books, 4 leaflets, 1 Research & Activity Report (2020-21), trained 11 M.Sc. Biotech students for their PG degrees.



MANDATE

The center has a mandate of promoting bioresource 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

Research activities carried out during 2021-22 in Regional Plant Resource Centre under various research and developmental projects are summarized below:

Morphotaxonomic characterization and documentation of fungi of Odisha

In order to document systematically and prepare a checklist of fungi of Odisha, a total 250 numbers of fungi have been characterized morphologically and identified tentatively. Compilation of different culture characteristics and taxonomic description aided with plate culture and microphotographs, camera lucida drawings has been completed and published in the form of book "Fungi of Odisha : Part I . The detailed morphotaxonomic description of 100 numbers of fungi of Odisha has been presented in this report. Part II of the book Fungi of Odisha-II is also under preparation for the publication.

Development of bioinoculant for growth enhancement of Dalbergia latifolia using native microflora

Use of beneficial microbes as bioinoculants /biofertilizers would reduce the cost of chemical fertilizers involved in plantation programmes. The effective utilization of bioinoculants for trees will not only provide economic benefits but also improve and maintain the soil fertility and sustainability in natural soil ecosystem. Two fungal cultures (*Aspergillus* and *Penicillium* sp.) and two bacterial strains (BA and BT) used as bioinoculants supplemented with fertilizer and/or organic manure to observe enhance in growth of seedlings of *Dalbergia latifolia* in nursery conditions. Raising of nursery of plants with such bioinoculants along with supplementation of fertilizer and organic manure may be helpful in establishment of seedlings in field conditions.

Screening of fungi for L-glutaminase free L-asparaginase

L- asparaginases are important anticancer enzymes and have therapeutic value against human leukemia. This enzyme would be more useful if it is free from L-glutaminases for which very less reports are available. Hence, screening programme has been taken up for the search of L-glutaminase free L-asparaginase enzymes. Total 260 numbers of fungi have been screened for this purpose and 14 number Fungi have been found with Glutaminase free L-asparaginase through plate culture methods. Extraction, purification and characterization of some selected fungal enzyme and evaluation of their anticancer properties is future target.

Production, purification and evaluation of anticancer properties of extracellular secondary metabolite from Colletotrichum sp.

Endophytic fungi have been reported as potential candidate for the production of various secondary metabolites and exploited in different agriculture, food, pharmaceutical and health care industries. On the other hand the huge requirement of potent drugs for various diseases induced researchers to explore and investigate alternative avenues for searching novel bioactive molecules. In this regard, endophytes appear to be most possible candidate for drug discovery and formulations. A fungal endophyte was studied for the production of secondary metabolite and further evaluated for anticancer properties.

Harnessing the potential of endophytes against root knot nematode, Meloidogyne incognita in banana

A NET Working project (DBT , Govt. of India) on North Eastern Region Banana has been carried out in Collaboration of TNU, Coimbatore and AAU , Assam. Endophytes isolated from different banana



cultivars were tested against *Meloidegryne icognita* (nematode) and two bacterial strains having nematocidal properties were under process for the field trial by collaborative centres.

Developing micropropagation methods for *Pterocarpus santalinus*, *Anogeissus latifolia*, *Santalum album* and *Desmodium oojeinense*, some endangered forest trees of Odisha.

Shoot induction and growth, multiple shoot induction and root initiation have been experimented. Nodal segments of *S. album* and *D. oojeinense* were cultured on MS media containing different concentrations of BAP to evaluate its effect on shoot initiation. The nodal explants of *S. album* showed shoot initiation on medium having different combinations of plant growth regulators.

Omics-approach to regulate ripening and enhance fruit shelf-life in banana: an important fruit crop for food security

The regulatory process of ripening mechanism in bananas, and proteins involved, has been studied for validation of functional roles in controlling ripening process either through RNAi or genome editing tools to enhance shelf-life.

Therapeutic validation of *Pterocarpus marsupium* and *Piper trioicum* as a cholinesterase inhibitor for the treatment of Alzheimer's disease (AD)

To screen appropriate inhibitors from natural products, an effective and fast assay system is needed. To establish *P. marsupium* and *P. trioicum* as forestry species of Odisha and exploring its bioactive lead molecules cholinesterase inhibitor for the treatment of Alzheimer's disease (AD), a study has been undertaken which will highlight the novel effect of *Pterocarpus marsupium* and *Piper trioicum* as a remedy for AD. The results of current investigation supported the potential role of *P. marsupium* and *P. trioicum* as a memory enhancer in AD.

Immunity boosting Natural fruits: Determination of Ascorbic Acid (Vitamin-C) for selection of potent species to promote domestication

It will be worth to explore the potentials of natural fruits and domesticate them as immune-boosters in large scale. Isolation and quantification of Vitamin- C (ascorbic acid) in selected 10 nos. of natural fruits were attempted in order to select potent species to encourage its conservation and domestication as immune boosting natural fruits. The project specified fruits were quantified for vitamin C through titration and spectrophotometer till date. *Phyllanthus acidus*, *Artocarpus lakoocha* and *Carissa spinarum* were found to have good content of Ascorbic acid.

Standardization of various macro-propagation methods of useful wild edible fruits of Odisha.

Various macro propagation methods have been adopted for propagation and production of quality planting materials through Cuttings, seedlings etc. using 10 selected useful wild edible fruit plants i.e., *Antidesma ghaesembilla*, *Carissa carandas*, *Carissa spinarum*, *Cordia dichotoma*, *Ehretia microphylla*, *Eugenia roxburghii*, *Glycosmis pentaphylla*, *Polyalthia suberosa*, *Toddalia asiatica* and *Ziziphus oenoplia*. Micro-stem Cuttings, Girdled stem cuttings, Stump cuttings, seed germination and wildlings were subjected to propagate & produce saplings. Some of these plants have high potential to be used for their medicinal, commercial and ecological values.

Conservation of salt-sensitive back-mangroves *Heritiera fomes* and *H. littoralis* through re-introduction in protected area: application of vegetative propagation technique.

In order to propagate, hardened and re-introduction of *Heritiera fomes* and *Heritiera littoralis*, various vegetative propagation methods were standardized. The propagated and salt- hardened saplings were re-introduced in Bhitarkanika National Park.

Phytochemical, antioxidant and cytotoxic activity of ornamental plant *Clerodendrum siphonanthus*.

Clerodendrum siphonanthus, basically an ornamental flower, belonging to family Verbenaceae was explored for biological activity using antioxidant, cytotoxic and phytochemical parameters. Four solvent leaf extracts of *Clerodendrum siphonanthus* were prepared and their phytochemical, Antioxidant and Cytotoxic activities was evaluated.

Phytochemical screening of leaf extract of *Clerodendrum siphonanthus*

The study revealed presence of alkaloids in the extracts and clearly indicate the medicinal potential of this ornamental plant as a number of alkaloids isolated from plants have been used as antibacterial, antiviral and antifungal agents.

Assessment of antifungal activity of *Vallis solanacea* and *Vernonia anthelmintica* solvent extracts against *Aspergillus flavus*.

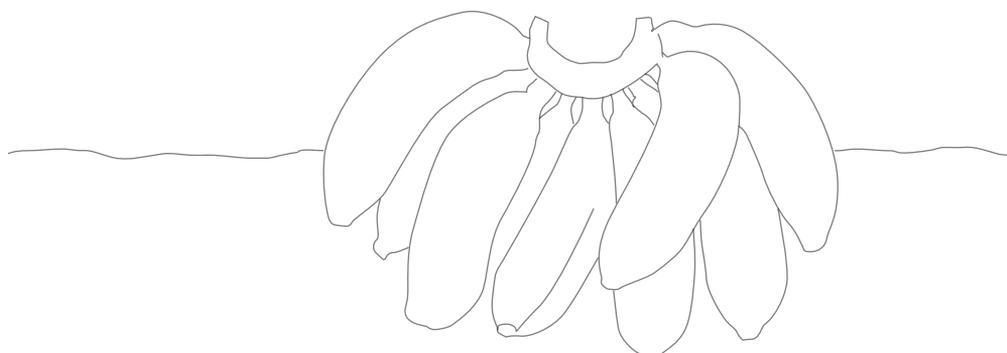
Aspergillus is a mycotoxigenic fungus that possesses the ability to produce a potent toxin and carcinogen known as aflatoxin. They also cause opportunistic infections such as aspergilosis in humans and animals. It is reported that one fourth of the world's crop is affected by mycotoxins and hence it is essential to find a remedy to make the crop free of mycotoxins, this study was aimed at the same objective.

Propagation and reintroduction of selected endangered species of Odisha.

Population inventory, standardization of seed biology and seed propagation methods for *Pterocarpus santalinus*, *Cryptocarya amygdalina*, *Oroxylum indicum*, *Alphonsea madraspatana*, *Litsea glutinosa* and *Cordia macleodii* and refinement of vegetative propagation methods have been studied. Re-introduction of *Pterocarpus santalinus*, *Cryptocarya amygdalina*, *Oroxylum indicum*, *Alphonsea madraspatana* and *Cordia macleodii* in suitable natural habitats and their performance evaluation through multi-locational traits undertaken.

Standardization of *in vitro* regeneration techniques in red banana and establishment of red banana in Odisha climate condition.

A study was carried out to standardize the protocol for micropropagation and establishment of red banana. Evaluation of plant growth regulators on shoot initiation, proliferation and multiplication, evaluation of salt strength and auxins on rooting of plantlet, nutritional factors of edible parts of red banana have been studied along with application of virus indexing for *in vitro* producing healthy and high yielding planting materials.

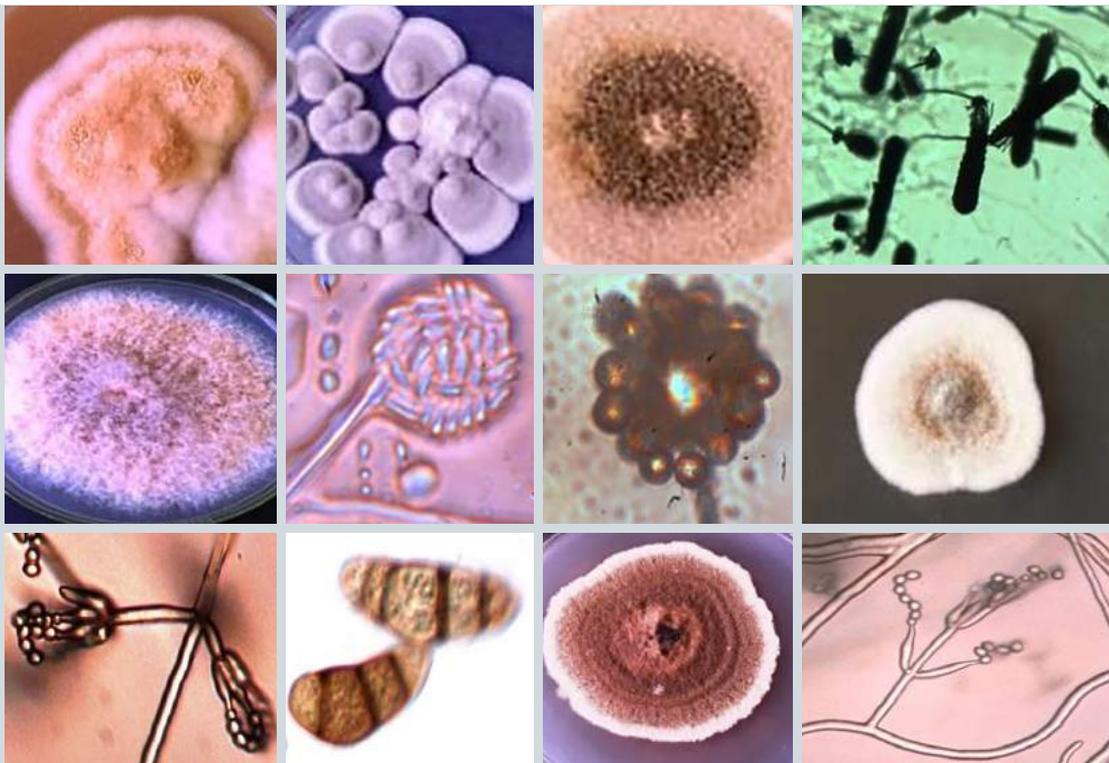


RESEARCH ACHIEVEMENT

Morphotaxonomic characterization and documentation of fungi of Odisha

PI: Dr.(Mrs.) Nibha Gupta, Principal Scientist

Fungi are important group of eucaryotic microorganisms and diversified pertaining to its morphology, physiological and metabolic activity. Besides association with other living organisms in the world, environmental and edaphic factors undoubtedly reveal vital role in creating diversity among them. Odisha endowed with wealth of diversified resources including heavy metal mine, mangroves, good and huge forest cover, very long sea coasts which develop a most suitable habitat for fungi and attained opportunity for multifarious diversity. We have collected fungi from different ecological habitats of Odisha like mangroves, mines, endophytic environment of orchids, medicinal plants etc. Since, this collection has been made under different projects, a regular sub culturing and enlisting was limited for a particular time period. A systematic documentation is required based on morphotaxonomy followed by molecular taxonomy in rare cases. Still, we are not able to find out the authenticated checklist of fungi of Odisha as compared to plant groups. The work emphasized in present proposal may contribute to some extent towards this direction. Total 250 number of fungi have been characterized morphologically and identified tentatively. Compilation of different culture characteristics and taxonomic description aided with plate culture and microphotographs, camera lucida drawings has been completed and published in the form of book "Fungi of Odisha : Part I. The detailed morphotaxonomic description of 100 number of fungi of Odisha has been presented in this book. Part II of this book is also under preparation for the forthcoming publication.



Different morphological types of fungi of Odisha

Development of bioinoculant for growth enhancement of *Dalbergia latifolia* using native microflora

PI: Dr.(Mrs.) Nibha Gupta, Principal Scientist

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 afforestation sites. Use of these beneficial microbes as bioinoculants /biofertilizers would reduce the cost of chemical fertilizers involved in plantation programmes. The effective utilization of bioinoculants for trees will not only provide economic benefits but also improve and maintain the soil fertility and sustainability in natural soil ecosystem. Some tree species are being cultivated in agro-forestry system by farmers and industries for their end users. Hence, an efficient production of quality seedlings of economically important native tree species is of paramount importance for better productivity in field. With this objective, a pot experiment on seedlings of *Dalbergia latifolia* was set with the inoculation of different fungal and bacterial inoculants. Data recorded on morphological parameters and growth of treated plants over control exhibited the positive response of 2 numbers of bacteria and fungi in enhancing growth of experimental plants under nursery conditions. Over 500 QPM seedlings of *Dalbergia latifolia* raised were transferred to Chandaka Wild Life Division for various plantation. Package of Bioinoculants has also been prepared for future field trial of other forestry species. The present experiment was conducted to evaluate the effect of microbial inoculants with and without fertilizer and organic manure on growth of *Dalbergia latifolia* grown under nursery conditions. Seedlings of 30 days old plants were inoculated

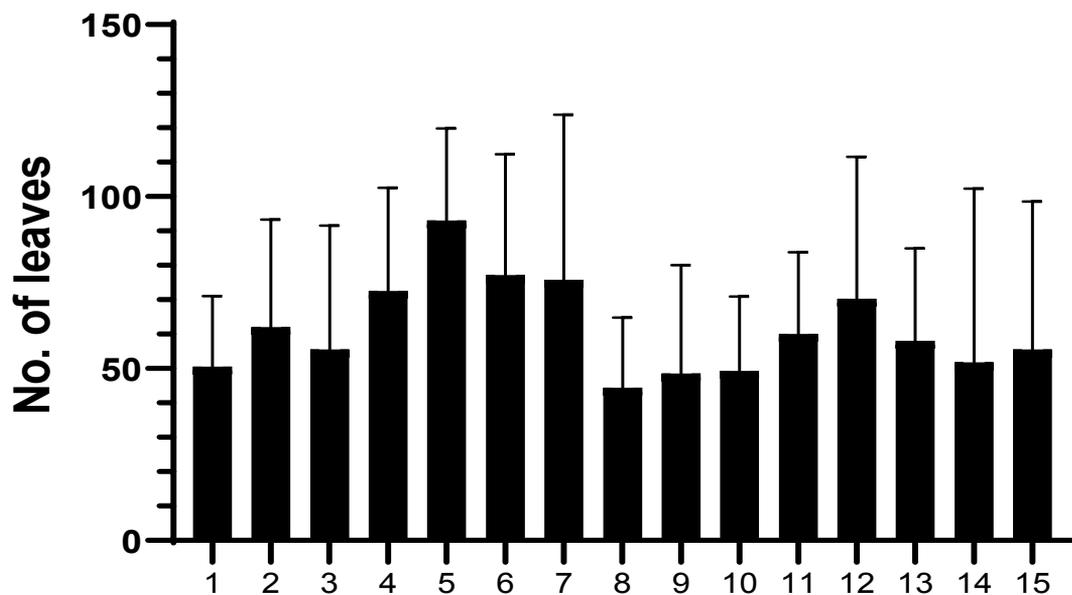
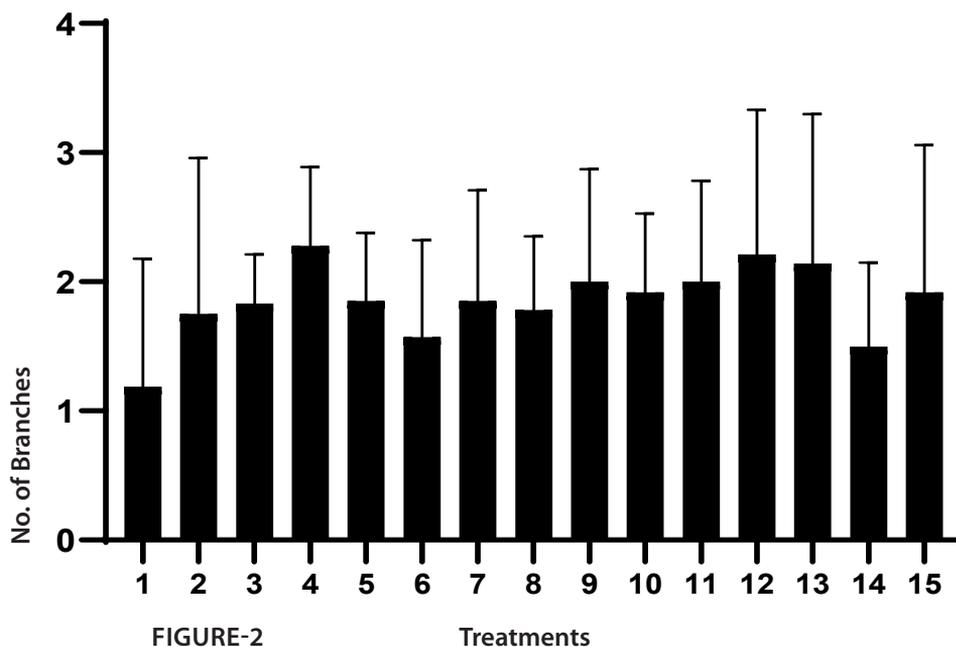
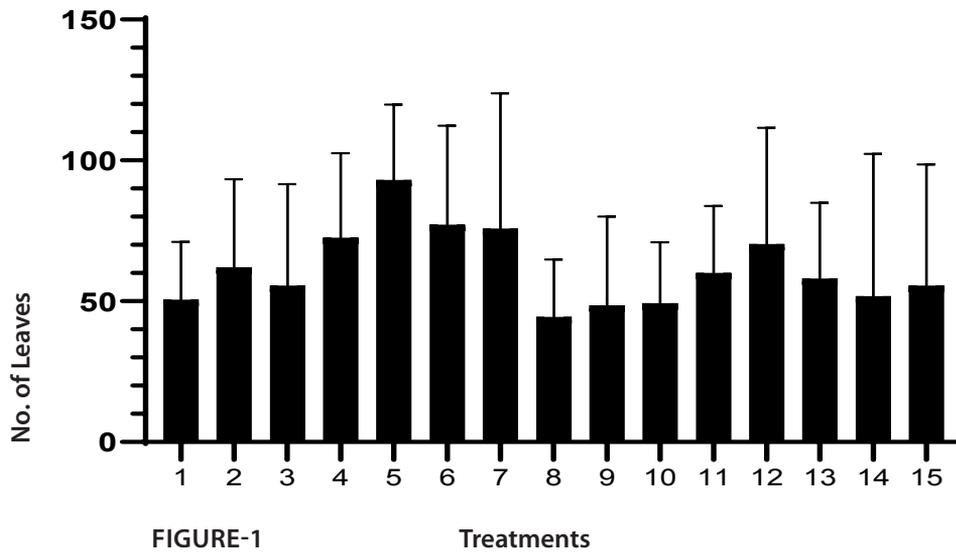
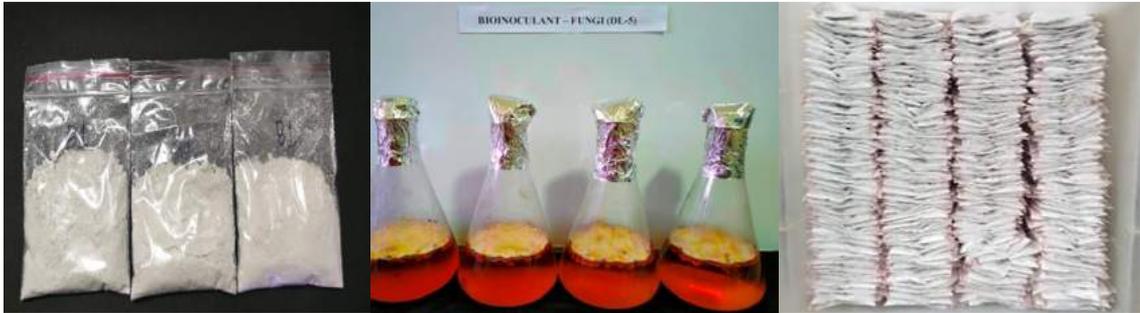


Figure -1 treatments



(thrice with interval of one month) with two fungal cultures (*Aspergillus* and *Penicillium* sp.) and two bacterial strains (BA and BT) with and without NPK and organic manure. Data recorded on number of leaves, branches and shoot height development exhibited the growth enhancing effect of fungal inoculation especially *Penicillium* sp. Plants inoculated with *Aspergillus* sp. produced more number branches comparatively. Individual inoculation of *Penicillium* sp. and Bacterial strain BT has shown increase in shoot height. The Relative growth rate and leaf area ratio revealed the growth enhancing impact of bioinoculants with supplemented with fertilizer and/or organic manure. Over all, microbial inoculations were found to be useful in enhancing growth of seedlings in nursery conditions. Raising of nursery of plants with such bioinoculants along with supplementation of fertilizer and organic manure will certainly be helpful in establishment of seedlings in field conditions.



Screening of fungi for L-glutaminase free L-asparaginase

L- asparaginases are important anticancer enzymes and have therapeutic value against human leukemia. Fungal L-asparaginases are becoming important due to its less allergic reactions than bacterial sources. This enzyme would be more useful if it is free from L-glutaminases for which very less reports are available. Hence, screening programme has been taken up for the search of L-glutaminase free L-asparaginase enzymes. Total 260 number Of fungi have been screened for this purpose and 14 number Fungi have been found with Glutaminase free L-asparaginase through plate culture methods. Extraction , purification and characterization of some selected fungal enzyme and evaluation of their anticancer properties is future target.

