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TGCHE SPONSORED

NATIONAL SEMINAR

on

"RECENT ADVANCES IN PLANT SCIENCE RESEARCH"

22nd & 23rd NOVEMBER - 2024

Organized by

DEPARTMENT OF BOTANY

Pingle Govt. College for Women (A)

Waddepally, Hanumakonda

Hanamkonda (Dist), TELANGANA STATE

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IJMER, Journal of Multidisciplinary Educational Research, concentrates on critical and creative research in multidisciplinary traditions. This journal seeks to promote original research and cultivate a fruitful dialogue between old and new thought.

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Dr. K. VICTOR BABU
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International Journal of Multidisciplinary Educational Research (IJMER) & Sucharitha: A Journal of Philosophy and Religion

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Editorial……

It is heartening to note that our journal is able to sustain the enthusiasm and covering various facets of knowledge. It is our hope that IJMER would continue to live up to its fullest expectations savoring the thoughts of the intellectuals associated with its functioning .Our progress is steady and we are in a position now to receive evaluate and publish as many articles as we can. The response from the academicians and scholars is excellent and we are proud to acknowledge this stimulating aspect.

The writers with their rich research experience in the academic fields are contributing excellently and making IJMER march to progress as envisaged. The interdisciplinary topics bring in a spirit of immense participation enabling us to understand the relations in the growing competitive world. Our endeavour will be to keep IJMER as a perfect tool in making all its participants to work to unity with their thoughts and action.

The Editor thanks one and all for their input towards the growth of the Knowledge Based Society. All of us together are making continues efforts to make our predictions true in making IJMER, a Journal of Repute

Dr.K.Victor Babu
Editor-in-Chief

Chairman
TGCHE
Hyderabad
Telangana

MESSAGE

I extend my warm greetings and congratulations to the entire college and department of Botany for organizing a two day National Seminar on "Recent Advances in Plant Science Research" on 22nd & 23rd November 2024. This is indeed a thought-provoking topic and a great opportunity for scholars and students to explore the significance of recent developments in plant science and research.

I wish the seminar all success and hope that it will be an enriching experience for all participants. May the discussions and deliberations inspire new perspectives and insights into the advanced technologies in plant science and research.

Please convey wishes to the organizers, resource persons and participants. I look forward to learn about the outcomes and takeaways from the seminar.

Best Wishes

Prof. V. Balkista Reddy
Chairman
TGCHE, Hyderabad

Prof. K. Pratap Reddy
Vice-Chancellor

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No. 113/VCP/KU/24

November 18, 2024

MESSAGE

On behalf of Kakatiya University, I extend my warm greetings to the esteemed organizers, participants, and contributors of the National Seminar on "Recent Advances in Plant Science Research," hosted by the Department of Botany, Pingle Government College for Women, Hanumakonda. This seminar, supported by TGCHE, serves as an exceptional platform to integrate academic rigor with a profound sense of social responsibility.

The seminar's focus on critical themes such as biodiversity conservation, molecular biology, phytoremediation, and the economics of plant sciences underscores its relevance not only for the academic community but also for addressing pressing global challenges. As researchers, educators, and practitioners, you hold the power to translate knowledge into solutions that benefit society, from sustainable resource management to combating environmental degradation.

Under the leadership of Kakatiya University, we emphasize fostering scientific inquiry that resonates with societal needs. The deliberations at this seminar are expected to lead to tangible outcomes, such as innovative research approaches, policy insights, and collaborative networks, that will strengthen both academic frameworks and social interventions. I am confident that the discussions and ideas exchanged will inspire actionable strategies that make a difference beyond the seminar's walls.

Let this event motivate each one of you to continue contributing meaningfully to both knowledge creation and societal well-being. I congratulate the organizing team for their dedication and extend my best wishes for the seminar's resounding success. Together, let us create a future where scientific advances empower and uplift communities.

Warm regards,

Professor K. Prathap Reddy

Dr. G. HANMANTHU
Ph.D
Dean & Professor

OFFICE OF THE DEAN
FACULTY OF SCIENCES
Kakatiya University
Hanumakonda – 506 009.