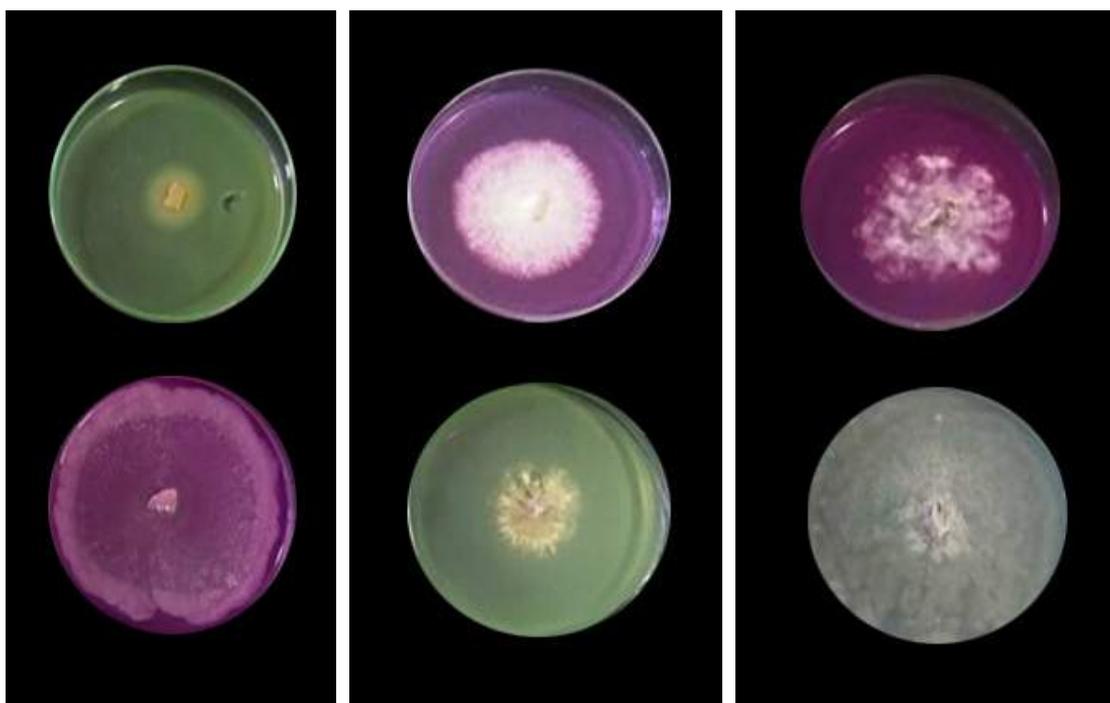


Plate cultures exhibiting L –asparaginase (pink coloured) and L-glutaminase activity (negative)

Production, purification and evaluation of anticancer properties of extracellular secondary metabolite from *Colletotrichum* sp.

PI: Dr.(Mrs.) Nibha Gupta, Principal Scientist

Endophytic fungi have been reported as potential candidate for the production of various secondary metabolites and exploited in different agriculture, food, pharmaceutical and health care industries . On the other hand the huge requirement of potent drugs for various diseases induced researchers to explore and investigate alternative avenues for searching novel bioactive molecules. In this regard, endophytes appear to be most possible candidate for drug discovery and formulations. A fungal endophyte was studied for the production of secondary metabolite and further evaluated for anticancer properties. The crude extract obtained through Mass culture and subsequent solvent extraction exhibited positive inhibitory activity against Human leukemic cancer cells K 562. Further optimization of purification of secondary metabolites is under process to confirm this result.

Harnessing the potential of endophytes against root knot nematode, *Meloidegyne incognita* in banana

PI: Dr.(Mrs.) Nibha Gupta, Principal Scientist

A NET Working project (DBT , Govt. of India) on North Eastern Region Banana has been carried out in Collaboration of TNU, Coimbatore and AAU , Assam. Endophytes isolated from different banana cultivars were tested against *Meloidegyne incognita* (nematode) and two bacterial strains having nematocidal properties were under process for the field trial by collaborative centres. Finally, a suitable bioinoculant will be obtained and the standardized liquid and soil formulations will be exploited for commercialization through various biofertiliser and biopesticide industries. Preliminary Profiling of Extracellular Enzymes, Polysaccharide and Bioactive Secondary Metabolites of *Pseudomonas* sp. and *Lysinibacillus* sp. isolated from Banana Cultivars of Assam has been done . Data recorded on extracellular metabolic activity (plate cultures) and antimicrobial activity of *Pseudomonas* sp. and *Lysinibacillus* sp. have been found very promising and may be useful parameter for selecting both the bacteria as bioinoculant for crop improvement of banana. Periodical observation of organic acid production by *Lysinibacillus* sp. and *Pseudomonas* sp. has been presented here (Fig. 1 and Fig. 2) . Bioformulations have been evaluated for their shelf life in different storage conditions and liquid formulation was found to be more durable and active during experimental conditions (Fig. 3) .

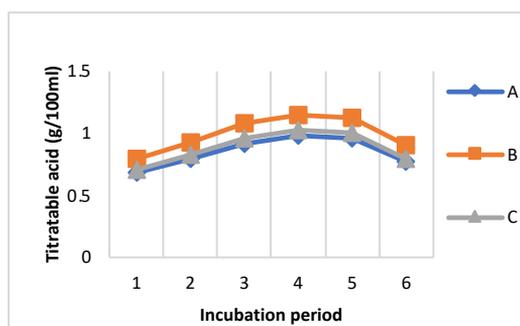
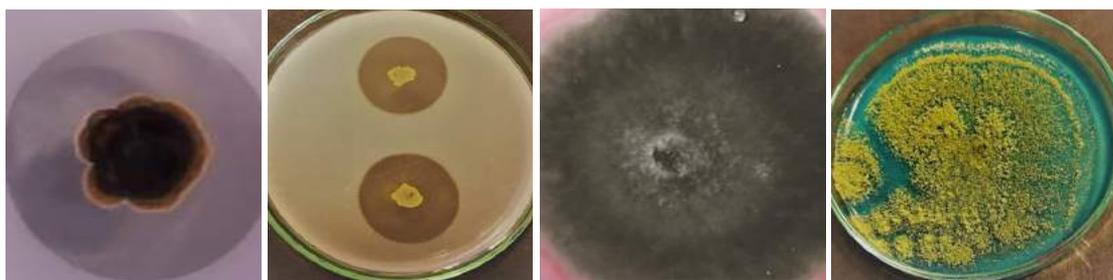


Figure 1

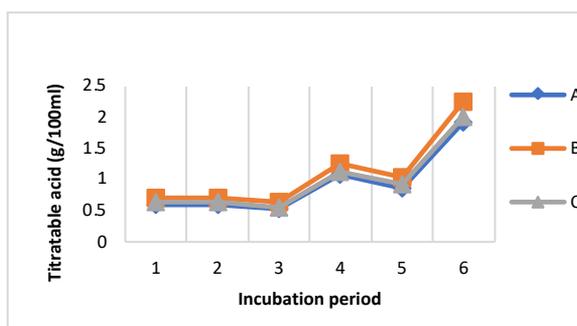


Figure 2

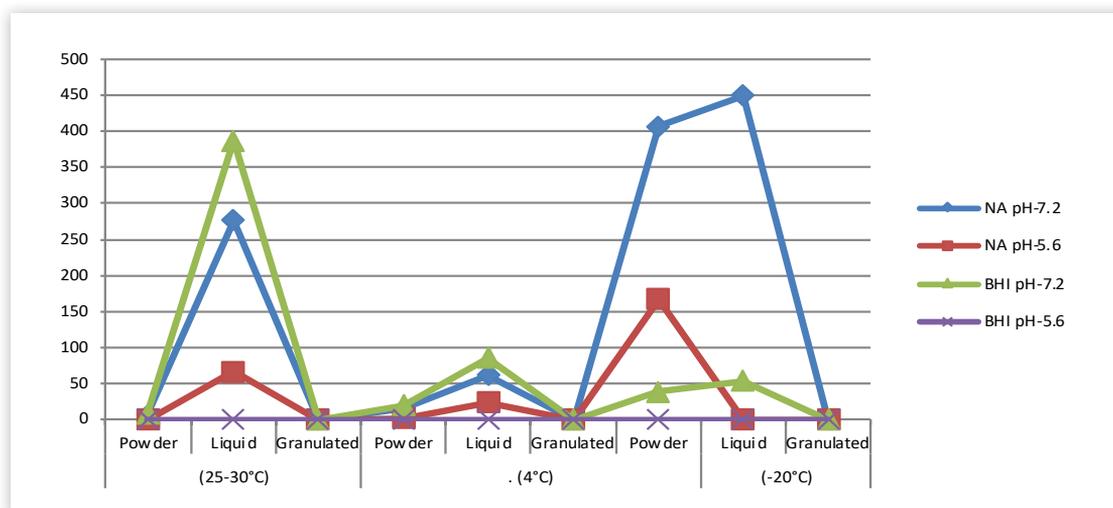


Figure 3

Establishment of Mass Propagation and Breeding Facility for Orchids

PI: Dr. Nihar Ranjan Nayak, Senior Scientist

Establishment of Mother Block-cum-Cut Flower unit of Dendrobium orchids

Orchids are highly valuable because of their extraordinary flower qualities. These are being used both as the cut flowers as well as potted flowers. The demand of the cut flowers in India is very high, currently it is being fulfilled from foreign countries. In the state of Odisha, the environmental conditions are highly conducive for growing orchids particularly for the cut flower production. The family of orchid is very large, among many hybrids, Dendrobium Sonia Ersakul, Dendrobium Sanun White and Dendrobium Singapore White are being used for the cut flower production. The major problem for the large-scale cultivation of orchids is the availability of quality planting materials, in general are produced through tissue culture. For this purpose, it is required to have mother plants of the orchids from which the young shoot buds will be collected.

Blocks of Dendrobium (Sonia, Sanun White and Singapore White) are established. Polyhouses with double door entries are being used for growing the plants. Inside the polyhouses, shadenet benches are constructed and used as the beds for growing plants. On these structures, the mother plants are growing on the top of the coconut husks. In three polyhouses, 6600 plants are growing with the proper application of fertilizers.



Dendrobium Sonia mother plants



Dendrobium Sanun White and Dendrobium Singapore White

Young shoot buds from these mother plants will be used to produce planting materials in mass scale. Since more than 6000 plants are growing in three polyhouses, the unit can be used for the cut flower production of these three varieties. The facility can also be used as the demonstration plots for the orchid cut flower production.

Development of molecular markers of orchids

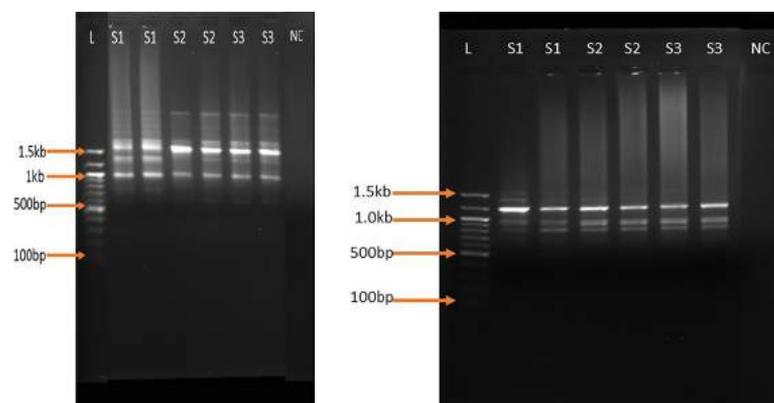
Molecular markers are small DNA sequences of the orchids could be used in addressing number of problems. The most important application is identification of different varieties when in blooming conditions. Other important application is identification of genetic uniformity among the planting materials produced through tissue culture. Since orchid breeding is a very complex process, molecular markers could be used for the identification of hybrid orchids. In recent years, number of molecular markers are available, among these Inter Simple Sequence Repeats (ISSR) are simple, reliable and has been used in several orchids. In this study, molecular markers are being used for identifying variables of different *Dendrobium* hybrids and Species.

Dendrobium Sonia

This hybrid orchid developed through a breeding programme are widely used for commercial cut flower production throughout the world . This hybrid is having different cultivars, differ in their flower morphology and color. Some of these are Sonia Ersakul, Sonia 19, and Sonia 18. The planting materials of these varieties are being produced through tissue culture for which ISSR molecular markers developed for the detection of soma clonal variation.

ISSR Profiles using two different primers of *Dendrobium* Sonia 18 (S1), *Dendrobium* Sonia 19 (S2), *Dendrobium* Sonia Earsakul (S3).

a) Showing different profiles



Mass Production of Selected Medicinal Plants of Odisha through Tissue Culture

PI: Dr. Nihar Ranjan Nayak, Senior Scientist

In vitro* propagation of *Paederia foetida

The species commonly known as 'Pasaruni', in Odisha widely used for its medicinal value. Mostly in the state the leaves are being used for the treating stomach problems. The aerial parts reported to have several glycosides having wide range of activities like anti-oxidant, antibacterial, analgesic, anti-inflammatory, diabetic, and hepatoprotective. Paederine and essential oil reported from different parts of the plant. Different types of volatile compounds are also isolated by steam distillation from the leaves and stems of which linalool is the major component. Linalool has uses in manufacturing of soaps, fragrances, food additives as flavors, household products, and insecticides.

The propagation of the plants is very simple, it propagates through both the seeds and stem cuttings. The latter responds very well in producing new plants. Thousands of plants could be produced in a short period of time. However, the plant tissue culture technology offers wide ranges of applications, the major advantage is the production of disease free and quality plants. In this study efficient procedure developed to produce quality planting materials in mass scale.

Nodal explants of the medicinal plant were cultured on MS medium containing Benzyl Adenine Purine (BAP), Kinetin (Kn) and Gibberellic Acid (GA3) with different concentrations and combinations. From the explants, new shoot buds were produced after 90 days of culture. Of the different combinations of growth regulators tested, MS medium containing 2.5 mg/l produced a maximum of the 5.0 number of shoot buds after 90 days of culture. These new shoots were elongated further and rooted successfully on MS medium without any growth regulators. On the elongation medium, the now shoots grew up to 3 to 4 cm in height and produced 4-5 leaves withing 120 days of culture.



Production of *Paederia foetida* plants under *in vitro* condition

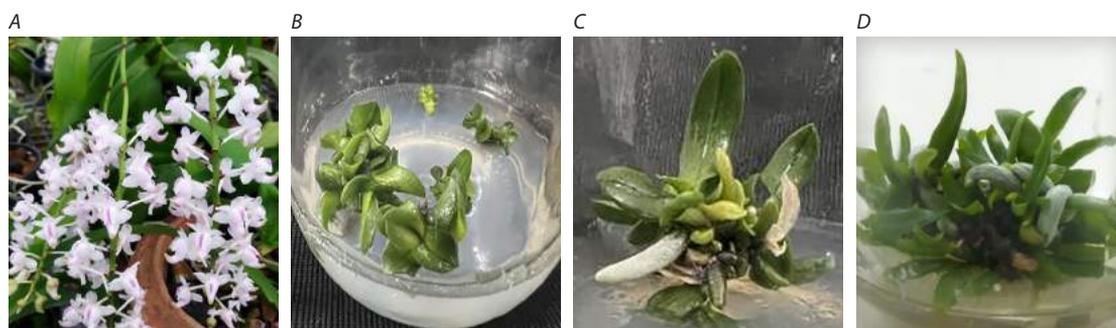
In vitro* propagation of *Aerides odorata

In Odisha, so far 151 orchids species have been reported from different parts of the state. Orchids are very rare because of their life cycle; one of the major problems associated with the orchids is that though they produce seeds in larger numbers, very few germinate under natural conditions because of lack of nutrient reserve. However, in recent years, it is possible to raise seedlings in larger quantity using tissue culture using tissue culture technology. In this process, both the seeds and other vegetative parts can be cultured to propagate into plants leading to adult flowering plants.

The orchid *Aerides odorata* is distributed in few of the Asian countries like China, India, Bhutan, and Nepal. This orchid is easy to grow and do have excellent quality flowers; cream to white color flowers with a purple or magenta lip, the major attraction is the fragrance. In the state of Odisha, widely distributed, however, population growth not observed. It is required to culture the planting materials in large scale to be used for the reintroduction purpose to its natural condition.

In this study, experiments were carried out to produce planting materials using different explants. Vegetative parts i.e., young shoots and leaves were used as the explants. From initial experiments, it is observed that matured leaf explants did not respond to produce new shoots, attempt is made on the young seedling explants. The young seedlings produced *in vitro* were used for the study. Murashige and Skoog's 1962 (MS) medium was used, in addition, six different combination of plant growth regulators were supplemented for the induction of new shoots. From these, the medium supplemented with BAP 1.0 mg/l along with Kn 2.5 mg/l produced the highest number of shoots from each explant after 90 days of culture. On this medium, each shoot had 3.66 number of leaves, however, only produced 0.33 number roots. Each shoot had attained 2.0 cm in height.

For induction of roots from the newly produced shoots, two different combinations of Indole Butyric Acid (IBA, 1 mg/l and 2mg/l) were tried. Among these produced the better effect in inducing a greater number of roots. With the application of 2.0 mg/l IBA in the nutrient medium 2.33 number of roots were found to produced from each shoot at 90 days of culture. The shoots with well-developed roots and leaves were transplanted on the coconut husks and transferred to the primary hardening chamber for further growth and development. The procedure developed in this study can be used for the production of planting materials in mass scale to be used for the re-introduction purpose.



Different stages of propagation

- a) Flower of *Aerides odorata*, b) Multiple shoot induction with BAP and Kn
c) Root induction from the shoots with IBA, d) Acclimatized shoots

In vitro* propagation of *Aerides multiflora

This orchid is popularly known as the 'foxtail orchid' produces long lasting fragrant flowers. The inflorescence is highly attractive with the presence of small size bright purple and white colored and compactly arranged flowers. Because of the good quality flowers, this species has been used in several breeding programs to develop hybrid orchids. It is distributed in few other Asian countries, including India. From many parts of the Odisha, it has been observed that the population are reducing requires immediate conservation measures. As that of other orchids, *in vitro* propagation methods are required for this species to produce planting materials to be used for the population restoration purpose.

In this study, since seed are not regularly available, vegetative parts were used as the explants to produce new shoots. Both leaves and young shoots were used and with the application of different plant growth regulators, new shoots were produced in large numbers. Initially, it was found that leaf segments did not respond, thus major experiments were carried out for the production new shoots using shoot buds. Among the different hormone supplements, it was found that the shoots on MS medium containing 2.5 mg/l produced 31.50 number of shoots at 90 days of culture. Each shoot had produced 3.0 number of leaves and attained 2.0 cm height. The shoots were transferred to MS medium containing 2.0 mg/l IBA for induction of roots. It was found that the roots were successfully induced under *in vitro* conditions; each shoot could produce 5.66 number of shoots at 90 days of culture. The small plantlets produced were transplanted on the piece of coconut husks for further growth and acclimatization in the primary hardening chamber.



a) Flower of *Aerides multiflora*, b) Multiple shoot induction with BAP C) Acclimatized shoots

Developing micropropagation methods for *Pterocarpus santalinus*, *Anogeissus latifolia*, *Santalum album* and *Desmodium oojainense*, some endangered forest trees of Odisha.

PI: Dr.Giridara Kumar Surabhi, Senior Scientist

Shoot induction and growth, multiple shoot induction and root initiation:

Nodal segments of *S. album* and *D. oojainense* were cultured on MS media containing different concentrations of BAP to evaluate its effect on shoot initiation. Explants grown on PGR-containing media showed growth and development of shoot depending on explants and different concentrations of BAP added in the media. The explant of *S. album* grown rapidly on the MS media containing PGRs. The explants of *D. oojainense* showed shoot induction on the culture bottle having MS media supplemented with PGR (i.e., BAP).

Santalum album

The nodal explants of *S. album* showed shoot initiation on medium having different combinations of PGRs (1.0 and 1.5 mg/L BAP). Early shoot initiation can be seen in 1.0 mg/L BAP supplemented culture medium after 10-days of inoculation. Shoot multiplication of *S. album* (each having 8-12 multiple shoots) were produced on MS media having 1.0 and 1.5 mg/L BAP after 6-8 weeks of inoculation. Sub-culturing of newly grown shoots was done and transferred to the new culture bottles having same media composition for further growth and development. Multiple shoots having 4-5 cm in length were excised from the nodal segments and subjected vertically (slanting mode) to the rooting media (1/2 MS + 1.0 mg/L IBA+ 0.5 mg/L BAP and MS (full strength) + 3.0 mg/L IBA) for root induction (after approx.70-90 days of inoculation) (Figure-1 to 3).

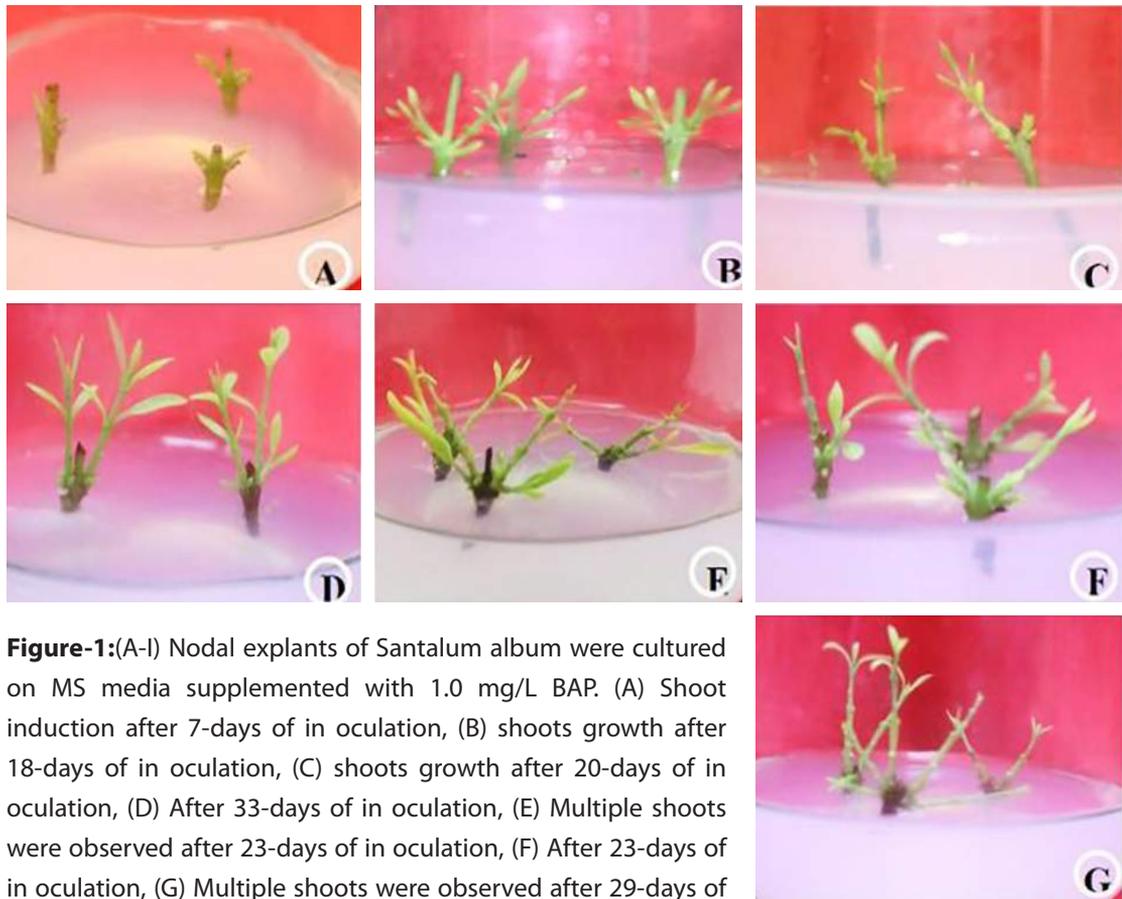


Figure-1:(A-I) Nodal explants of *Santalum album* were cultured on MS media supplemented with 1.0 mg/L BAP. (A) Shoot induction after 7-days of in oculation, (B) shoots growth after 18-days of in oculation, (C) shoots growth after 20-days of in oculation, (D) After 33-days of in oculation, (E) Multiple shoots were observed after 23-days of in oculation, (F) After 23-days of in oculation, (G) Multiple shoots were observed after 29-days of in oculation.

Figure-2:(a) and (b) observed multiple shoot induction after 31-days of in oculation on MS supplemented with 1.5 mg/L BAP, (c) Multiple shoots were observed after 60-days of in oculation on 1.0 mg/L BAP, (d) and (e) showed multiple shoots after 67-days of in oculation (MS + 1.0 and 1.5 mg/L BAP).

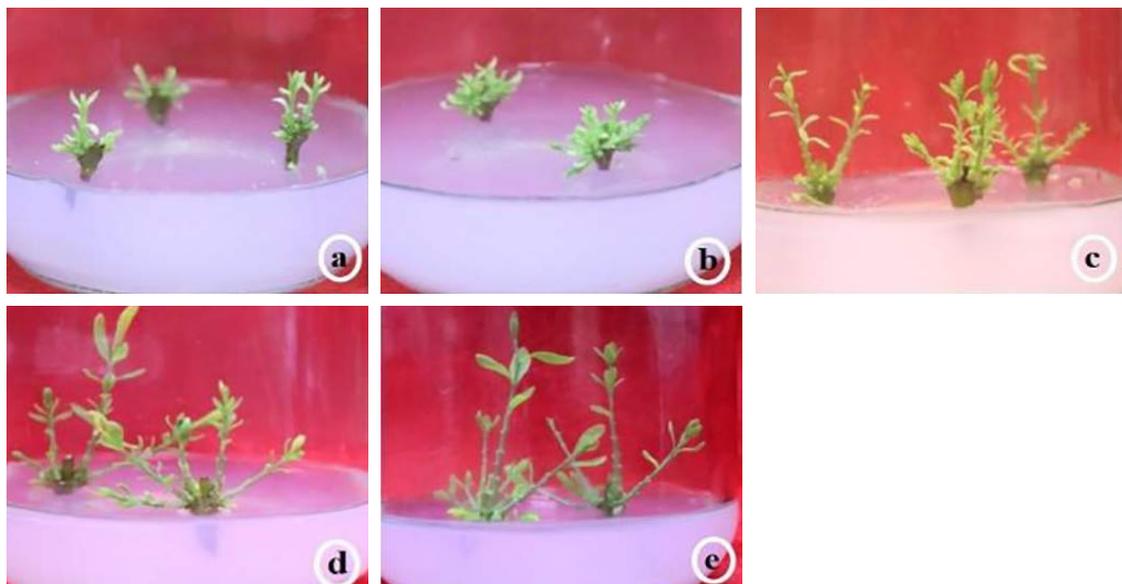




Figure-3:(I-J): Root induction: 3-4 cm of shoots was transferred to rooting media. (H) Individual shoots were transferred to the rooting media ($\frac{1}{2}$ MS + 1.0 mg/L IBA+ 0.5 mg/L BAP) after 85-days of in oculation. (I) Individual shoots were transferred for root induction after 80-days of in oculation (MS+3.0 mg/L IBA), (J) Multiple shoots were transferred to the rooting media after 70-days of in oculation (MS+3.0 mg/L IBA).

Desmodium oojeinense

The nodal explants of *D. oojeinense* showed shoot initiation on medium having 1.0 and 1.5 mg/L BAP. Observed better shoot induction in 1.0 mg/L BAP medium after 7-days of in oculation. Sub-culturing of newly grown shoots was done and transferred to the new culture bottles having same media for further shoot growth and development. Multiple shoots (4-6) were observed after 40-45 days after explant in oculation (Figure-4).



Figure (4) (a-i): Explants of *Desmodium oojeinense* were cultured on full strength MS media + 1.0 mg/L BAP+ ascorbic acid (50 mg/L) + citric acid (22.689 mg/L), (a) and (b) shows bud growth after 7-days of in oculation. Explants showed shoot growth in (c), (d), and (e) after 11-days of in oculation on MS + 1.0 mg/L BAP. (f) and (g) Showed elongated shoots after 25-days of in oculation. (h) Showed shoot elongation after 34-days of in oculation when transferred into MS medium supplemented with 1.5 mg/L BAP. (i) and (j) Showed shoot elongation after 34-days of in oculation when transferred into MS medium supplemented with 1.0 mg/L BAP.

Omics-approach to regulate ripening and enhance fruit shelf-life in banana: an important fruit crop for food security

PI: Dr.Giridara Kumar Surabhi, Senior Scientist

Bananas belonging to the family Musaceae are the fourth most important food crop after rice, wheat and corn. Banana is a fruit crop cultivated across tropical and subtropical regions of the world with an overall consumption of 21 kgs per person per year. The fruit is rich in calories but also other important components for human nutrition, such as vitamins, minerals, anti-oxidants and prebiotics. As a climacteric fruit, the physico-chemical changes that occur during banana ripening are fast, resulting in a notably perishable fruit. While ripening is a genetically controlled, coordinated and irreversible phenomenon, it leads to the desirable quality attributes of edible fruit. Nevertheless, excessive softening intensifies the damage occurring during handling, which decreases the shelf-life of fruits towards postharvest of pathogens. In India, every year about 35-40% of the produced fruit and vegetables are lost due to excessive softening.

A gel-free proteomic approach was employed to study protein changes in different tissues at climacteric stages of banana fruit. The protein samples were subjected to orbitrap fusion mass spectrometry coupled with nano LC-MS/MS which identified a total of 950 and 1300 proteins from pulp, 1416 and 1279 proteins from peel tissues at pre-climacteric and climacteric stages of banana, respectively. Mass-spectrometry identified the protein categories those are involved in sugar metabolism, cell wall modification, and detoxification of reactive oxygen species (ROS), those were found to be increased in number during climacteric stage as compared to pre-climacteric stage of pulp tissue. Proteins such as α -1,4-glucan (α -gluc) phosphorylase, pectin esterases, β -galactosidase (β -gal), α -mannosidase (α -man), pectate lyase, xyloglucan endotransglucosylase/hydrolase (XTH), pectin acetyltransferase and β -hexoaminidase (β -hex) were found to be more in number in climacteric stage and responsible for pulp softening, de-greening of the peel, alterations in texture and fruit quality. The study revealed that sugar metabolism related proteins in the form of sucrose synthase and fructose bis-phosphate aldolase were found to be more in number at climacteric stage as compared to pre-climacteric stage, explaining its involvement in starch breakdown and synthesis of sugars. Interestingly, some of the proteins that play a key role in the hormonal regulation were identified in the form of cysteine synthase (#17) and aminomethyltransferase (#10). Further, cysteine synthase proteins those involved in ethylene biosynthesis pathway were present more in number in banana pulp at climacteric stage. Some of the stress related proteins were also identified in the form of AdoHcyase, aldehyde dehydrogenase (ALDH), glutathione reductase (GR) and rubredoxins which were exclusively present in banana peel tissue at pre-climacteric stage, suggesting that these proteins could be actively participates in protecting peel tissue of banana during loss of water. Further, this investigation has employed an array of bioinformatic tools to decipher protein-protein interactions among identified proteins, and it disclosed that the xyloglucan endotransglucosylase/hydrolase protein 8-related (PTHR31062) or XTH family members with XTH4 forming a central node of interacting partners. Protein-protein interaction study confirms that the XTH could be an ideal candidate that is known to be associated with unique pathways in peel at climacteric stage. Further, the candidate proteins identified in this study could improve our knowledge on the regulatory process of ripening mechanism and helpful in controlling the ripening process either through RNAi or genome editing tools.



Fig. 1. Visual appearances of banana fruit at 90-DAF (A) (pre-climacteric) and 12-DAR (B) climacteric stage.

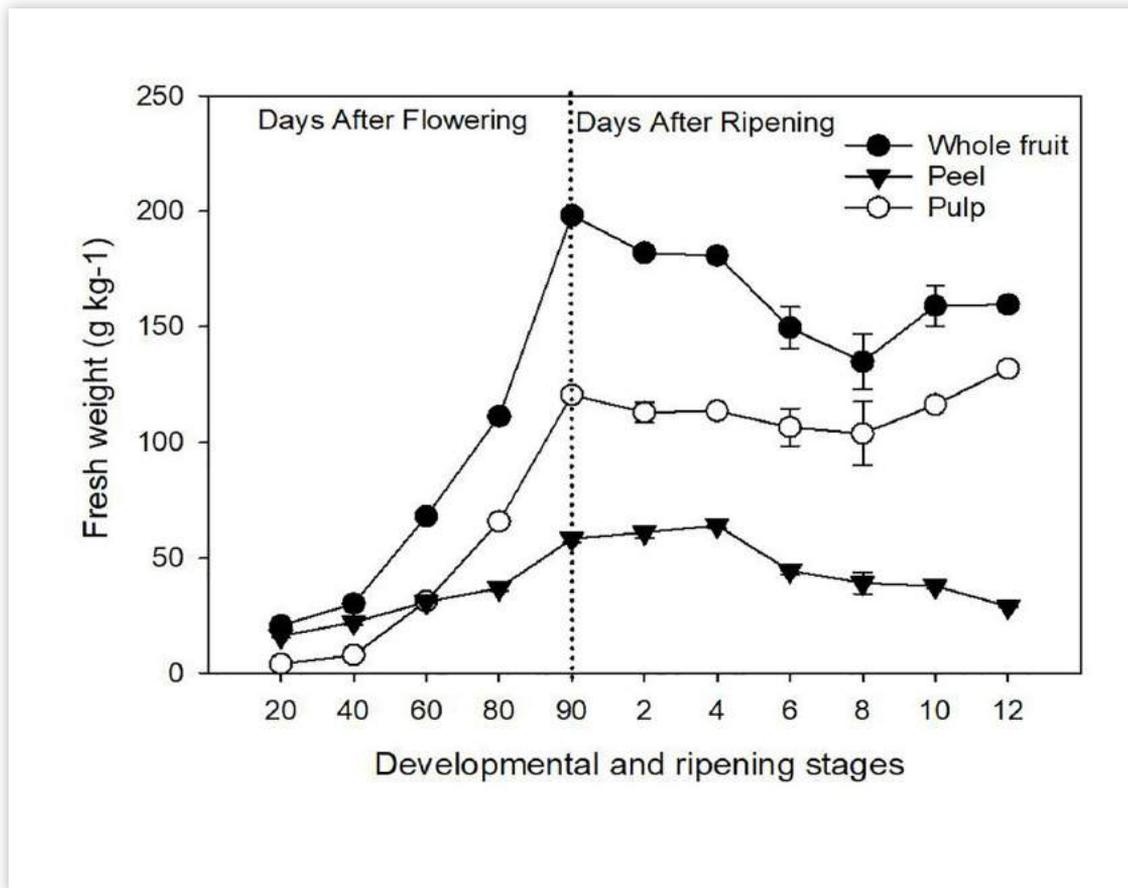


Fig. 2. Fresh weights of banana whole fruit pulp and peel tissues at different developmental and ripening stages. Error bars represent the standard deviation (SD).

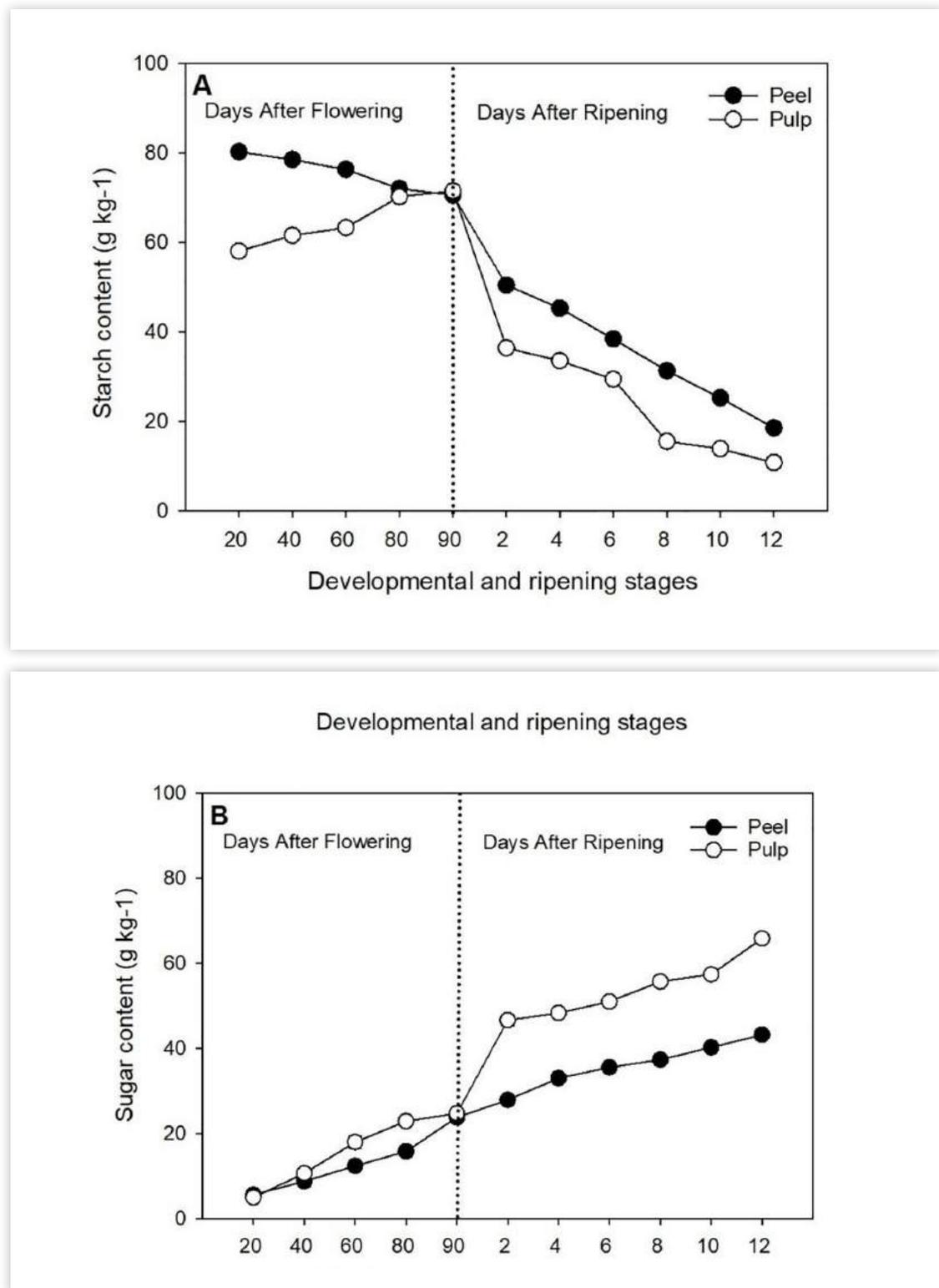


Fig. 3. Represents the biochemical changes in peel and pulp tissue of banana fruit during different developmental and ripening stages. (a) Starch content of banana peel and pulp tissues at different developmental and ripening stages, measured in g kg⁻¹ (b) total sugar content of banana peel and pulp tissues at different developmental and ripening stages, measured in g kg⁻¹. Error bars represent the standard deviation (SD).

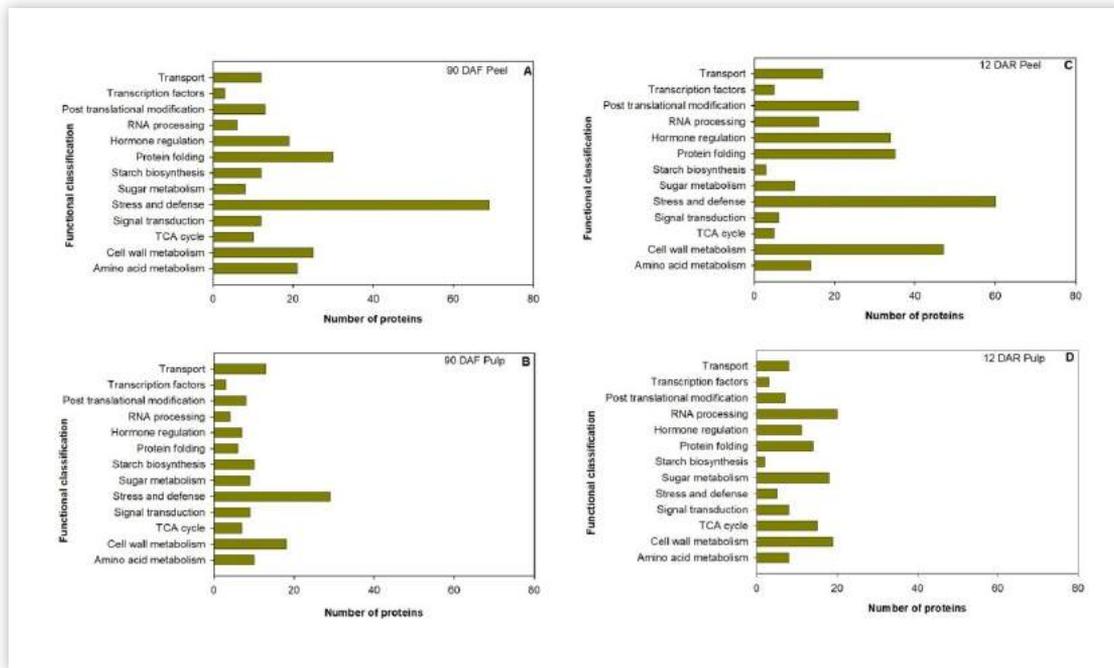


Fig. 4. Functional categories of the identified proteins from banana fruit tissues at different developmental and ripening stage represented as (A) 90-DAF peel (B) 90-DAF pulp (C) 12-DAR peel (D) 12-DAR pulp, through Orbitrap fusion mass spectrometry (mass spectrometer combines best of quadrupole, orbitrap and linear ion trap; tribrid) analysis. Different functional categories of proteins were distributed based on their role.

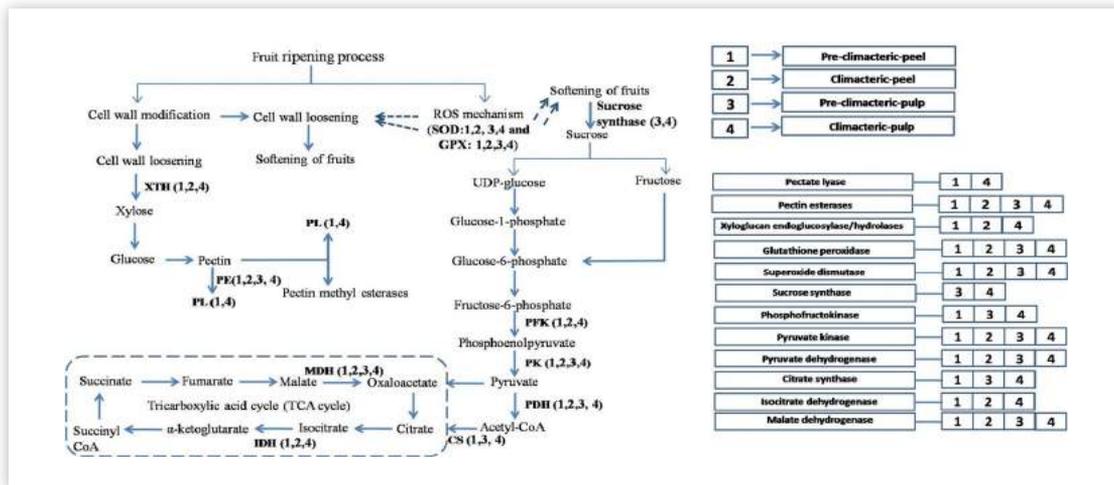


Fig. 5. Schematic overview/illustrations of the proteins and their regulation in different pathways during banana fruit ripening process. Identified proteins were represented in bold letter which were involved in cell wall modification, ROS mechanism and sugar metabolism. Cell wall modification proteins; Xyloglucan endotransglucosylase (XTH), pectate lyase (PL), pectin esterase (PE), ROS mechanism proteins; superoxide dismutase (SOD), glutathione peroxidase (GPX), sugar metabolism proteins; sucrose synthase, TCA cycle; phosphofructokinase (PFK), pyruvate kinase (PK), pyruvate dehydrogenase (PDH), citrate synthase (CS), isocitrate dehydrogenase (IDH) and malate dehydrogenase (MDH). Identified proteins were present in specific stage and tissue type. Different digits/codes were assigned for pulp and peel tissues of pre-climacteric and climacteric stage (1-4).

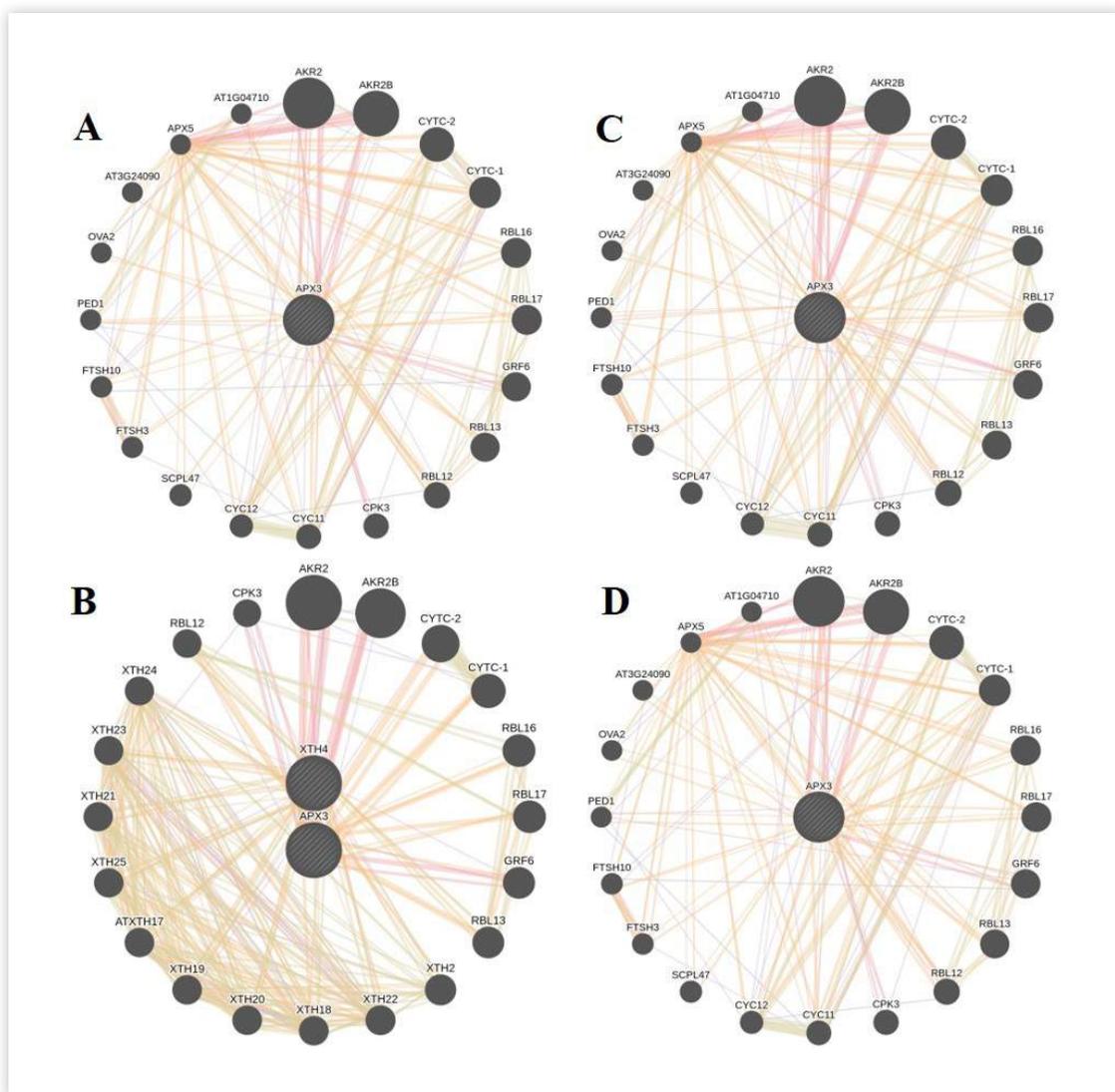


Fig. 6. The image showing annotated list of all proteins interacting from co-expression based on domains in a network mode for four different tissues of banana studied in the experiment.(A) 90-DAF peel, (B) 12-DAR peel, (C) 90-DAF pulp, (D) 12-DAR pulp.

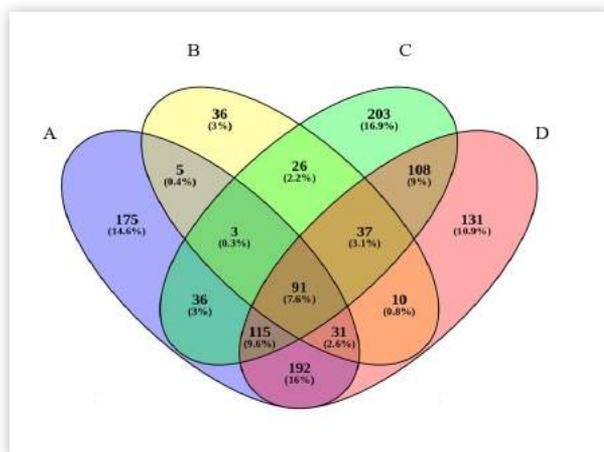


Fig. 7. Venn diagram exhibiting the commonality and uniqueness of identified proteins in different tissues and stages of banana fruit.(A) 90-DAF peel, (B) 90-DAFpulp, (C) 12-DAR pulp, (D) 12-DAR peel.

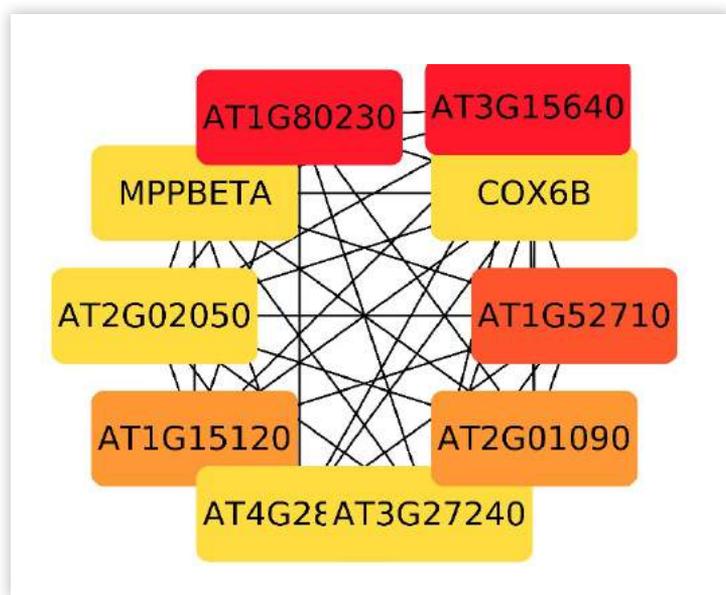


Fig 8. Sub-network analysis of top ranked proteins with their expanded network analyzed by cytohubba using Arabidopsis network data base. Higher the contrast, greater is the rank (Maroon being top and light yellow being the lowest among top 10 ranking clusters).

This study provides a first gel-free proteome approach to shed light on the important biological processes occurring during banana fruit ripening. The functional classification of identified proteins showed differential abundance between the pre-climacteric and climacteric stages of banana. Functional categorization of proteins from banana peel and pulp tissues at pre-climacteric and climacteric stage revealed that proteins were involved in various metabolic pathways and biological processes such as amino acid metabolism, sugar metabolism, starch biosynthesis, hormonal regulation, stress and defence mechanism, cell wall modification, signaling, transport, protein folding, energy and carbohydrate metabolism etc. Moreover, the presence of numerous cell wall modification proteins in the climacteric stage compared to the pre-climacteric stage of banana fruit clearly indicates that cell wall modification proteins actively participate in the fruit ripening process. Identification of high numbers of sugar metabolism related proteins in the climacteric stage clearly showed the phenomena of starch breakdown into simple sugars during the fruit ripening process.

Interestingly, some of the proteins were identified in the form of β -adaplin, ferritin, 2-Hacid_dh_ domain, PAP-fibrillin, ADK-lid domain, why domain, GLP and clathrin protein whose specific role in fruit ripening is still unexplored. Further, some of the uncharacterized proteins were also identified in our study, which could be considered as novel proteins (whose functional validation is not carried) as sequence information is not available in the protein database. The presence of a high number of unique sets of proteins (based on venn) revealed distinct metabolic pathways operations in different tissues and stages of banana during ripening, suggesting the importance of tissue specific proteome studies.

Some of the important cell wall modification proteins identified in this investigation such as α -man and β -hex were enhanced shelf-life in other fruit crops and could play a similar role in banana in enhancing fruit shelf-life. However, further studies are sought to validate and assign a functional role for these proteins in bananas. The protein-protein interaction study revealed that, the XTH family members with XTH4 forming a central node of interacting partners and XTH protein 8-related (PTHR31062) is the ideal candidate that is known to be associated with unique pathways in peel at climacteric stage. Importantly, XTH proteins were found to be involved in the auxin and ethylene-mediated signalling

and postharvest softening of fruits. It necessitates in conducting further investigation to unlock the functional role of XTH protein in banana fruit ripening. This study will shed light on the regulatory process of ripening mechanism in bananas, and proteins identified can be further validated to assign functional roles in controlling ripening process either through RNAi or genome editing tools.

Therapeutic validation of *Pterocarpus marsupium* and *Piper trioicum* as a cholinesterase inhibitor for the treatment of Alzheimer's disease (AD)

PI: Dr. Atish Kumar Sahoo, Senior Scientist

Alzheimer's disease (AD) is a progressive, unrepairable neurodegenerative disease which causes cognitive disorder, decline in memory, behavioural changes and deficits in activities of affected individuals. Approximately 10 million people worldwide are affected by AD. Multiple pathological features, such as cholinergic deficiency, deposition of β -amyloid peptide, neurofibrillary tangles (NFTs), generation of reactive oxygen species (ROS) and mitochondrial dysfunction, are associated with AD. Acetylcholine (ACh) is a neurotransmitter inhibited primarily by acetylcholinesterase (AChE) and butyrylcholinesterase (BChE), and is considered to play a role in the pathogenesis of AD. Though the pathogenic cause of AD remains incompletely understood, the leading factor is considered to be the "amyloid hypothesis," and the most effective tools against AD have been found to be inhibitors of AChE and BChE. To screen appropriate inhibitors from natural products, an effective and fast assay system is needed. So, this study will highlight the novel effect of *Pterocarpus marsupium* and *Piper trioicum* as a remedy for AD.

Pterocarpus marsupium is a multipurpose leguminous tree. Based on the preliminary scientific claim, *P. marsupium* rhizomes, heartwood, and stem has been used in neurodegenerative disease associated with oxidative stress. Heart wood is astringent, bitter, acrid, cooling, anti-inflammatory, depurative, haemostatic, revulsive, anthelmintic, constipating, rejuvenating memory learning and neurological disorders. The paste of seed and wood is useful in anaemia, body pain and diabetes.

Piper is an economically and ecologically important genus in the family Piperaceae. This family comprises more than 2,000 species of shrubs, herbs, and lianas. *Piper trioicum* (Piperaceae) is distributed in South Asian countries and the whole plant is used as rubefacient, diuretic, hepatoprotective and also used in the treatment of diabetes, muscular pains, headache, toothache, internal remedy for cholera in folk medicine. The root is used as diuretic (Madhava et al., 2008). *Piper* species are used as a memory enhancer but till date there is no scientific evidence of *P. trioicum* to prove its neuroprotective activities in AD. There is no literature evidence to get insight the mechanism to validate the lead finding in *P. marsupium* and *P. trioicum* towards cholinesterase inhibition studies. So, this project proposes the therapeutic validation of *P. marsupium* and *P. trioicum* with the strategic approach to establish the lead finding as a cholinesterase inhibitor for the treatment of Alzheimer's disease (AD).

To establish *P. marsupium* and *P. trioicum* as forestry species of Odisha and exploring its bioactive lead molecules cholinesterase inhibitor for the treatment of Alzheimer's disease (AD).

- *In vivo* experiment in scopolamine induced waister rat model for both *P. marsupium* and *P. trioicum*
- Toxicity profiling of *P. marsupium* and *P. trioicum*
- Antioxidant enzyme (MDA, SOD, CAT and GSH) studies of serum and brain

- Evaluation of brain cholinesterase (AChE and BChE) activity
- Evaluation of brain β -secretase (BACE1 and BACE2)

The study highlights the modulatory role of *P. marsupium* and *P. trioicum* in mitigating scopolamine-induced neurotoxicity in experimental rats of Alzheimer's disease via attenuation of cholinesterase, β -secretase levels and inhibition of oxidative stress imparts inflammation. Traditionally both of these species are used for various therapeutic purposes including memory enhancer. *In vitro* studies of both the species were carried out and showed impressive results against various antioxidants. Anti-cholinesterase activities of both species were performed and test results proved the species have potential activities against AD-associated neurotransmitters. So further to scientific validate their therapeutic activities on cellular level, the most potent fractions of both the species were taken for *in vivo* studies on scopolamine (SCP) induced neurotoxicity in Wistar rat model.

Animal experimental procedures were followed according to the guidelines of committee for the purpose of control and supervision of experiments on animals (CPCSEA) and approved by Institutional Animal Ethical Committee (IAEC) of Regional Plant Resource Centre (Regd. Number 1807/GO/R/S/15/CPCSEA). Wistar rats weighed about 150–200 g (either sex) were purchased from M/S. VAB Bio Sciences, Hyderabad, India and kept in well ventilated specific designed polypropylene cages at 25–30 °C under 12 h light/dark cycles in an environmentally controlled room temp. Rats were fed with standard rodent diet and water *ad libitum*. Prior to the experiment, rats were acclimatized to laboratory conditions for a week to nullify the psychological sickness during transportation and handling stress (swain et al., 2020). The acute toxicity study of the bioactive extract (hydroalcohol) based on *in vitro* study were considered for the toxicity profiling. LD₅₀ of *P. marsupium* (heart wood, PMHHA); *P. marsupium* (bark, PMBHA); and leaves of *P. trioicum* (PMHA) were determined as per OECD guidelines. Acute toxicity study was performed to assess the adverse effect, lethality and effective doses of a single dose of test sample. PMHHA, PMBHA and PTHA were administered to rats in group-I to V at a dose of 500–4000 mg/kg, respectively for each extract. The rats in group I, II and III did not show any mortality whereas rats in group III were excessively defecated as a sign of toxicity. The rats in groups IV and V showed mortality rate of 1/6 and 2/6, respectively within 24 h of dose administration. Since, PMHHA, PMBHA and PTHA seems to be safe up to a dose level of 4000 mg/kg with less than half of rats in group V were died, the LD₅₀ of PMHHA, PMBHA and PTHA were considered > 4000 mg/kg. So, two effective dosages of 400, and 300 mg/kg were considered to be safe for preclinical evaluation Experimental procedures.

To investigate the protective actions of PMHHA, PMBHA and PTHA against oxidative stress in cognitive impairment condition we determined the levels of various serum oxidative stress parameters in SCP-induced Wistar rats. Serum SOD, CAT and GSH level significantly decreased, while MDA level markedly increased in SCP-induced group compared to normal group. These changes were accompanied by a significant decrease in the redox ratio (Fig.1A-H). According to oxidative stress mechanism, reactive oxygen species (ROS) is the key factor responsible for brain ageing via affecting the biomolecules (lipids, nucleic acids, proteins and carbohydrates) in cells. It is reported that scopolamine causes brain complication via oxidative damage and generate ROS in the biological system (Brownlee, 1995; Vlassara and Uribarri, 2014). This causes extreme production of MDA (lipid peroxidation maker) and alteration in antioxidant defence enzyme (SOD, CAT and GSH).

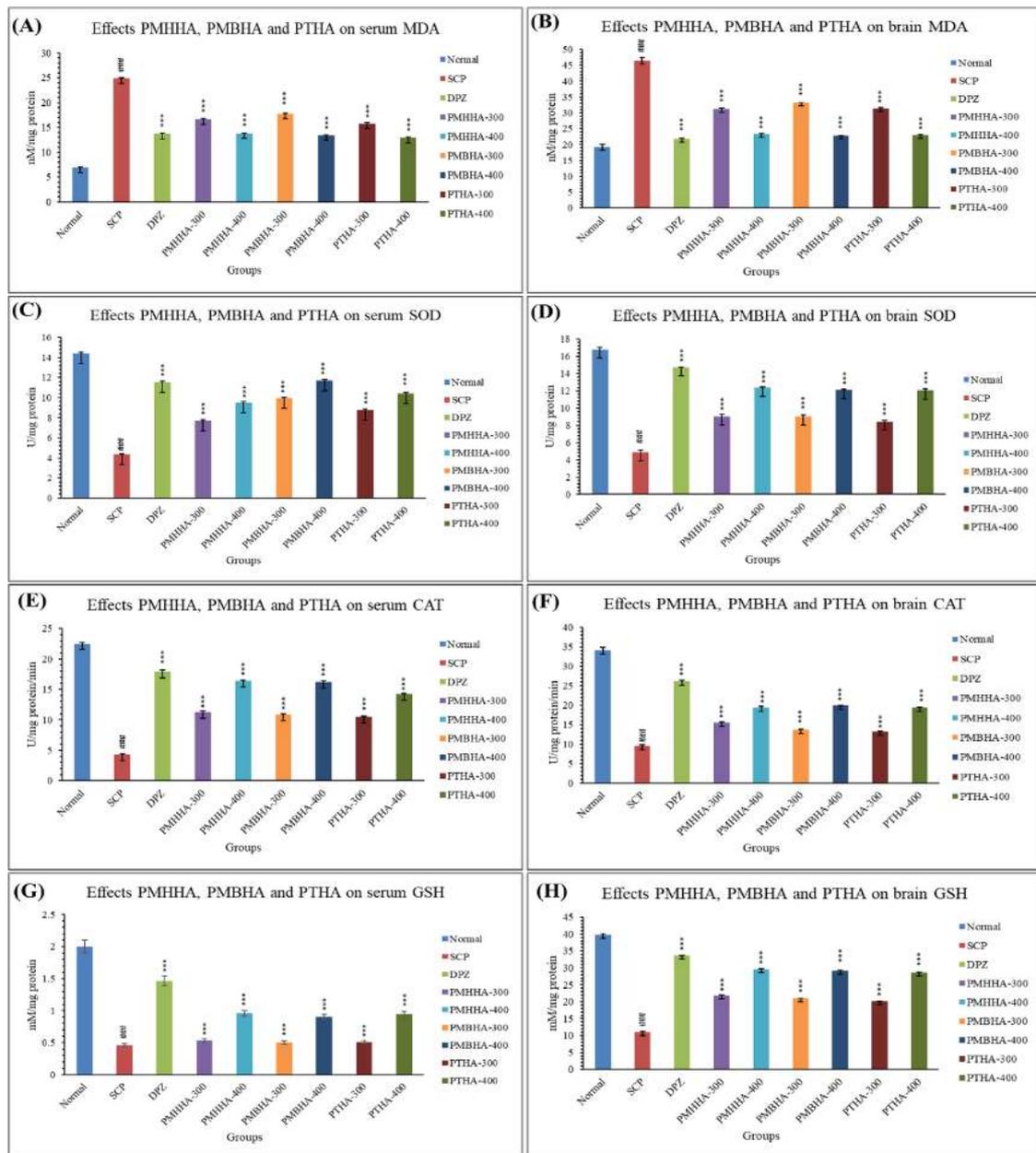


Fig.1. Effects of PMHHA, PMBHA and PTHA on serum and brain MDA, SOD, CAT and GSH levels in SCP-induced rat model.

In the current research, we found that the MDA level of serum and brain significantly raised ($p < 0.001$) in SCP-induced groups compared to normal control. Whereas, the oral administration of PMHHA-400, PMBHA-400 and PTHA-400 significantly ($p < 0.001$) inhibited oxidative stress via balancing antioxidant enzymes and restored the MDA level towards normal in both serum and brain; were found similar to DPZ treated positive control(Fig. 1A and B).The results in SOD assay, we found that the SOD level in serum and brain significantly ($p < 0.001$) reduced in SCP-induced group as compared to normal control. But,oral administration of PMHHA-400, PMBHA-400 and PTHA-400 significantly ($p < 0.001$) elevated the SOD level in serum and brain. The results were found similar to DPZ-treated positive control(Fig. 1C and D). Similarly, the CAT level significantly ($p < 0.001$) reduced

in SCP-induced group as compared to normal control. While, pre administration of PMHHA-400, PMBHA-400 and PTHA-400 significantly ($p < 0.001$) elevated the CAT level in both serum and brain and the results were found similar to the DPZ-treated positive control (Fig. 1E and F). The GSH level in SCP-induced rat significantly ($p < 0.001$) lowered as compared to normal. While, oral administration of PMHHA-400, PMBHA-400 and PTHA-400 significantly ($p < 0.001$) restored to GSH level towards normal in serum and brain (and were found similar to DPZ-treated positive control (Fig. 1G and H). The current finding signified that PMHHA, PMBHA and PTHA has potent intracellular radical scavenging activities for the prevention of neurological disease like AD. This may due to the synergistic effect of prime compounds present in PMHHA, PMBHA, and PTHA.

Furthermore, to understand the neuroprotective nature against AD, the *in vivo* studies were conducted in the brain tissue by considering the neuro related markers such as cholinesterase and β -secretase activity in the diseased and treated condition. AChE and BuChE are found in glial cells and neurons. The key role of AChE and BuChE are to hydrolyse ACh to acetate and choline, thus any disruption in these pathways leads to neurodegenerative diseases like AD. So, the inhibition of AChE and BuChE is an important strategy to combat AD (Mesulam et al., 2002; Tiwari et al., 2009). To understand the clinical potential of all the extracts e.g., PMHHA, PMBHA and PTHA towards neurodegenerative conditions the rate of cholinesterase activities (AChE and BuChE) were determined (Fig. 2A and B).

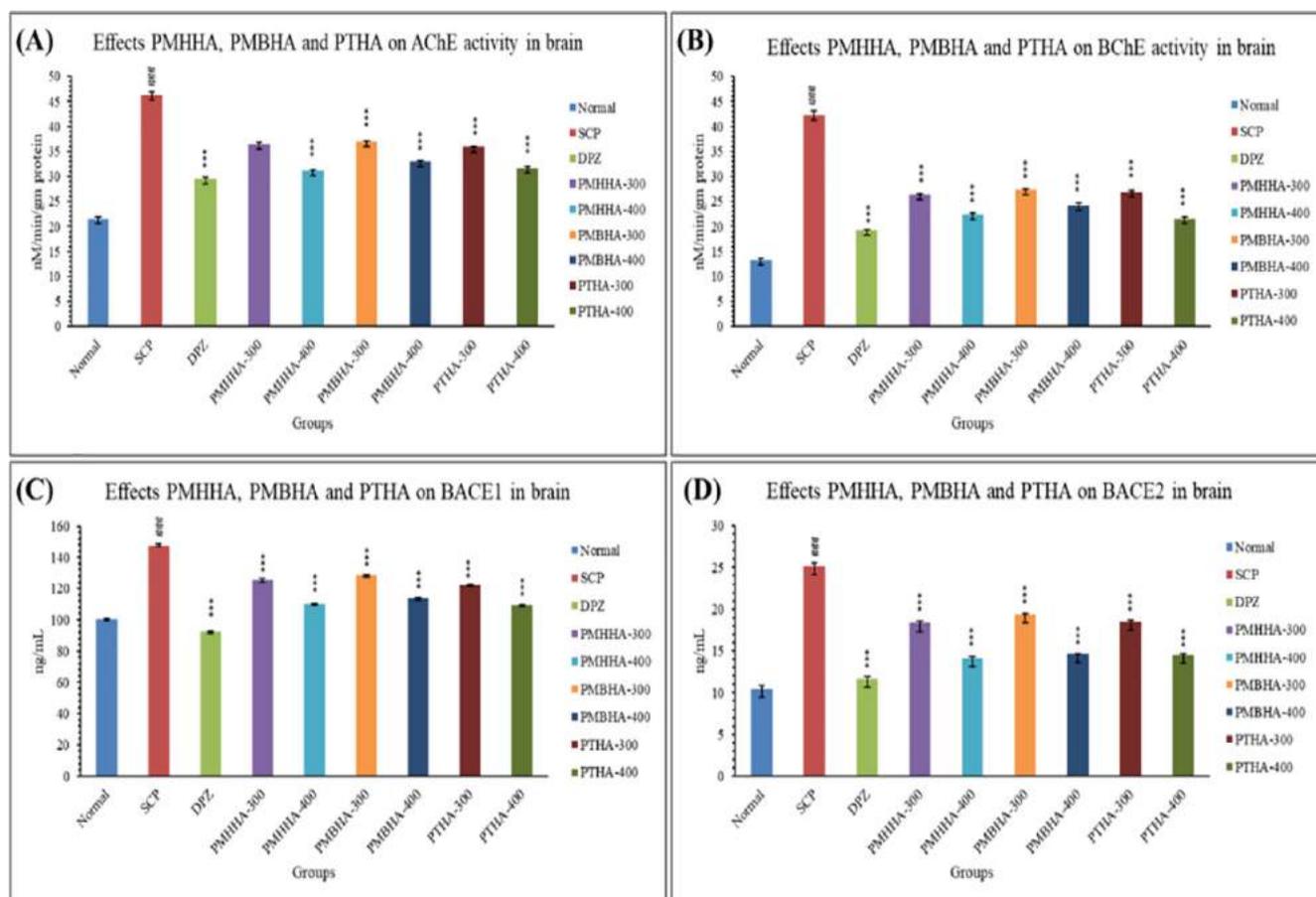


Fig.2. Effects of PMHHA, PMBHA and PTHA on cholinesterase (AChE and BChE) and β - secretase (BACE1 and BACE2) activity in SCP-induced rat model.

The present experimental study showed that cholinesterase levels were significantly ($p < 0.001$) elevated in SCP-induced group as compared to normal one. While, PMHHA-400, PMBHA-400 and PTHA-400 significantly ($p < 0.001$) reduced and restored the AChE and BChE towards normal level and were found similar to the DPZ treated positive control (Fig.2A and B). The synergistic effect of antioxidant and neuroprotective molecules in PMHHA, PMBHA and HAPT were responsible for cholinesterase inhibition in brain. Likewise, in the current research, we found the level of BACE1 and BACE2 were significantly ($p < 0.001$) elevated in SCP induced group as compared to normal control group. Whereas, oral administration of PMHH-400, PMBHA-400 and PTHA-400 significantly ($p < 0.001$) reduced the β -secretase level BACE1 and BACE2 and were found similar to the DPZ-treated positive control (Fig.2C and D). The findings of the study evidenced the protective effect of PMHHA, PMBHA and PTHA which may be due to the cumulative action of various bioactive compounds present in the above fraction.

The results of our current investigation supported the potential role of *P. marsupium* and *P. trioicum* as a memory enhancer in AD. Based on the significant *in vitro* cholinesterase (AChE and BChE) inhibition and radical scavenging activities of various fractions of both the plants, it may be inferred that both the plants are a good source of antioxidant and anticholinesterase compounds. We have demonstrated this activity through antioxidant assays DPPH and ORAC. It was also concluded that hydroalcohol fraction of *P. marsupium* (heart wood and bark) and *P. trioicum* had potential antioxidant effects (MDA, SOD, CAT and GSH) in cellular level and improved neurodegenerative condition by the inhibition of cholinesterase (AChE and BChE) and β -secretase (BACE1 and BACE2) activity in SCP-induced waister model. Future investigations such as QSAR analysis of compounds, various signalling pathways, and mechanism of action of lead compounds in cortex region of brain are necessary to further validate its therapeutic use in Alzheimer's disease.

Immunity boosting Natural fruits: Determination of Ascorbic Acid (Vitamin-C) for selection of potent species to promote domestication

PI: Dr. Uday Chand Basak, Sr. Scientist

The wild edible fruits are regarded as nutraceutical as they are rich in minerals and nutrients. They serve as the chief functional foods because of their rich content in proteins, polyphenols, amino acids, vitamins, fibers and minerals like sodium, potassium, magnesium, iron, calcium etc. that provides us with necessary dietary supplements and has various pharmaceutical uses. They are widely consumed by the rural and tribal people. Wild fruits are natural in origin thus considered as the natural immunity boosters. Immunity is a complex biological system of the body endowed with capacity to recognize foreign materials and neutralize, eliminate or metabolize them without hampering its own tissues. In the pandemic era, it has thus become important to have a constant good immunity level and what comes handy is Vitamin-C (ascorbic acid). Vitamin-C is an essential water soluble vitamin, micronutrient found mostly in citrus and other fruits and vegetables. It is also known as one of the most powerful antioxidants, which help in preventing or delaying some types of cell damage as well as provide immunity, hence known as an immune-booster. They inhibit oxidation, a chemical reaction that can produce free radicals and chain reactions that may damage the cells of organisms. It is widely sold as a dietary supplement available in form of tablets for the treatment of scurvy. Most common health benefits of ascorbic acid are in the prevention of common cold. Several reports have

shown tropical fruits like lemon, oranges, jackfruit, guava etc. have high level of vitamin-C. But reports show that civilians of low and middle income countries have vitamin-C deficiencies, and this could be minimized by consumption of natural fruits that have ascorbic acid values close to cultivated fruits should be encouraged rather than consuming pills because the natural fruits along with vitamin C also provide other essential nutrients. It is therefore advisable to explore the potentials of natural fruits and cultivate them as immune-boosters in a large scale.

In the backgrop of the above, the following objectives are taken into consideration for the study i.e. Isolation and quantification of Vitamin - C (ascorbic acid) in selected natural fruits in order to select potent species to encourage its conservation and domestication as immune boosting natural fruits.

For this piece of work, ten project specified wild fruits species were collected from the Chandaka Forest Division and Kapilash Forest Range, Dhenkanal Division according to the availability. Fruits are stored at -20°C until further use and were targeted for the present study of Vitamin – C. Fruits were grouped into three replications for each species. The laboratory evaluation was carried out following completely randomized design with three replications. Three analytes were made from each replication for analysis.



Antidesma ghaesembilla *Artocarpus lakoocha* *Carmona retusa* *Carissa spinarunm* *Ficus auriculata*

For identification and quantification of ascorbic acid volumetric, spectrophotometric and HPLC analysis were carried out. Using the methodology of Sadasivam and Manickam (1992) with slight modification, the volumetric method was carried out. The volume of dye consumed was noticed and was considered as the amount of ascorbic acid.



Glycosmis pentaphylla *Limonia acidissima* *Mimusops elengi* *Phyllanthus acidus* *Polyalthia suberosa*

The amount (mg/100g) of Ascorbic Acid was calculated by using the formula:

$$\frac{0.5}{V1} * \frac{V2}{5} * \frac{100}{\text{weight of the sample}} * 100$$

For the spectrophotometric method (Al-Majidi and Al-Gubury,2016), the fruit samples were first homogenized using 10% acetic acid, filtered and final volume was made upto 100 ml. After this, 2ml of the filtrate was taken in a test tube and few drops of bromine water was added to it until the solution become coloured followed by addition of few drops of 10% thiourea to remove excess amount of bromine. Now 2, 4-dinitrophenylhydrazine solution was added thoroughly and kept at 37°C for 3 hours. After 3 hours, the test tube was cooled in ice bath for 30 minutes and was treated with 5 ml pre-chilled 85% sulphuric acid. Then the OD was measured at 280nm using spectrophotometer. (AnalytikJena, Spekol 2000, Germany).

For determination of ascorbic acid, reverse phase HPLC method with UV detection has been used (Rodriguez et al., 1992). HPLC analysis was performed in HPLC system (Thermo Fisher Scientific, Dionex™ Ultimate 3000) equipped with binary pump and porous silica with 5µm diameter C-18 column controlled by software Chromeleon™7.2.8.10783 version. Chromatography analysis was performed by means of a C-18 column and a mixture of in acetonitrile and H₂O as mobile phase. The flow rate was 0.4ml/minute and the detection was done at 254nm.

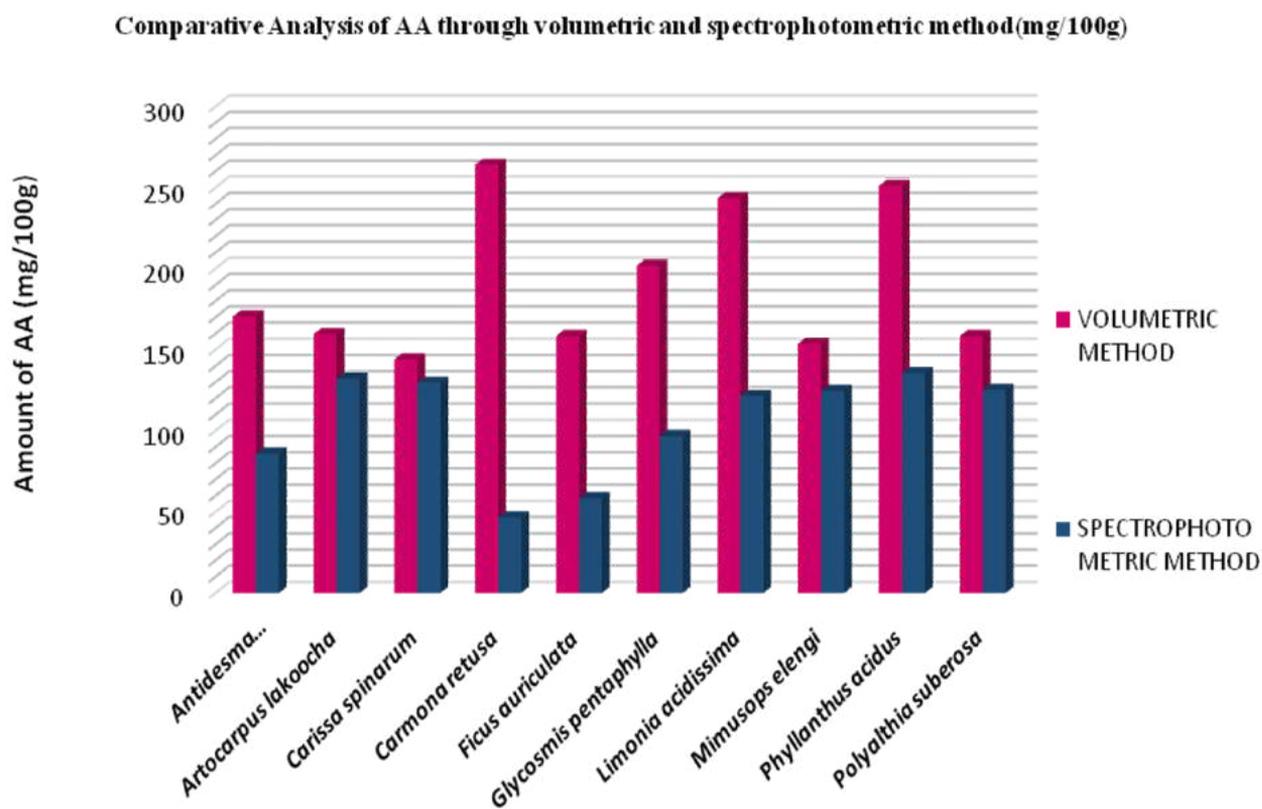
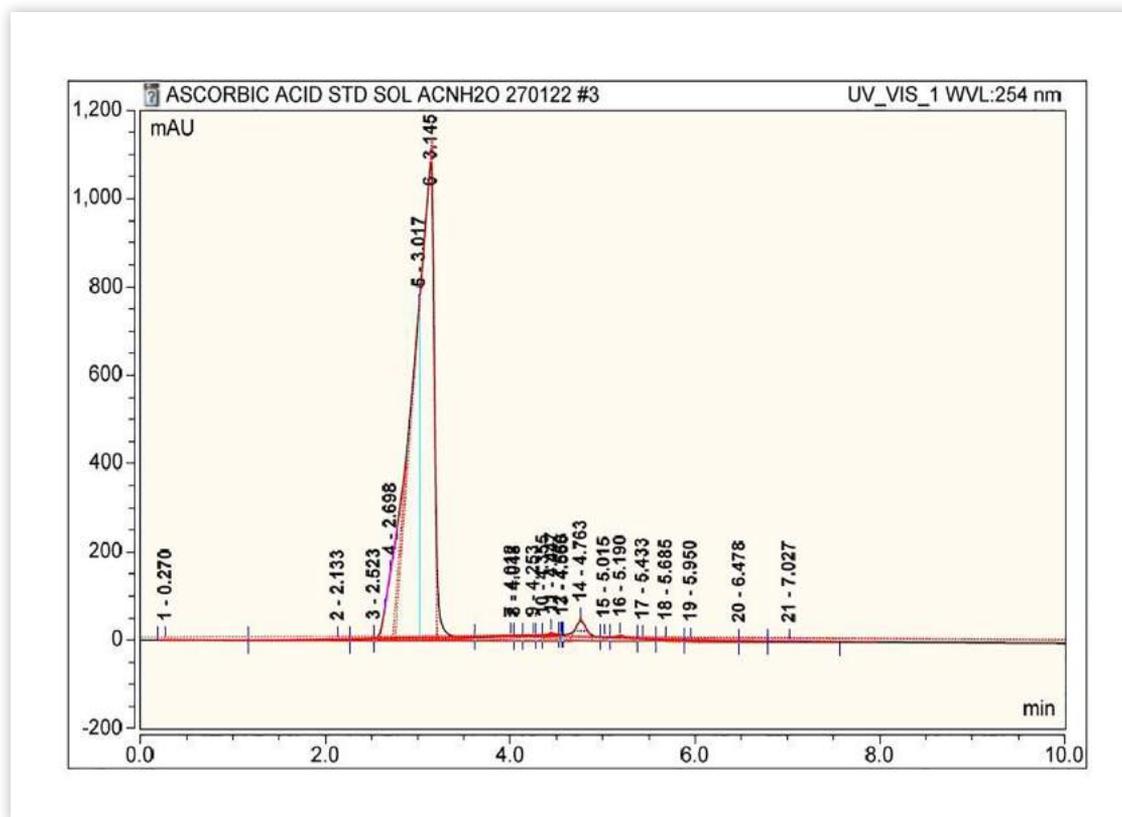
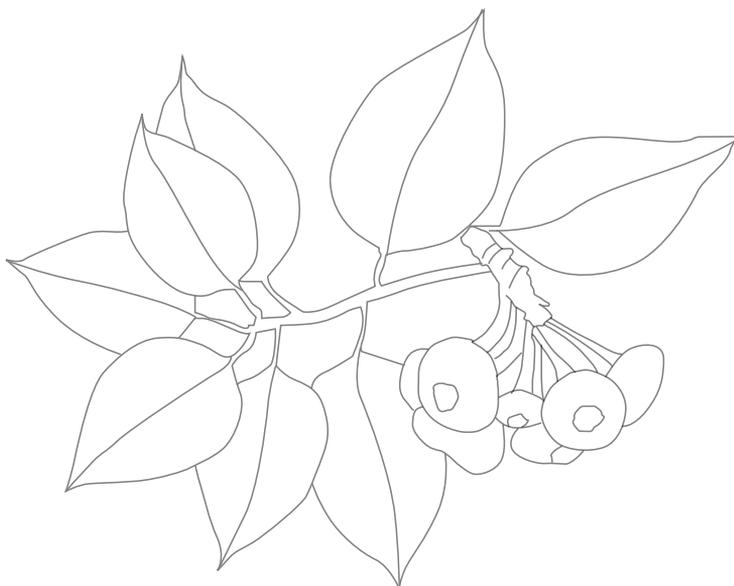


Fig:1 Quantified concentration of Ascorbic Acid obtained through volumetric method & spectrophotometric method]



[Fig: 2 Chromatogram for Ascorbic acid standard]

Ascorbic acid is a water-soluble vitamin that is naturally present in natural fruits, added to others, and available as a dietary supplement. Through this research conducted so far, we found that the ten project specified species are rich in Vitamin –C, that are widely consumed by tribal people. The project specified fruits were quantified for vitamin C through titration and spectrophotometer till date. It was the fruits of *Phyllanthus acidus*, *Artocarpus lakoocha* and *Carissa spinarum* have the highest amount of Ascorbic acid.



Standardization of various macro-propagation methods of useful wild edible fruits of Odisha.

PI: Dr. Uday Chand Basak, Senior Scientist

Odisha is one of the diversified regions that comprise about 150 wild edible fruit plants species occur in different dry and moist deciduous forests which have become a valuable livelihood strategy for rural population and urban dwellers. These are important source of nutrition and income for their users, comprise broad-spectrum essential nutrients, vitamins and secondary metabolites; they can be considered for cultivation, consumption and utilization. Beside forests, Wild edible fruit species also thrive in diverse environment. Sometimes, these wild fruits may not taste good unlike cultivated tropical fruits but they hold good proportions of antioxidants, essential nutrients and bioactive molecules. Moreover, many wild fruits serve as possible future source of income for local communities in rural areas. Suitable macro-propagation methods may facilitate process of domestication of wild edible fruit plants which would be cultivated and utilized as a source of food material for an ever-increasing population.

This piece of work was undertaken to develop suitable propagation methods (seed or vegetative) for mass production of selected wild edible fruit plants to promote conservation and utilization of promising species through imparting training to stake holders. A total 10 wild edible fruit plants viz. *Antidesma ghaesembilla*, *Carissa carandas*, *Carissa spinarum*, *Cordia dichotoma*, *Ehretia microphylla*, *Eugenia roxburghii*, *Glycosmis pentaphylla*, *Polyalthia suberosa*, *Toddalia asiatica* and *Ziziphus oenoplia* was selected for the study and subjected to propagate them through various methods using Micro-stem Cuttings, Girdled stem cuttings, Stump cuttings, seed germination and wildlings.

Rooting was induced applying rooting hormones prepared with IBA & NAA at various combinations and concentrations. One year old healthy shoots were selected and were cut into small pieces of 5cm-6cm length leaving 2-3 nodes in a single micro-stem cutting. The basal ends were cut obliquely and desired Rooting Hormones (IBA, NAA) were applied. Then the basal ends smeared with hormone paste and dry for 10 min. Each of the stem cuttings was carefully planted into the pots vertically. From the base end of the stem cutting, half inch was planted into the potting media. The stem cuttings were placed inside the nursery shed and were observed on a daily basis, any debris that comes in contact with those cuttings, immediately removed to prevent pathogen proliferation. The stem cuttings were sprayed with fungicide after planting.

For Girdled Stem Cuttings, one season old tender healthy stems of the targeted plants were selected and were girdled leaving 20-25cm from growing tips. The girdled parts were treated with hormones and after 30-45 days shoots were cut below the girdled point leaving 1-2 pairs of leaves. The basal ends were dipped for 5-10 min in IBA/NAA in various combinations and concentrations. The treated cuttings were planted in plastic pots/polybags containing soil, sand and coir dust in 1:1:1. The cuttings

were kept under poly shade cover or under mist condition having temperature of 32-36 degree and 60-70% relative humidity. Regular watering is needed till rooting occurs. Rooted stem cuttings were placed in plastic pots/polybags containing a mixture of soil sand and coir dust in equal ratio and kept under shade in nursery condition for hardening and further growth and subsequent planting in the next season.

Wildlings and elongated roots and stump cuttings (15-25 cm) of targeted species were collected by uprooting from different areas of the forest. Collected wildlings and root cuttings were covered by wet paper sheets/clothes and later transplanted into polybags for raising saplings. Wildlings of targeted species were placed in polybags/pots containing soil and sand mixture and kept under nursery shade followed by regular watering for further growth and subsequent planting. Shoot length, Shoot numbers, Root numbers, Root length were obtained from 10 randomly selected micro-stem cuttings (Fig.1), girdled stem cuttings (Fig.2), elongated roots (Fig.3), stump cuttings (Fig.4) and wildlings (Fig.5) with fully developed leaves and roots. Percent (%) of survival and hardening of stem cuttings were obtained. Collection of data was done at 120 days after planting of the hardened saplings.

For seed germination experiment, matured fruits were collected from the mother plants during their fruiting period. Fruit pulp was taken out and the seeds were air-dried and stored in plastic/polythene containers. Overnight hot water soaking/acid and mechanical scarification was done in some seeds to get better % of germination. Treated seeds were sown at a depth of one cm below the surface media in plastic/GI Trays/Root-trainer blocks. One tray/root-trainer block represents one replication. The medium was watered regularly and uniformly and germination counts were recorded for a period of 6-8 weeks. Germination period, Growth of seedlings, hardening period were recorded from randomly selected seedlings with fully developed leaves and roots. Percent (%) of survival of transplanted seedlings was obtained. Collection of data was done at 90-120 days after planting of the seedlings.

During this study, various macro-propagation methods were standardized for 10 selected wild edible fruit species of Odisha. Some species have the rooting ability through stem cuttings using root promoting hormones at various concentrations. While others can only be propagated by seed germination and root cuttings. Our result indicates that *Ehretia microphylla*, *Glycosmis pentaphylla* and *Polyalthia suberosa* are the most promising species for vegetative propagation by micro-stem cuttings. While attempting the micro-stem cuttings, root initiation is delayed and rooting percentage is lower in *Polyalthia suberosa* but girdled stem cuttings have shown higher rooting percentage in the species. Early root induction and higher survivability rate was seen in girdled stem cuttings of *Toddalia asiatica* as compared to *Polyalthia suberosa*. Seed germination rate and survivability rate of seedlings was relatively higher in *Glycosmis pentaphylla* followed by *Ziziphus oenoplia*, *Eugenia roxburghii*, *Ehretia microphylla*, *Polyalthia suberosa* and *Toddalia asiatica*. Root cuttings can be an alternate method for production of QPM. *Glycosmis pentaphylla*, *Ehretia microphylla*, *Carissa spinarum* & *Antidesma ghaesembilla* have shown good results propagated through root cuttings.



Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Rooted Micro-stem cuttings

Elongated roots, Stump Cuttings and wildlings



Fig. 6

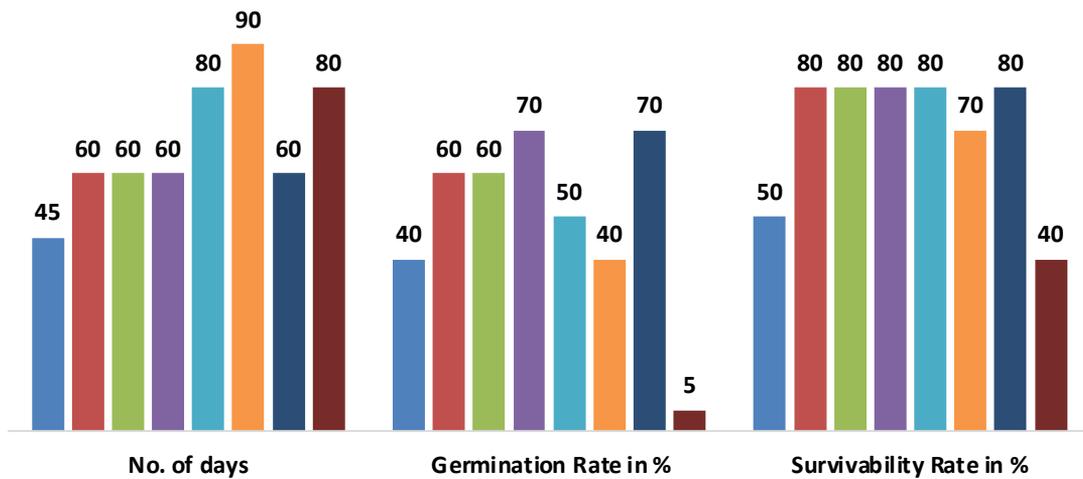
Fig. 7

Fig. 8

Fig. 9

Germination & Survivability Rate of Seedlings

- *Carissa spinarum*
- *Ehretia microphylla*
- *Eugenia roxburghii*
- *Glycosmis pentaphylla*
- *Polyalthia sube rosa*
- *Toddalia asiatica*
- *Ziziphus oenoplia*
- *Antidesma ghaesembilla*



Conservation of salt-sensitive back-mangroves *Heritiera fomes* and *H. littoralis* through re-introduction in protected area: application of vegetative propagation technique.

PI: Dr. Uday Chand Basak, Senior Scientist

Mangrove wetlands are among the most noticeable biological systems in the low lying waterfront region of the coastal Odisha, they are probably going to be the primary ecosystems to be impacted by worldwide environmental change. Exceptionally high ocean salinity level ascent might pulverize the majority of the mangroves in the Indian subcontinent. The responsiveness and versatility of the species in the primary mangrove Ecosystems become essential to evaluating the degradation of these groups. Sea level rise is a major threat, especially to back mangroves that have no area to expand. Mangrove species with a habitat on the landward margin are particularly vulnerable to sea level rise if owing to coastal development their movement inland is blocked. It is likely that non-viviparous 'back mangrove' (including RET) species in the coastal mangrove ecosystems of Odisha such as *Heritiera fomes* and *H. littoralis*, may not compete successfully in the extensive hyper saline conditions and may be disappear gradually. These species are not subject to the same degree of tidal inundations as experienced by 'true mangrove' species, growing near mangrove stands towards the landward habitat having very low soil and water salinities. The back mangrove trees (land ward) such as *Heritiera fomes*, *H. littoralis* form characteristic association with other major true (*Rhizophoraceae*, *Sonneratia*, *Avicennia spp.* etc.) mangroves. Moreover, the above species contribute a considerable population density and thus play a major role in formation of total mangrove vegetation systems. In spite 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. Moreover, species recovery programme necessitate re-establishment of back mangroves in association with true mangrove species (especially viviparous) in order to maintain over all species diversity. Application of vegetative macro-propagation offers a unique opportunity of avoiding the above mentioned problem. Development of this technique represents the first step in the process of domestication of wild tree species. The adventitious roots produced from juvenile micro-cuttings are allowed to move downward and remain un-curved inside the root-trainers. Thus, the lengthy adventitious roots help in proper establishment of the rooted micro-cuttings to a new individual plant. The technique of using micro-stem cuttings offers avoidance of destructive method of propagations. This objective is to standardize vegetative macro-propagation techniques using micro-cuttings in *Heritiera fomes* and *Heritiera littoralis*, wherever re-introduction protocols was incorporated through hardening of plants and evaluation of adaptability in the protected areas of wild habitat.

Propagation & Re-Introduction of *Heritiera fomes* & *H. littoralis*

Adventitious rooting was induced in pre-girdled (Black taped) micro-cuttings using pre-propagated germ-plasm of *Heritiera fomes* & *H. littoralis* as a source of explants for rooting. Cost-effective black-taping method was employed to induce rooting through pre-girdling of the hard-wood micro-stem cuttings of this difficult-to-root species with exogenously applied rooting hormones like IBA+NAA. In so doing, around 83% rooting success was achieved followed by hardening of the rooted micro-cuttings with around 72% of survival rate. Re-introduction sites were surveyed at Bhitarkanika as

well as Kujanga (WL) & locations were mapped with GPS-GARMIN ETREX: 30. Re-introduction were conducted in selected locations at Bhitarkanika National park & at Kujanga (WL) by planting vegetatively propagated pre acclimatized *Heritiera fomes* and *Heritiera littoralis* saplings. By accessing growth & development status of re-introduced saplings: Morphological & adoptability assessment of re-introduced plants of *Heritiera fomes* & *H. littoralis* were studied comparing site/ locations (in Bhitarkanika National Park as well as Kujanga WL) specific re-introduced individuals based on standard biological & geographical factors.

The observation and reports available represents the occurrence of these two species *Heritiera fomes* and *H. littoralis* in the region is sporadic in distribution. The survivability & Establishment Status of both the species (i.e. *Heritiera fomes* and *H. littoralis*) shows relatively good in growth as per the time interval of three month to one year. The species are rare, endangered and threatened, so alternative method of regeneration is necessitated to combat the depletion of this two species. Furthermore, environmental awareness as well as training programme is needed to local forest stake holders for promoting its alternative way (i.e. Vegetative propagation) of regeneration as well as conservation of existed species.

Awareness & Training programme:

Environmental awareness programme as well as Mangrove propagation techniques training programme was conducted to forest Stakeholders at Bhitarkanika regarding Mangrove propagation & conservation for ecological benefit of the state.



Propagation of *Heritiera littoralis* & *Heritiera fomes*



Field Re-introduction Sites: Kujanga Range (WL)

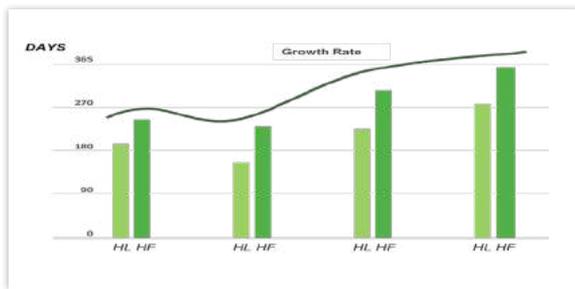


Bhitarkanika National park (Dangamal)

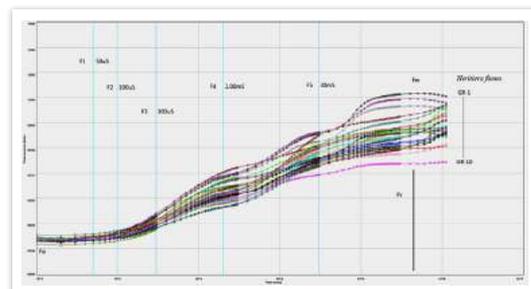


Sujore Plantation Site

Growth & Development Status Analysis in Re-introduced plants of *Heritiera fomes* & *H. littoralis* (Planted during February 2021, Data recorded April 2022)



Growth Status of Re-introduced plants



Adaptability Status Analysis in Re-introduced plants



Awareness programme at RPRC on February 2021



Propagation Training programme at BKNP conducted by RPRC on 12th June 2022





Phytochemical, antioxidant and cytotoxic activity of ornamental plant *Clerodendrum siphonanthus*

PI: Dr. S. Bhatnagar, Sr. Scientist

Clerodendrum siphonanthus is basically an ornamental flower belonging to family Verbenaceae which consists of a number of medicinally important plants. Studies on the extracts of different species of the genus *Clerodendrum* have been carried out by a number of researchers round the globe. Roots and leaf extracts of *C. indicum*, *C. phlomidis*, *C. serratum*, *C. trichotomum*, *C. chinense* and *C. petasites* have been used for the treatment of rheumatism, asthma and other inflammatory diseases. Plant species such as *C. indicum* and *C. inerme* were used to treat coughs, serofulous infection, venereal infections, skin diseases and as a vermifuge, febrifuge and also to treat Beriberi disease. Repellent response of *Clerodendrum viscosum* to the larvae and adults of flour Beetle, *Tribolium confusum* has also been studied by Scientists. The commonly reported useful parts of the plant for therapeutic uses are Root and Leaves (Ayurvedic Medicinal Plants website). The antifungal activity of the ethanolic extract of leaf of *C. viscosum*, has also been reported. The free radical scavenging potential of the roots of *C. viscosum* was also studied reported by researchers. Thus it is expected from the member of same genus, that it might also be harbouring such medicinal properties. Keeping all the above in view the selected plant was explored for biological activity using antioxidant, cytotoxic and phytochemical parameters.

Four solvent leaf extracts of *Clerodendrum siphonanthus* were prepared and their phytochemical, Antioxidant and Cytotoxic activities was evaluated. Solvent extracts showed the presence of Tannins and Alkaloids. Qualitative and quantitative antioxidant assay was carried out by using TLC based antioxidant assay and DPPH free radical scavenging assay, Ferric reducing anti-oxidant power assay (frap assay) respectively. In TLC based antioxidant assay most of the bands observed in chloroform extract followed by ethyl acetate and Methanol extracts in BEA solvent. In FRAP assay, ethyl acetate and Methanol extracts exhibited mild activity. In DPPH assay ethyl acetate and chloroform extract have effective antioxidant activity. Hexane extract showed cytotoxic potential with 100% activity at highest dose administered.

Moisture content of *Clerodendrum siphonanthus* was 51.10% percent and as can be seen in Table 1, methanol extract showed maximum yield suggesting that polar molecules outnumber the non polar.

Table 1: Percentage of yield.

Extract	Weight of sample	% of yield
Hexane	1.35gm	2.5%
Chloroform	4.30gm	8.2%
Ethyl acetate	3.14gm	6.01%
Methanol	22.57gm	43.19%

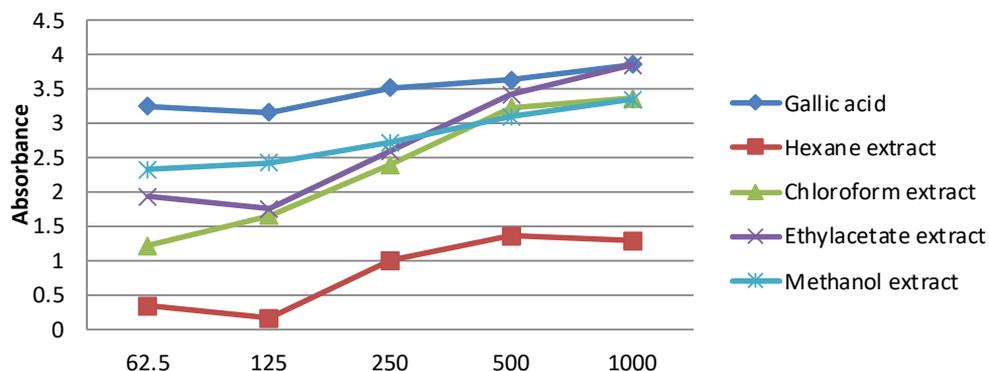
Phytochemical screening of leaf extract of *Clerodendrum siphonanthus*

Presence of alkaloids was predominant as it was found positive in all the three tests. Tannin was present in all the extract except hexane. All other phytochemicals were not detected. However when total phenolics content was estimated(Fig.1), ethyl acetate extract showed similar absorbance when compared to the standard Gallic acid at the highest dose. At highest concentration of 1000mg, chloroform and methanol extract showed equivalent activity but was less than the standard. Presence of alkaloids in the extracts clearly indicate the medicinal potential of this ornamental plant as a number of alkaloids isolated from plants have been used as antibacterial, antiviral and antifungal agents.

Table 2: Phytochemical analysis of leaf extracts of *Clerodendrum siphonanthus*

Phytochemical	Hexane extract	Chloroform extract	Ethyl acetate extract	Methanol extract
Alkaloids				
Mayer's test	+	+	+	+
Wagner's test	+	+	+	+
Dragendroff's test	+	+	+	+
Flavonoids	-	-	-	-
Anthraquinone	-	-	-	-
Saponin	-	-	-	-
Tannin	-	+	+	+
Terpenoids	-	-	-	-
Phlobatannins	-	-	-	-
Cardiac glycoside	-	-	-	-

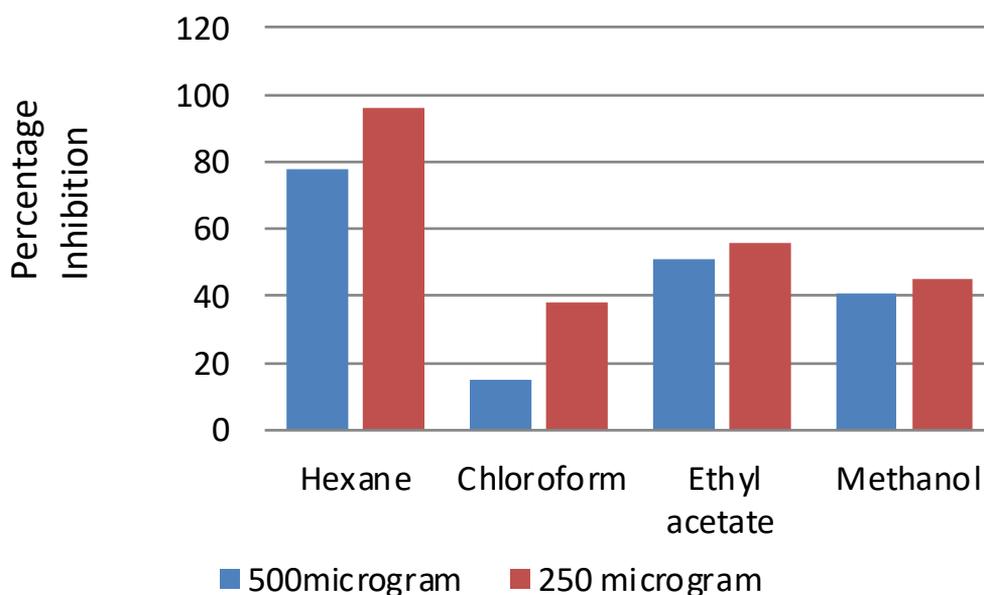
Fig 1: Phenol estimation of solvent extracts of *Clerodendrum siphonanthus*



Cytotoxic activity

As can be observed from Fig 2, all the extracts showed dose dependent activity. A highly significant activity was obtained in hexane extract which was 98% at the highest dose of 500 microgram and 79% at 250 microgram dose. This needs further exploration for isolating active principles. The activity against brine shrimp larvae is an important parameter to assess the anticancer activity as both the activities are co related.

Fig 2. Cytotoxic activity of solvent extracts of *Clerodendrum siphonanthus*



Antioxidant activity

As depicted in Table 3, all the extracts showed the presence of antioxidant bands with maximum number of antioxidant bands in Chloroform extract in BEA solvent. However, in case of Qualitative DPPH radical scavenging assay, methanol extract showed better antioxidant potential but was less than the standard Ascorbic acid (Fig 2). In FRAP assay (Fig 3) three extracts chloroform, ethyl acetate and methanol extract showed similar activity but was less than the pure compound Ascorbic acid. This could be due to the fact that extracts are a combination of a number of molecules which either mask one another's activity or enhance one other's activity. As at higher doses antioxidant activity of standard and other extracts was marginally different so same needs further elaboration.

Thus, overall study has provided lead for further explorative work in the form of a potent hexane extract with significant cytotoxic activity and three extracts for their antioxidant potential. Presence of alkaloids in the extracts is further indication of medicinal potential of the ornamental plant *Clerodendrum siphonanthus*.

Table 3: TLC based antioxidant assay of solvent extracts of *Clerodendrum siphonanthus*

Solvent extracts	SOLVENT	Number of Anti-oxidant bands	Rf values
HEXANE	BEA	1	0.3
	CEF	1	0.31
	EMW	1	0.29
CHLOROFORM	BEA	8	0.75, 0.57, 0.50, 0.48, 0.39, 0.32, 0.25, 0.20
	CEF	4	0.66, 0.26, 0.21, 0.16
	EMW	4	0.64, 0.39, 0.32, 0.24
ETHYL ACETATE	BEA	5	0.70, 0.40, 0.36, 0.31, 0.25
	CEF	5	0.55, 0.40, 0.35, 0.17
	EMW	3	0.65, 0.44, 0.34
METHANOL	BEA	4	0.70, 0.40, 0.37, 0.31
	CEF	5	0.74, 0.63, 0.42, 0.35, 0.28
	EMW	2	0.79, 0.74

Fig 3: DPPH assay of solvent extracts of *Clerodendrum siphonanthus*

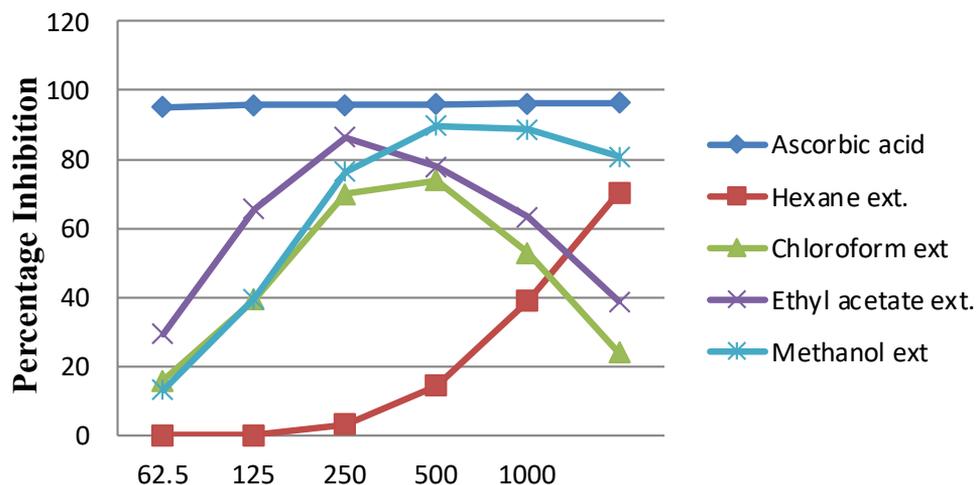
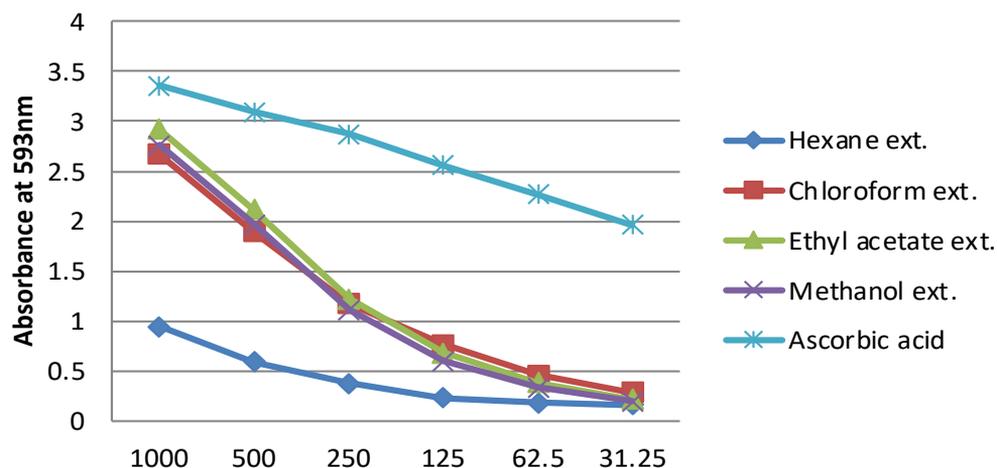


Fig 4: FRAP Assay of solvent extracts of *Clerodendrum siphonanthus*



Assessment of antifungal activity of *Vallis solanacea* and *Vernonia anthelmintica* solvent extracts against *Aspergillus flavus*

Dr. S. Bhatnagar, Sr. Scientist

Aspergillus is a mycotoxigenic fungus that possesses the ability to produce a potent toxin and carcinogen known as aflatoxin. Some mycotoxins that are produced by *A. flavus* include – nitropropionic acid, aflatoxin B1, aflatoxin B2, aflatoxin B2a, aflatoxin G1, aflatoxin G2, aflatoxin M, aflatoxin, aspertoxin, cycloplazonic acid, gliotoxin, sterigmatocystin, and versicolorin A and aspergellin acid. This fungus

is pervasive in the environment, being readily isolated from plants, air, soil, and insect. Aflatoxin is harmful in plant, human and animals. Some commodities that have been found contaminated are peanuts, cotton, corn, cereals, dried fruits, oilseed, wheat, rice, soybean etc. It also causes an ear rot. The pathological effects of aflatoxin are hepatotoxicity(liver damage), bile duct hyperplasia, hemorrhage(intestinal tract).They also cause oppoetunistic infections such as aspergilosis in humans and animals. The food and agriculture organization(FAO) said that ,one fourth of the world's crop is affected by mycotoxins and hence it is essential to find a remedy to make the crop free of mycotoxins, this study was aimed at the same objective.

Vallaris solanacea is a climbing ornamental shrub. This plant species is used mainly for the treatment of gastrointestinal ailments, fever, malaria, pain, and diabetes. It has very good medicinal value for skin disease treatment, wound healing, and many more. In a ethnobotanical survey it is reported that the bark of *Vallaris solanacea* is bitter and astringent and is chewed by the Kols for fixing loose teeth. It is one of the ingredients of *Vishagarbha taila*, an ayurvedic medicine. The milky sap or latex produced by the *Vallaris Solanacea* plant is a mild irritant and is applied to wounds and old sores; it is said to hasten healing. It is a popular remedy for toothache and inflamed gums. The stem of *Vallaris Solanacea* contains β -sitosterol. The stem of the plant has an antiulcer antioxidant activity, which was expressed in Wistar Albino Rat. The milky latex of the plant has many applications that are used for the treatment for ringworm, skin infections. The oils from the bark have anticancer, antimicrobial, analgesic, anti-inflammatory, anti-diarrheal, and cardiotonic properties.

V. anthelmintica is used in traditional system of medicine to treat various physiological conditions. It is an important source of various types of compounds as well as pharmacological activities. It is notable for its medicinal properties and it has a long history of traditional use for the management of several disorders related to skin, central nervous system, kidney, gynecology, gastrointestinal, metabolism, and general health. It is commonly known as Purple Fleabane, has been used in local medicine to cure a wide spectrum of disorders including asthma, sores, inflammatory swellings, skin ailments, kidney troubles, itching of eyes, hiccough. The plant extracts are used in ayurvedic composition for white leprosy and skin diseases. The medicinal plant has been reported to possess a variety of pharmacological activities such as antimicrobial, anticancer, antidiabetic, anti-inflammatory, analgesic, antipyretic, as well as a diuretic and larvicidal activities. As both the plants have already shown activity against other microbial organisms, hence were considered in this study for exploration against *Aspergillus flavus*.

Vernonia anthelmintica : The moisture content of the *Vernonia anthelmintica* leaves was found to be 80.17% As can be shown below, the methanol extract showed maximum yield followed by ethyl acetate, chloroform and hexane. Thus yield of polar extracts was more than non polar extract like hexane and chloroform suggesting the predominance of polar molecules in the extract.

Table 1: Yield of solvent extracts of *Vernonia anthelmintica*

Solvent extract	% of yield
Hexane	2.2
Chloroform	7.63
Ethyl acetate	17.14
Methanol	25.41

Antifungal activity using radical growth method:

All the four extracts were tested for radical growth and comparison of growth was done with control samples in order to calculate the percentage inhibition in the growth by respective extract. Two doses of the extracts were administered for the study, these were 2000 and 1000microgram. Ethyl acetate extract showed higher percentage of inhibition 60 percent on day 2 on higher dose, Chloroform extract showed mild activity 14 percent on day 4 comparison to all other days of chloroform, whereas other extracts were inactive. With time effect of extracts on inhibition declines could be due to the reduced amount of extract available with time.

Antifungal activity using agar well diffusion method:

As can be seen from the Table 3, the lower dose of hexane and chloroform extract were totally inactive and had no inhibition. However the methanol extract showed mild activity and the ethyl acetate extract showed best activity 1.2 mm zone at a dose of 1000 microgram per ml dose, but 0.4mm zone at a dose of 2000 microgram per ml. Thus in both the experimental models ethyl acetate extract was found better antifungal activity as compared to the other extracts. However in case of biomass reduction it was found(Table 2) that methanol extracts showed highest biomass reduction. This is indicative of the fact that methanol extract has long term consistent effect on *Aspergillus flavus* whereas ethyl acetate extract has direct effect for short term duration.

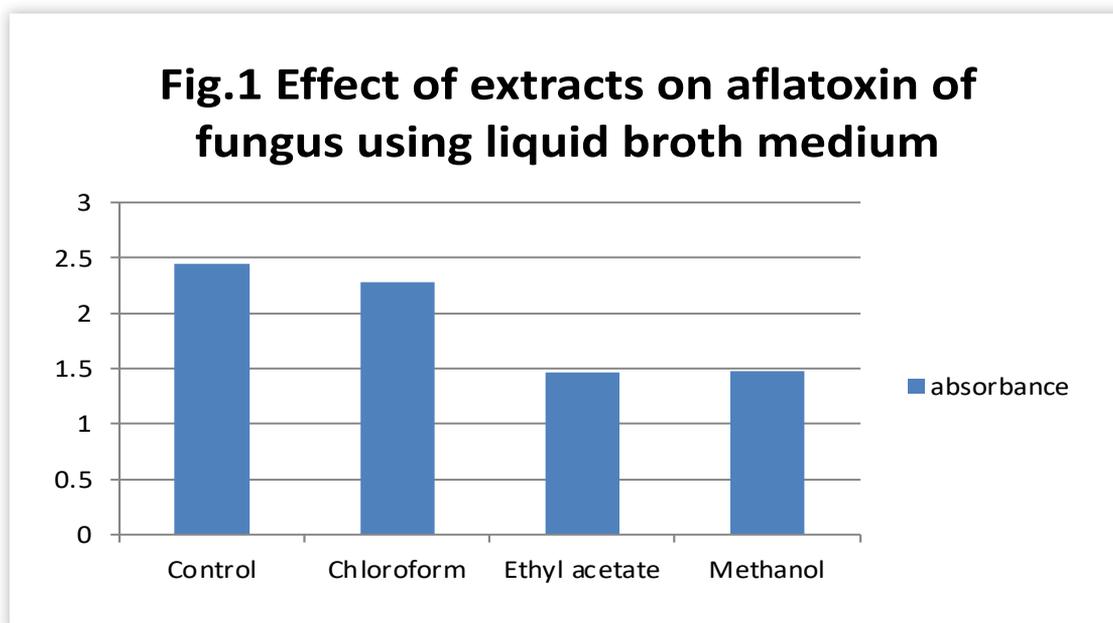
Table 2: Antifungal activity of solvent extracts of *Vernonia anthelmintica* using zone of inhibition method and biomass reduction.

Dose	Hexane extract		Chloroform extract		Ethylacetate extract		Methanol extract	
	Zone of Inhibition	Biomass Reduction	Zone of Inhibition	Biomass Reduction	Zone of Inhibition	Biomass Reduction	Zone of Inhibition	Biomass Reduction
Microgr/ml								
500	Nil	Nil	Nil	5.21	0.1	8.3	0.2	12.83
1000	Nil	2.77	Nil	9.33	1.2	9.72	0.5	30.55

Isolation of aflatoxin from liquidbroth medium and quantitative studies :

Table 3 : Isolation of aflatoxin from liquid medium and quantitative studies					
	Sample	Weight of aflatoxin	% of inhibition	Absorbance at 400nm	Biomass reduction
Control	1	0.025	Mean =0.046	2.235	
	2	0.067		2.65	
<i>Vernonia</i>	Chloroform	0.003	93.47%	2.286	21.62
	Ethyl acetate	0.001	97.82%	1.465	36.48
	Methanol	0.02	56.52 %	1.476	22.29

As can be observed from Table 4, Chloroform and Ethyl acetate showed the more than 90% inhibition in aflatoxin content when compared to controls. Absorbance is directly correlated to the amount of aflatoxin, as can be seen in the Fig 1 Control sample showed highest absorbance as compared to experimental samples. Ethyl acetate extract was able to reduce the absorbance hence the aflatoxin content in the sample. Even biomass reduction was also highest in ethyl acetate extract. Thus ethylacetate extract of *Vernonia anthelmentica* has proved itself as potent antifungal candidate needing further exploration.

***Vallaris solanacea*: Moisture content and solvent extracts yield**

The leaves of the plant were collected and the moisture content was estimated. It was found that the moisture content of the plant (*Vallaris solanacea*) leaves was found to be 82.89%. Yield of methanol extract was highest amongst the solvent extracts followed by hexane, chloroform and ethyl acetate (Table 1).

Table 1: Yield of different solvent extracts

SOLVENT EXTRACTS	PERCENTAGE
HEXANE	1.87%
CHLOROFORM	2.6%
ETHYL ACETATE	0.20%
METHANOL	11.05%

Antifungal activity using radical growth method

All the four extracts were tested for radical growth and comparison of growth was done with control samples in order to calculate the percentage inhibition in the growth by respective extract. Two doses of the extracts were administered for the study, these were 2000 and 1000microgram. Chloroform extract showed mild activity of 14 percent on day 4, Ethyl acetate also showed mild activity (16-21%) consistently on all the days, other extracts were inactive (Table 3). Thus, it can be observed that extracts were not able to arrest the growth of fungus. Even there was no biomass reduction in any of the extracts.

Table 2: Radical growth activity of solvent extracts of *Vallis solanacea*

Sample	Dose (in µg)	Day-2		Day-4		Day-6		Day-8		Day-10	
		Growth (in cm) Mean	% inhibition ±SD	Growth (in cm) Mean	% inhibition ±SD	Growth (in cm) Mean	% of inhibition ±SD	Growth (in cm) Mean	% of inhibition ±SD	Growth (in cm) Mean	% of inhibition ±SD
Control		1.56		3.9		5.8		7.3		8.52	
Hexane	2000	1.9	Nil	4.3	Nil	6.2	Nil	7.7	Nil	8.9	Nil
	1000	2.2	Nil	4.7	Nil	6.3	Nil	8.0	Nil	9.1	Nil
Chloroform	2000	1.6	Nil	3.32	14.71 ±2.77	6.7	Nil	8.25	Nil	8.4	1.4 ±2.7
	1000	1.8	Nil	4.1	Nil	6.2	Nil	7.9	Nil	8.9	Nil
Ethyl acetate	2000	1.3	16.66 ±0.054	3.05	21.79 ±0.133	4.75	18.1 ±0.099	6.62	9.31 ±0.1	6.95	18.42 ±0.008
	1000	2.6	Nil	3.99	Nil	6.0	Nil	7.3	Nil	8.66	Nil
Methanol	2000	2.38	Nil	4.04	Nil	6.62	Nil	7.1	2.73 ±0.06	7.85	7.56 ±6.9
	1000	2.4	Nil	3.8	Nil	5.9	Nil	7.9	Nil	8.8	Nil

Antifungal activity using agar diffusion method and biomass reduction:

As we can be seen from the table 3, Hexane and chloroform extracts were totally inactive and had no effect on the inhibition as there was no zone of inhibition from around the site of inoculation. Ethyl acetate extract showed best activity 1.5mm at the dose 1000µg/ml, however increasing the dose to 2000µg/ml was not fruitful. As more than 10mm zone of inhibition is considered as active, so all the extracts failed to illicit any significant effect. At higher dose all the extracts showed biomass reduction ranging from 9.58% to 35.6%. Thus all the extracts reduced the density of biomass to some extent.

Table 3 : Antifungal activity of solvent extracts of *Vallis solanacea* using zone of inhibition method

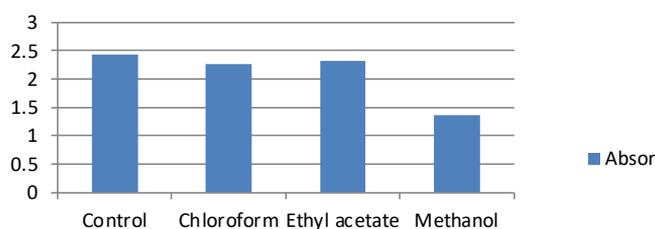
Sno	Doses (microgram / ml)	Hexane extract	Chloroform extract	Ethyl acetate extract		Methanol extract		
		Anti fungal activity	Anti fungal activity	Biomass	Anti fungal activity	Biomass	Anti fungal activity	Biomass
1	2000	nil	nil	16.43	1	16.43	1.13	9.58
2	1000	nil	nil	Nil	1.5	Nil	1.29	1.36
3	500	nil	nil	Nil	0.1	8.21	0.2	Nil

Aflatoxin content in solvent extracts

Crude aflatoxin was isolated as per the standard protocol of liquid liquid separation. Based on weight of residue and spectrophotometric absorbance method (Fig1) methanol extract showed highest inhibition in aflatoxin content followed by chloroform and ethyl acetate extracts.

Sample	Weight of aflatoxin	% of inhibition
Control	0.046	
<i>Vallis solanacea</i>	Chloroform	63.04%
	Ethyl acetate	56.52%
	Methanol	69.56%

Fig1: Effect of extracts on aflatoxin of fungus using liquid broth medium



Propagation and reintroduction of selected endangered species of Odisha.

PI: Dr. Kalidass, C., Scientist

In the present study of mass propagation and reintroduction of selected endangered species of Odisha, we have been carried out local tour for the collection of seed materials of selected endangered plants such as *Oroxylum indicum* (L.) Kruz. [Bignoniaceae], *Pterocarpus santalinus* L.f. [Leguminosae], *Cryptocarya amygdalina* Nees [Lauraceae] and *Cordia macleodii* Hook.f. & Thomson [Boraginaceae] that were taken for mass propagation up to the desirable level, which is various procedure have been followed for the mass propagation of the different plants through the seed germination, rooting of stem cutting with different media composition of sand, vermicompost and soil mixture and also air-layering treated with different plant growth regulators of various concentrations of each plant in different sessions.

***Oroxylum indicum* (L.) Kruz.**

Oroxylum indicum used for stomach ache, ulcers, rheumatism, enlarged spleen, cough, bronchitis, piles, jaundice, dyspepsia, small pox, colic, leukoderma, pharngodymia, cardia arrest, gastropathy, cholera, purgative, diarrhoea, dysentery, epilepsy, muscular sprains, fever, cancer, arthritis, scabies and also seed oil used for perfume industry. It has collected the different localities of seed materials to germinate and study the seed biology, and for the above point of view for breaking the seed dormancy through different methods/ procedure have been used such as physical and chemical treatment with plant growth regulators and scarification, hot & cold-water treatments.

Mature fruits were collected from 50 *Oroxylum indicum* healthy trees in different locations of Odisha. The seeds were collected in different season and the seed length, width, thickness and weight are mentioned **Fig.1**. Results have been recorded that seed germination of *O. indicum* in reaching a high germination percentage in greenhouse condition with soil mixture with treatment of plant growth regulators. Finally, we have been raised the plants up to the desirable level [2,000 number of plants] **Fig.2**.

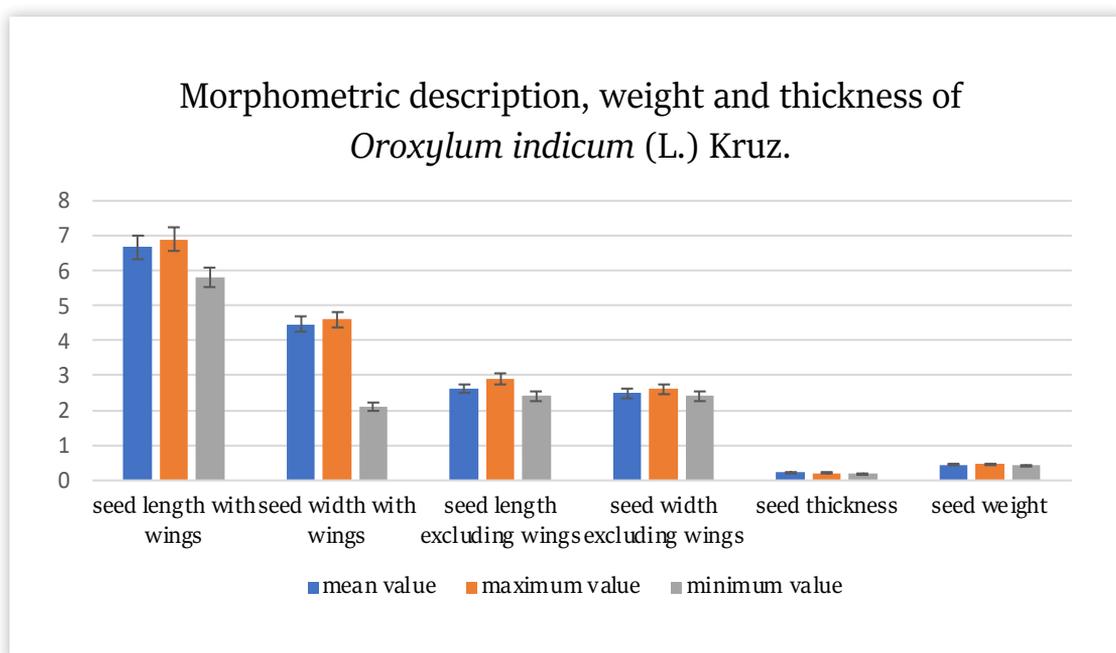




Fig. 1. Morphometric description, weight and thickness of *Oroxylum indicum* (L.) Kruz. Seeds.



Fig. 2. *Oroxylum indicum* (L.) Kruz. Mass propagated plants in polybags conditions for reintroduction/restoration into wild/same mother agroclimatic regions in Odisha.

***Pterocarpus santalinus* L.f.**

For the second species of *Pterocarpus santalinus*, seed materials have been collected from local market as well as wood and traditional seed propagation of *P. santalinus* gives no response germination due to hard testa, poor viability and sensitivity to temperature. Seed germination as well as improved plant growth and seedling survival to other treatment with gibberellic acid for 48h in dark chamber resulted in 45% seed germination observed [Fig.3], which is reviewed that natural germination of seed are well significantly stimulated by fire and under artificial condition or nursery techniques is generally showing low response.

***Cryptocarya amygdalina* Nees**

Third species of *Cryptocarya amygdalina*, we have been used for various procedure for the mass propagation like air-layering, rooting of stem cutting and seed germination for this experiment. In the vegetative propagation has noticed that low response for the root induction and air-layering has showed 50% response for root developed and also scarcity of seed materials to conduct the seed biology experiment [Fig. 4].



Fig.3. Breaking the dormancy with gibberellic acid treatment; a view of enlarge the radicle appearance and different stages of polybags conditions of seedlings.

Fourth species of *Cordia macleodii*, vegetative propagation of different types of rooting of stem cutting with treated plant growth regulators has been used for the mass production, which is low & long time to response for the root induction and shoot sprouting. Finally, we are continuing the mass propagation of the selected endangered plant species to reach up to target level for reintroduction/ restoration into the wild/nature.



Fig. 4. *Cryptocarya amygdalina* Nees: Air-layering for the selected endangered plant in roots developed, isolated and established in to poly pot condition.

Standardization of *in vitro* regeneration techniques in red banana and establishment of red banana in Odisha climate condition.

PI: Dr. Kalidass, C., Scientist

Micropropagation is the practice of rapidly multiplying stock plant materials to produce a high number of progeny plants under aseptic conditions using modern plant tissue culture methods. Banana is one of the most established and second biggest developing organic product edit on the plant. The red bananas are smaller, plumper, and softer and have a unique flavour, similar to yellow, but mixed with the taste of raspberries. When ripe, raw red bananas have flesh that is cream to light pink in colour. They have no fat, cholesterol or sodium and contain more digestible carbohydrates than any other fruit. An empowering finding from money saving advantage investigation of the task is that tissue culture banana generation is more profitable as an undertaking than conventional banana creation. Therefore, the earnest requirement for a lot of ailment free planting material set off the advancement of the red banana explants culture procedure. The new technology of banana tissue culture plants has to prove its importance in today's scientific field of agriculture sector and also to be proving a large number of diseases free and high yielding plants can be produced. Through the tissue culture technology has meet the challenges of high yielding production in red banana because it is need of today's world demand for food. So, attempt has been taken to study the different plant hormone to standardize the procedure of the red banana variety in Odisha. An important objective of micro propagation of red banana is to produce large number of disease-free planting material and to satisfy the large need of banana planting materials.

Current study was carried out to standardize the protocol for micropropagation and establishment of red banana. The nature of project outcome was we have been collected and selection the red banana sucker to establishment of mother block in RPRC [Fig.1a &1b], which is used for the initiated the new tissue culture of red banana and also documentary of the details of the banana variety. To collect sucker the soil around the mother plant is taken out and carefully the soil from the base of the healthy sucker is removed. The sucker is the cut and separated from the mother plant with its meristem region fully intact. After the selected suckers where outer leaf sheath is removed and is trimmed. The upper leaf and lower roots are removed along with the rhizome outer layer. Finally, the suckers are ready to be sterilized properly to remove all types of contamination from the selected suckers [Fig. 2]. Initiation and maintenance of aseptic culture are indispensable steps in any micropropagation procedure. This is primarily due to high risk of contamination from microbes. Contamination can be controlled to a certain extent by the use of explants obtained from the green house plants, since they are grown in more hygienic were effectively cleaned and surface sterilized and used for culture in oculation. In the present study, the explants will be washed with normal water followed by washing with detergent (Lobeline and Tween-20) to remove excess mud from it. Then washed with running water to remove the remaining detergent on it, and treated with 2% Bavistin for 30minutes we have taken 3-surface sterilant for our experiments. First 1% and 3% of $\text{Na}(\text{ClO})_2$ is used for surface sterilization of explant. The time duration for both concentrations were 15minutes and 10mins respectively. Secondly 0.1% of HgCl_2 and 1% AgNO_3 for 6min and 5 min. Afterwards, the explants would be washed three times in sterile water in aseptic condition (under laminar air flow) to remove all traces of the $\text{Na}(\text{ClO})_2$, HgCl_2 and AgNO_3 (Fig. 3). The outer surface of explant exposed to sterilizing agent will be removed and the explants trimmed using scalpel to bring the final size to about 2.0cm. X 3.0cm. The entire surface

sterilization process will be done in an aseptic condition (inside laminar air flow) to avoid infection. The Shoot tip of red banana cultured onto MS basal media alone failed to show any morphogenetic response. Addition of cytokinin BAP, Kn and auxin IAA to the basal medium had a positive effect on shoot formation from the explants. The first visible changes of the cultured light greenish into dark reddish colour were observed within the two weeks of culture (**Fig. 4**). A combined effect of cytokinin and auxin was also evaluated for multiple shoot induction. Addition of NAA along with BAP plus Kn to the basal medium enhanced the shoot regenerative response significantly. We have been recorded the data of percent apical buds' response and the number of shoots produced per explants were highest in MS basal medium supplemented with 3.0mg/l BAP 5.00 mg/l Kn and 0.25mg/l IAA. After sterilized initial culture were inoculated on MS medium supplemented with different concentrations of cytokinin viz; 6-BAP and Kinetin with Auxin like IAA to determine their effect on the shoot multiplication. The results are depicted in the graph [**Fig. 5**] the number of shoots per explants. Among different combinations analyzed, MS basal media with 3.0 mg/l of BAP, 50. mg/l Kin and 0.50 mg/l IAA medium showed good results both for shoot initiation and multiplication.



Fig. 1a. Sword Suckers collected from NRCB; Plantation of Red banana suckers



Fig. 1b. Established the Red banana mother block in RPRC



Fig. 2. Sword suckers of red banana plants collected from banana mother germplasm & sucker processing for initial tissue culture work.

Various steps involved for the sterilization of explant



Fig. 3. Different steps involved the surface sterilization of sword suckers; 2.0% Bavistin treatment and followed by 3% of $\text{Na}(\text{ClO})_2$ and 0.1% of HgCl_2 .



Fig. 4: Various stages of initial tissue culture of Red Banana: Inoculated shoot tip explants of red banana in initial culture medium and growth of explants

Different stages in in vitro of Red Banana



Fig. 5. Effect of PGRs on shoot proliferation and multiplication of *in vitro* regenerated plants of red banana

RESEARCH PROJECTS

STATE PLAN FUNDED PROJECTS (2021-22)

Sl.No	Title	PI	Funding
1	Development of bioinoculant for growth and development of <i>Dalbergia latifolia</i> and <i>Desmodium oogeinense</i> by using native microflora.	Dr. Nibha Gupta Principal Scientist	F & E Dept. GoO
2	Morphotaxonomic characterization and documentation of fungi of Odisha	Dr. Nibha Gupta Principal Scientist	F & E Dept. GoO
3	Production, purification and evaluation of anticancer properties of extracellular secondary metabolite from <i>Colletotrichum</i> sp.	Dr. Nibha Gupta, Principal Scientist	F & E Dept. GoO
4	Screening of fungi for Glutaminase free L-asparaginase	Dr. Nibha Gupta Principal Scientist	F & E Dept. GoO
5	Mass production of selected medicinal plants of Odisha through tissue culture.	Dr. N.R. Nayak Senior Scientist	F & E Dept. GoO
6	Developing micropropagation methods for <i>Pterocarpus santalinus</i> , <i>Anogeissus latifolia</i> <i>Santalum album</i> , and <i>Desmodium oojeinense</i> , some endangered forest trees species of Odisha	Dr. G.K. Surabhi Senior Scientist	F & E Dept. GoO
7	Therapeutic validation of <i>Pterocarpus marsupium</i> and <i>Piper trioicum</i> as a cholinesterase inhibitor for the treatment of Alzheimer's disease	Dr. A. K. Sahoo, Senior Scientist	F & E Dept. GoO
8	The protective diabetic neuropathy effect of <i>Buchanania lanzan</i> Spreng. in streptozotocin induced type 2 diabetic rats	Dr. A. K. Sahoo, Senior Scientist	F & E Dept. GoO

9	Standardization of various macropropagation methods of useful wild edible fruits of Odisha	Dr. U. C. Basak Senior Scientist	F & E Dept. GoO
10	Immunity boosting natural fruits : determination of Vitamin-C (Ascorbic Acid) for selection of potent species to promote domestication	Dr. U. C. Basak Senior Scientist	F & E Dept. GoO
11	Assessment of antifungal activity of <i>Vallaris solanacea</i> and <i>Vernonia anthelmentica</i> solvent extracts against <i>Aspergillus flavus</i>	Dr. Sunita Bhatnagar Senior Scientist	F & E Dept. GoO
12	Phytochemical, antioxidant and cytotoxic activity of ornamental plant <i>Clerodendrum siphonanthus</i>	Dr. Sunita Bhatnagar Senior Scientist	F & E Dept. GoO
13	Propagation and reintroduction of selected endangered species of Odisha	Dr. C. Kalidass Scientist	F & E Dept. GoO
14	Standardization of <i>in vitro</i> regeneration techniques in red banana and establishment of red banana in Odisha climate condition.	Dr. C. Kalidass Scientist	F & E Dept. GoO

EXTERNALLY FUNDED PROJECTS (2021-22)

Sl.No	Title	PI	Funding
1	Harnessing the potential of endophytes of <i>Piper longum</i> as an alternate source for piperine production: optimization of protocol for laboratory production and exploration of its anticancer properties"	Dr. N. Gupta, Pr. Scientist	NMPB
2	Harnessing the potential of endophytes against root knot nematode <i>Meloidogyne icognita</i> in banana	Dr. N. Gupta, Pr. Scientist	DBT

3	Establishment of Tissue Culture Based Mass Propagation Facility of Banana and Plantains	Dr. N.R. Nayak, Sr. Scientist	RKVY
4	Mass Propagation of Local Musa Varieties of Odisha, Commercialization using Tissue Culture Techniques	Dr. Bandita Deo, Sr. Scientist	RKVY
5	OMICS approach to regulate ripening and enhance fruit shelf-life in banana an important fruit crop for food security	Dr. G. K. Surabhi, Sr.Scientist	RKVY
6	Establishment of Mass Propagation and Breeding Facility for Orchids	Dr. N.R. Nayak, Sr. Scientist	RKVY
7	Conservation of salt-sensitive back mangroves <i>Heritiera fomes</i> and <i>H. littoralis</i> through re-introduction in protected area: application of vegetative propagation technique	Dr. U.C. Basak, Sr.Scientist	DBT

PUBLICATIONS

Research Paper

Year 2022

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Tripathy, S., Bhatnagar, S. (2021) *Pancreatium verecundum*: A comparative analysis of leaf and bulb extract. *International Journal of Pharmacy and Pharmaceutical Research* 21(1), 337-346

Book

Gupta N., Manoharachary C., P. Mekro , Behera, R. (2022). *Fungi of Odisha : Part I . Regional Plant Resource Centre, Bhubaneswar* pp. 1-239.

Mekro, P. Basak U C , Kalidass, C. (2022). *Edible Flowers and Their Food, Medicinal and Other Uses. Regional Plant Resource Centre, Bhubaneswar* pp. 1-60.

Research Report

Basak U.C and Mekro P. (2022). *Research and Activity Report 2020-21. Published by Regional Plant Resource Centre, Bhubaneswar.* pp.1-92

TRAINING & EDUCATION

Regional Plant Resource Centre provides short term training to the students of M.Sc. / B.Tech. / M/Tech. and other courses every year from January to June for a duration of 6 months. Training is imparted on various subjects pertaining to 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. Training/course completion Certificate is issued at the end of the scheduled course period infavour of the student trainee.

Detailed account of the Training provided in the Year 2022

Sl.No	Name of the student	Scientist	Supervisor/Guide
1	Mr. Abhjit Sahoo Trainee, SOA, BBSR	Studies on pigment producing fungi and their antimicrobial activity.	Dr. N. Gupta, Pr. Scientist
2	Mr. Subhransu Panda Trainee, SOA, BBSR	Screening of fungi for bioactivity against plant pathogens.	Dr. N. Gupta, Pr. Scientist
3	Ms. Himadri Das Mohapatra Trainee, SOA, BBSR	Studies on bioactivity of fungi against fruit deteriorating bacteria.	Dr. N. Gupta, Pr. Scientist
4	Ms. Chandana Dalai Trainee, SOA, BBSR	Development of Tissue Culture Based Propagation Methods of <i>Aeridesodorata</i> Lour. (Orchidaceae).	Dr. N. R. Nayak, Sr. Scientist
5	Mr. Jyotiprakash Padhan Trainee, SOA, BBSR	Development of Inter Simple Sequence Repeat (ISSR) Molecular Markers of <i>Dendrobium aphyllum</i> (Roxb.) C.E.C.Fisch.	Dr. N. R. Nayak, Sr. Scientist
6	Mr. Satyasumanta Jena Trainee, SOA, BBSR	Development of Tissue Culture Based Propagation Methods of <i>Aeridesmultiflora</i> Roxb. (Orchidaceae).	Dr. N. R. Nayak, Sr. Scientist
7	Ms. Arpita Pattnaik Trainee, SOA, BBSR	Development of Inter Simple Sequence Repeat (ISSR) Molecular Markers of <i>Dendrobium Sonia</i> .	Dr. N. R. Nayak, Sr. Scientist
8	Mr. Sibasis Parida Trainee, SOA, BBSR	Evaluation of ascorbic acid and other antioxidant in <i>Sonneratia caseolaria</i> : A mangrove fruit.	Dr. U. C. Basak, Sr. Scientist
9	Ms. Monalisha Behura Trainee, SOA, BBSR	Analysis of nutritional value of <i>Suregada multiflora</i> L. Juss.: An edible wild fruit of Odisha.	Dr. U. C. Basak, Sr. Scientist
10	Ms. Soumya Choudhury Trainee, SOA, BBSR	Assessment of immune response anti-oxidant properties in fruit of <i>Elaeocarpus serratus</i> L.	Dr. U. C. Basak, Sr. Scientist
11	Mr. Abinash Kumar Mohanty Trainee, SOA, BBSR	Determination of oxidative stress response and anti-oxidant properties in two different mangrove species (<i>Heritiera fomes</i> L. & <i>Heritiera littoralis</i> L.)	Dr. U. C. Basak, Sr. Scientist

Ph.D. Awarded/Pursuing

Sl. No	Name of the Supervisor/ candidate	Title of the Doctoral program	University registered/ Year	Status
1	Dr. Nibha Gupta, Pr. Scientist			
	Mr. Hruda Ranjan Sahoo	Bioprospecting of phosphate solubilising fungi and their application for improving the growth of some RET medicinal plants.	Utkal University, Bhubaneswar. (Reg. Number03- Life Science 2012-13)	Pursuing
	Ms. Smitha Behera	Optimization of cultural and nutritional conditions for enhanced production of exopolysaccharide by some fungi.	Utkal University, Bhubaneswar (Reg. Number07 –Life Science 2015-16)	Pursuing
2	Dr. Nihar Ranjan Nayak, Sr. Scientist			
	Mrs. Sulagna Subhasmita Jena	Production of Quality Planting Materials and elucidation of diversification of flowering time (FT) gene in Orchids.	Utkal University, Bhubaneswar. (R.Number03/ Biotech/2015-16)	Awarded
	Mrs. Johnnita Tirkey	Development of molecular tools for dendrobium species and their hybrids (Orchidaceae) for application in horticulture industry.	Dept. of Botany Utkal University. (Reg. No 06-Biotechnology, 2017-18)	Pursuing
	Mr. Debabrata Dash	Optimization of Various Parameters for the Production of Second Generation Bioethanol from the Efficient Biomass Producing Plants of Odisha.	Utkal University, Bhubaneswar. (Reg. No 07-Biotechnology, 2017-18)	Pursuing
3	Dr. Giridara Kumar Surabhi, Sr. Scientist			
	Mr. Subhankar Mohanty	A proteome approach to investigate fruit ripening and identification of key ripening proteins/genes in banana.	Utkal University, Bhubaneswar. 06-Biotechnology, 2017-18	Pursuing
	Mr. Kousik Mukherjee	Studies on genetic diversity of sal (<i>Shorea robusta</i> Gaertn.) tree population in Odisha using molecular markers and development of mass propagation protocol through <i>in vitro</i> culture	Utkal University, Bhubaneswar. Botany in process	Pursuing

	Mr. Dinesh Pradhan	Transcription profiling and molecular characterization of candidate fruit ripening associated genes in banana.	Utkal University, Bhubaneswar. 03-Biotechnology, 2018-19	Pursuing
4	Dr. A.K. Sahoo, Sr. Scientist			
	Mr. Satish Kanhar	Phytochemical and Biological Evaluation of three Indian <i>Homalium</i> species with special reference to Hepatoprotective activity in CCl ₄ -Induced oxidative stress in Wistar rats.	Utkal University, Bhubaneswar. (Regd. Number 02-Pharmacy-2016-17).	Pursuing
	Mr. Umesh Chandra Dash	Pharmacological profiling of <i>Geophilarepens</i> and <i>Bacopa floribunda</i> and evaluation of their therapeutic potential against Alzheimer disease.	Utkal University, Bhubaneswar. (Regd. Number 10 - Biotechnology -2016-17).	Pursuing
	Mr. Sandeep Kumar Swain	Ethnopharmacological significance and therapeutic evaluations of <i>Hydroleazeylanica</i> in experimentally induced type 2 diabetes in rats.	Utkal University, Bhubaneswar. (Regn.number 01-Biotechnology-2017-18	Pursuing
	Mrs. Deeptimayee Rout	Ameliorative effects of <i>Homaliumzeylanicum</i> on diabetes induced oxidative stress and inflammation in Wistar rats.	Utkal University, Bhubaneswar. (Regd. Number 11-Biotech-2016-2017).	Pursuing
5	Dr. U. C. Basak, Sr. Scientist			
	Mrs. Jyotimayee Nayak	Screening of some medicinally important wild edible fruits of Odisha for nutrient content, antioxidant and antibacterial activities.	Utkal University, Bhubaneswar (Reg. Number: 08-Botany-2012-2013)	Pursuing
	Ms. Pragyan Aparichita Patra	Evaluation of some lesser known wild edible fruits for their nutritional, antinutritional and antioxidant properties. (Reg. Number 06-Biotech-2016-2017)	Utkal University, Bhubaneswar. (Reg. Number 06-Biotech-2016-2017)	Awarded
	Ms. Swadha Baral	Essential amino acid profiling of some wild edible fruits of Odisha. (Reg. Number 04-Biotechnology-2017-18)	Utkal University, Bhubaneswar. (Reg. Number 04-Biotechnology-2017-18)	Pursuing

6	Dr. C. Kalidass, Scientist			
	Ms. Madhusmita Mallia	Study of diversity, distribution and systematics of the family Solanaceae in Eastern Ghats of India	Utkal University(Reg. Number 09-Botany-2018-19)	Pursuing
	Mrs. Sasmita Pati	Study of the ethnobotany and traditional conservation practices of the Saora tribes of Odisha	Utkal University (Reg. Number 09-Botany-2020-21)	Pursuing

LIBRARY

The library of the centre has collection of 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. Several Indian Journals of repute are included as annual subscription.

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.

EX-SITU CONSERVATION & GERMLASM COLLECTION

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.

RPRC has its rich living collections of different plant groups like 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 Roses. These have been introduced to the living collection division and are being studied.

Wild Edible Fruits Garden : With a view to create awareness among various stake holders including foresters, plant lovers, researchers and general citizen about various wild edible fruits occurring in Odisha, RPRC has created an *ex situ* conservation garden housing more than 110 species of fruits, nuts & berries. Since plant conservation and research are major objectives of the centre, this germplasm collection is also meant to provide important wild fruit bioresource for undertaking research on propagation, cultivation, analysis and utilization.



RET Corner: Conserved more than 35 RET species like *Lasiococca comberi*, *Hildegardia populifolia*, *Cycas sphaerica*, *Homalium tomentosum*, *Hypericum gaitii*, *Cordia macleodii*, *Gnetum ula*, *Homalium tomentosum* etc.



Jagannath Vatika: A special garden housing 125 species of trees and plants used in different rituals of Lord Jagannath and the plants are grouped under 7 categorized such as -1.Construction of chariots and special carts to transport the holy logs of Neem for making the idols.2.Selection of holy Neem plants for making the idols and special characteristics of the site.3.Making a special floral crown "Tahia" for the deities.4.Preparation of "Dasamula"- An Ayurvedic drug.5.Preparation of fragrant herbal oil called "Phuluri"6. Leaves and flowers used in different attires, rituals and festivals and 7 Fruits and seeds used in daily rituals, attires and special occasions.



Fragrance Flower Garden: The iconic Botanic Garden (Ekamrakanan) of RPRC offers visitors a living museum of native and exotic plant collections of fragrant flowers, both wild and cultivated, in its themed section called 'Fragrant Flower Garden'. With a collection of more than 70 species of plants with scented flowers, the fragrance garden established in a unique landscape over about 3.5 acres of land and thus a must-visit site for everyone. The centrally placed giant Ashoka Chakra is surrounded by several landscapes represented by majority of Magnolias, Jasmines, Gardenias, Tabernae montanas and many more scented flower groups inter-connected with network of visitors path and shed to enjoy the beauty and fragrance of the of the garden.



Clematis gouriana



Jasminum sambac *Clematis gouriana*



Cananga kirki



Rose Garden: The Centre has collection of around 1000 varieties of roses. The available varieties include Alec's Red, Black Lady, Double delight, French perfume, Nurjahan, Surkhab, Tiara etc,

Palmetum: Representing nearly 60 species of palms including *Archontophoenix alexandrae*, *Calamus spp*, *Corypha umbraculifera*, *Dypsis lutescens*, *Livistonia chinensis*, *Ravenea rivularis* etc.



Bambusetum : Having collection of around 30 species of bamboos like *Arundinaria chino*, *Arundo donax*, *Bambusa balcooa*, *Dinochloa maclellandii*, *Melocanna baccifera*, *Phyllostachys nigra*, *Pseudosasa japonica* etc.



Hibiscus Garden : The garden has a collection of 52 varieties of *Hibiscus* species.

Cacti and other Succulents: The Centre houses more than 1000 Varieties and cultivars of cacti and succulents, both for sale and display for visitors.



Orchidarium: Having germplasm collection of nearly 100 species of Orchids. Some species/hybrid orchids are also displayed in orchadarium in botanical garden & many hybrid orchids are available for sale.



GARDEN COMPETITION ; PRIZE DISTRIBUTION CEREMONY 2022

The Regional Plant Resource Centre (RPRC), in association with Plant Lovers' Association (PLA), Bhubaneswar organised this prize distribution ceremony facilitating winners of Garden Competitions held during the month of January, 2022. The event has been organized with the support of Odisha Mining Corporation Ltd.

On this occasion, Shri Rajiv Kumar, PCCF-cum-Chairman, Odisha Biodiversity Board, Government of Odisha, inaugurated the Prize distribution ceremony as Chief Guest.

Smt. Pusazhule Mekro, IFS, PCCF & Chief Executive, RPRC, Sri Khirod Pattnaik, President, Plant Lovers' Association and other dignitaries attended the function.

All the Staffs of RPRC and Plant Lovers Association were also present.

RPRC organised this "Garden Competition" in the Capital city of Bhubaneswar to encourage the residents and institutions/offices for raising Gardens and growing plants to add to the beauty of the City. The winners of Gardens are being awarded with prizes and trophies in this indoor function held on 23rd April, 2022.

This year the Garden competition comprised of 8 different categories such as 'Residential Building', 'School Garden', 'Teaching & Training Institution', 'Corporate Garden', 'Govt. Office', 'Public Garden', 'Nursery' and 'Theme Park/Garden'.

In the wake of the pandemic Covid-19, this year too, entry to the function was restricted to a permissible number of concerned person only.

The scientists, staff, students and workers of RPRC; the office bearers and members of PLA had put their best efforts to make this function a continuity. The financial assistance from OMC, Odisha and help and cooperation obtained from different participating institutions and individuals are gratefully acknowledged by RPRC.





RELEASE OF BOOKS AND OTHER PUBLICATIONS



RPRC Publications 2022 Released On occasion of World Environment Day (June 5, 2022)

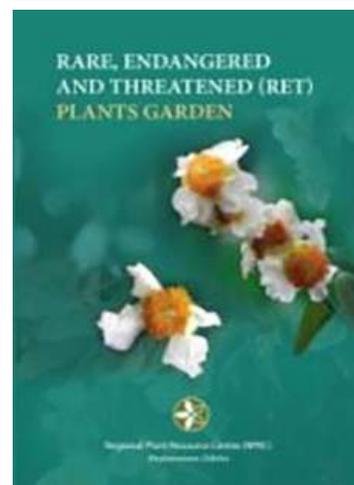
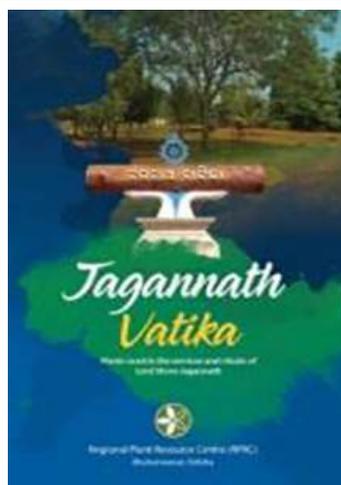
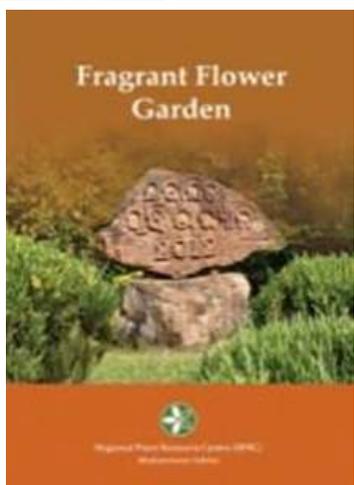
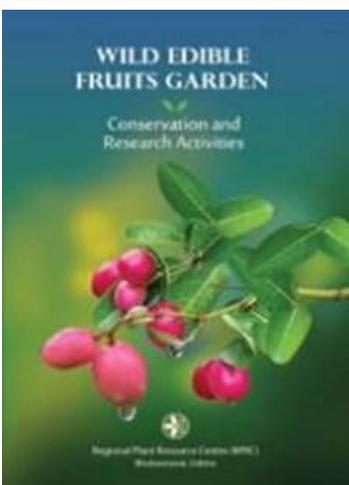
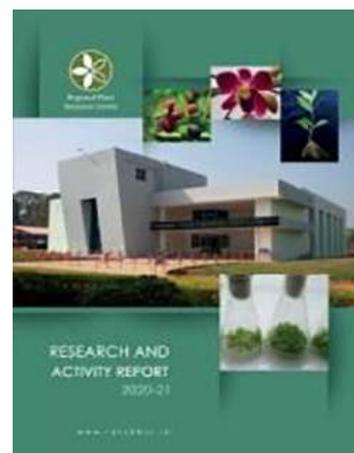
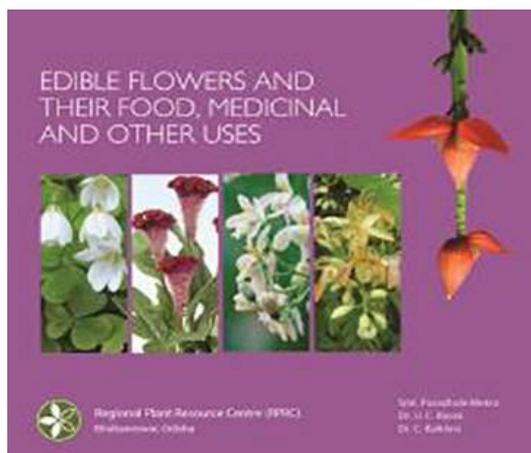
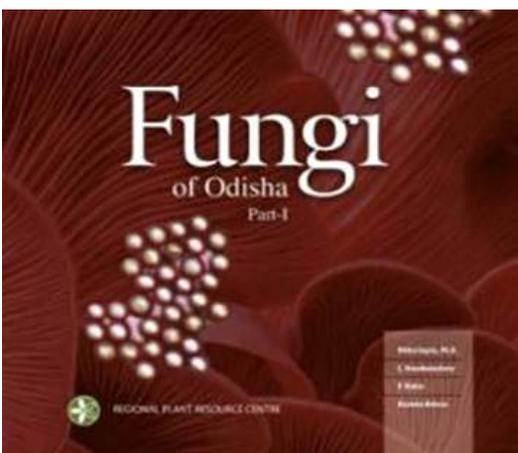


Publications Released

Books
 Fungi of Odisha, Part-I
 Edible Flowers and their Food,
 Medicinal and other Uses
 Jagannath Vatika Rare, Endangered and
 Threatened (RET) Plants Garden

Annual Report
 Research and Activity
 Report 2020-21

Pamphlets
 Wild Edible Fruits Garden
 Fragrant Flower Garden
 Jagannath Vatika
 Rare, Endangered and
 Threatened (RET) Plants Garden



NEW INITIATIVES & MISCELLANEOUS EVENTS

- i. **Recognition:** RPRC has received the Accreditation Certificate by DBT to produce Tissue Culture raised plants under NCS-TCP programme.
- ii. **Re-introduction** of Orchids plants on various host plants inside RPRC campus.
- iii. **Intiation of Collaboration** with primitive institutions viz., CSIR-NBRI, Lucknow & ICAR-NRCB, Trichy.

LIST OF NEW GERMPLASM IN RPRC

S.No	Botanical name of the Plant
1	<i>Alphonsea lutea</i> Bedd.
2	<i>Aporosa octandra</i> (Buch.-Ham. ex D.Don) Vickery
3	<i>Ardisia solancae</i> Roxb.
4	<i>Cordia macleodii</i> Hook.f. & Thomson
5	<i>Cryptocarya amygdalina</i> Nees.
6	<i>Dillenia pentagyna</i> Roxb.
7	<i>Diospyros ferrea</i> (Willd.) Bakh.
8	<i>Flacourtia jangomas</i> Steud.
9	<i>Hypericum gaitii</i> Haines
10	<i>Lasiococca comberi</i> Haines
11	<i>Leea indica</i> (Burm.f.) Merr.
12	<i>Litsea monopetala</i> Pers.
13	<i>Monoon coffeoides</i> (Thwaites ex Hook.f.) B.Xue& R.M.K. Saunders
14	<i>Monoon simiarum</i> (Buch.-ham. ex Hook.f. & Thomson) B.Xue& R.K.S. Saunders
15	<i>Nothopegia castaneifolia</i> (Roth) Diny Hou
16	<i>Oroxylum indicum</i> (L.) Benth. ex Kurz.
17	<i>Psydrax dicoccos</i> Gaerth.
18	<i>Pterocarpus marsupium</i> Roxb.
19	<i>Pterocarpus santalinus</i> L.f.
20	<i>Radermachera xylocarpa</i> K.Schum.
21	<i>Sterculia foetida</i> L.
22	<i>Symplocos racemosa</i> Roxb.

S.No	List of new Banana variety
1	Chini Champa
2	Dakhin Sagar
3	Karpuravalli
4	Kaveri Harita
5	Kaveri Kalki
6	Kaveri Saba
7	Kaveri Sugantham
8	Mukuni
9	Nalikadali
10	Nendran
11	Neypoovan
12	Paunsiakadali
13	Poovan
14	Red banana
15	Udhayam

New Germplasm in RPRC



Alphonsea lutea



Aporosa octandra



Ardisia solancae



Cordia macleodii



Cryptocarya amygdalina



Dillenia pentagyna



Diospyros ferrea



Flacourtia jangomas



Hypericum gaitii



Lasiococca comberi



Leea indica



Litsea monopetala



Monoon simiarum



Nothopegia castaneifolia



Oroxylum indicum



Pterocarpus marsupium



Pterocarpus santalinus



Psydrax dicoccos



Rutia fruticosa



Dendrobium Rose Betty Blue



Radermachera xylocarpa



Sterculia foetida



Symplocos racemosa

New Banana Germplasm in RPRC



Red Banana

Dakhin Sagar

Chini Champa



Champa



Red Bantala



Bantala



Paunsia Bantala



Patkapura



Grand9



Bantala



NEW Germplasm of Orchids



Habenaria plantaginea



Pomatocalpa decipiens



Acampe rigida



Acampe praemorsa



Aerides odorata



Pholidata imbricate



Dendrobium moschatum



Ground Orchid: *Nervilia crociformis*



NEW Germplasm of Ferns and other Plants



Fern (from Khurda)



Mangrove Fern: Acrostichum aureum



Szechuan Pepper: Zanthoxylum simulans



Star Fruit: Averrhoa



Introduction of RET plants & Edible Fruits in RPRC Campus during Van Mahotsav 2022



Introduction of Orchids in RPRC Campus during Van Mahotsav 2022

Introduction of *Careya arborea* (Kumbhi)



Introduction of *Careya arborea* (Kumbhi) by ACS in Botanic Garden of RPRC during Van Mahotsav 2021



Establishment of *Careya arborea* (Kumbhi) planted by ACS in Botanic Garden of RPRC (2022)

New Germplasm of Ornamentals

Aglaonema commutatum
 Aglaonema commutatum 'China Red'
 Aglaonema snow white
 Alocasia 'Black Velvet'
 Bougainvillea hanging
 Caladium
 Caladium hortulanum
 Caladium hortulanum 'White Wing'
 Calathea bella
 Calathea IN
 Calathea insignis
 Calathea louisae
 Calathea orbifolia
 Calathea ornate 'Sanderiana'
 Calathea picturata 'vandenheckei'
 Calathea stromata
 Cryptanthus bivittatus 'Red'
 Cryptanthus bivittatus 'Tricolor'
 Dieffenbachia maculata 'Jupiter'
 Dischidia nummularia
 Marble Money Plant
 Oxy cardium
 Oxy cardium 'Black'
 Pedilanthus hanging
 Peperomia caperata 'Variegata'
 Peperomia scandens
 Philodendron birkin



New Germplasm Succulents

Crassula
 Echeveria
 Euphorbia hybrida
 Gasteria liliputana 'Variegata'
 Gastrolea bendinghausii
 Howarthia foschae
 Kalanchoe tomentosa
 Pachiphytum oviferum
 Pachiphytum oviferum 'Moonstone'
 Sedum morganianum 'Giant
 Burrofail'
 Senecio jacobsenii
 Senecio petraeus
 Zamia zamifolia



New Germplasm of Ornamentals



Peperomia scandens



Oxy cardium



Dischidia nummularia



Peperomia scandens



Oxy cardium



Dischidia nummularia



Oxy cardium 'Black'



Pedilanthus hanging



Calathea IN



Aglaonema commutatum 'China Red'



Aglaonema commutatum



Calathea picturata 'vandenheckei'



Calathea bella



Calathea louisiae



Cryptanthus bivittatus 'Tricolor'



Cryptanthus bivittatus 'Red'



Caladium hortulanum



Cryptanthus bivittatus 'Tricolor'



Caladium



Caladium



Caladium hortulanum 'White Wing'



Alocasia 'Black Velvet'



Calathea orbifolia



Calathea insignis



Calathea stromata



Calathea ornate 'Sanderiana'

New Germplasm of Succulents



Gasteria liliputana 'Variegata'



Sedum morganianum



'Giant Burrofail'



Euphorbia hybrid



Senecio petraeus



Zamia zamifolia



Senecio jacobsenii



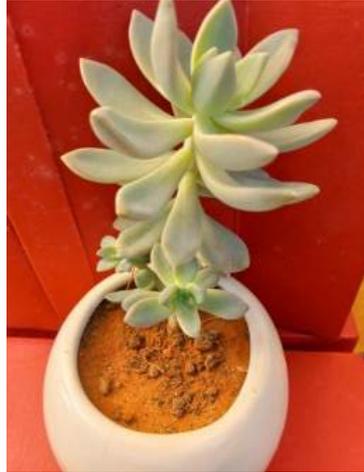
Howarthia foschae



Pachiphytum oviferum 'Moonstone'



Crassula



Echeveria



Echeveria



Pachiphytum oviferum



Pachiphytum oviferum



Kalanchoe tomentosa



Crassula



Gastrolea bendinghausii

SEMINAR/TALK BY SUBJECT EXPERTS AND RESEARCH SCHOLARS



Dr. A. Mao, Director, BSI, Kolkata, delivering a talk to scientists & research scholars of RPRC on various facets of Plant Conservation and Taxonomy.



Dr. S. Uma, Director, ICAR-NRCB, Trichy delivering a talk to scientists & research scholars of RPRC on various facets of Banana Research & Product development in presence of PCCF & Chief Executive, RPRC.



Seminar-cum-Orientation Programme in RPRC



Orientation programme on Short-term Training to MSc Biotech Students

EXPOSURE VISITS OF VARIOUS INSTITUTIONS TO RPRC



PCCF & Chief Executive of RPRC Addressing Forest Officials during their visit to RPRC (April, 2022)



Training to forest personnels at RPRC



Exposure visit of Forest Rangers from GFRC, Gujarat (2022)

Exposure visit of Students of Sri Sri University to RPRC (2022)



Exposure visit of Students of Navodaya Vidyalaya to RPRC (2022)



Exposure visit of Forest Rangers from TSFA, Telangana (2022)



Inauguration of Banana Tissue Culture Production Certification (DBT, NCS-TCP Programme) by Dr. Mona Sharma, ACS, Govt. of Odisha in presence of Chief Executive RPRC (2022)



Inauguration of Orchid Cultivation and Breeding Facility by Dr. Mona Sharma, ACS, Govt. of Odisha in presence of Chief Executive RPRC (2022)



REGIONAL PLANT RESOURCE CENTRE

NAYAPALLI, BHUBANESWAR-751015

BALANCESHEET AS ON 31.03.2022

LIABILITIES	SCHEDULE	AMOUNT(RS.)	ASSETS	SCHEDULE	AMOUNT(RS.)
General Fund	1	8,97,52,655	Fixed Assets	5	8,83,50,286
Grant for Non-recurring Expenses	2	15,25,75,414	Work-in-Progress	6	3,69,86,813
Advance Received for Contract Work	3	72,20,370	Fund Transfer to opening new scheme account		45,65,034
Current Liabilities	4	1,00,87,638	Current Assets	7	10,56,80,025
			Loans & Advances		1,621
			Cash in Hand		2,40,52,297
			Cash at Bank		25,96,36,076
Total		25,96,36,077	Total		25,96,36,076

UDIN: 22301929AYRJCX2001

Place: Bhubaneswar

DATE: 28/04/2022

For PARTHA S. MISHRA & Co.

Chartered Accountants

Soumya Kumar Patra

CA S.K. Patra (FCA, DISA)

Partner. M. No- 301929



Administrative-Cum-Finance Officer

Regional Plant Resource Centre

Bhubaneswar



Regional Plant Resource Centre

Forest, Environment and Climate Change Department, Govt. of Odisha
Nayapalli, Bhubaneswar 751015, Odisha, India,
Phone: (0674) 2557925, E-mail: rprcbbsr@gmail.com

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