Kakatiya University Accredited with "A+" Grade by the NAAC

MESSAGE

It gives me immense pleasure to appreciate the Department of Botany, Pingle Government College for Women(A), Waddepally, Hanumakonda for organizing the National Seminar on "**Recent Advances in Plant Science Research**" to be held on 22[nd] & 23[rd] November 2024. I congratulate the organizers and faculty members for organizing national level seminar in the department and for their zeal in planning and conducting the seminar.

The recent development in the field of plant sciences are quiet encouraging and contributing technologies to mitigate the sufferings of the people. I am particularly happy to note that the seminar deals with the recent developments and aspects of this rapidly advancing field.

Plant biotechnology will solve the problems of food crisis, human health care and environment. It is popular subject in the present society.

The seminar would pave the way to good exposure to modern and latest developments of the plant sciences and create a scientific ambience for interaction between scientists of national repute and budding scientific force for development of strong human resources in the country.
On this memorable and historic occasion, I wish your seminar a very success in these endeavors.

Prof. G. Hanmanthu

Date : 18/11/2024

Prof. Md. MUSTAFA
M.Sc., Ph.D., FBS; FIAT; B.Ed.
Former Head & Chairperson
BoS in Botany, KU, Warangal

MESSAGE

It gives me immense pleasure to appreciate the Department of Botany organizing TGCHE sponsored National Seminar on "Recent Advances in Plant Science Research" on 22^{nd} and 23^{rd}, November, 2024.

I congratulate the organizers and faculty members for their zeal in planning and conducting the seminar. The seminar would pave to have good exposure to recent advances and techniques in plant research. The expertise from the national level would be useful to the academia involved in active research.

I wish the seminar a grand success.

(Prof. Md. Mustafa)

Prof.B.Chandra Mouli
Principal Pingle Government College for Women(A) Waddepally, Hanumakonda

MESSAGE

At the outset, I congratulate the Department of Botany for taking lead to organize two day National Seminar on "Recent Advances in Plant Science Research" on 22^{nd} and 23^{rd} November, 2024 sponsored by Telangana State Council of Higher Education (TGCHE), Hyderabad.

This Seminar includes diversified subjects including modern approaches in the concerned subject areas. The future mankind is dependent on plants, microbes, fungi. Rapid development in Biotechnology, Molecular Biology, genomics, green chemistry, biodiversity and phytoremediation provide great opportunities for improving plant productivity and yield.

It is a great opportunity to our students to get interactions with eminent personalities and imbibe the spirit of academic and research instinct for building their future career and serving our country with their scientific outlook.

I congratulate the Department of Botany for bringing out a Souvenir with Abstracts which would certainly help the students and create great interest in the research field.

I wish that the deliberations for these two days on Recent Advances in Plant Sciences will be fruitful and hope the seminar a grand success.

(Prof. B. Chandra Mouli)

Dr. D. Suneeta
Convener &Organizing Secretary
NSRAPSR-2024

Dear delegates

It gives me immense pleasure to welcome you all to the TGCHE sponsored Two Day National Seminar on "Recent Advances in Plant Science Research". I feel it is a great privilege to organize this seminar. Botany, is the science of plant life and branch of Biology. The term "Botany "comes from the ancient Greek word "Botane" meaning "grass" or "fodder". With the efforts of early humans to identify and cultivate edible, medicinal and poisonous plants making it one of the oldest branches of science. Modern Botany is a broad multidisciplinary subject with inputs from other areas of science and technology. Developments in plant sciences have been driven bymodern techniques of electron microscopy, analysis of chromosome number, spectroscopy, chromatography and electrophoresis. With the rise of the related molecular studies biological approaches of molecular biology, genomics, proteomics, the relationship between the plant genome and most of the biochemistry, physiology, morphology and behavior of plants can be subjected to detailed experimental analysis.

The concept originally stated by Haberlandt in 1902 that plant cells are totipotent and can be grown invitro ultimately enabled the use of tissue culture technique to extract medicinally valuable secondary metabolites. The use of genetic engineering experimentally to knock out a gene or genes responsible for a specific trait or to add genes such as GFP that report when a gene of interest is being expressed.

We are becoming increasingly aware that the microbes are the basis of biosphere. They are ancestors of all living things and support system for all other forms of life. Microbiology research is changing rapidly due to the emergence of globally significant diseases, threats of bioterrorism, increasing failure of effective antibiotics. Studies are focusing on the linkage between microbes and their phylogenetic originsand between microbes and their habitats.

Green chemistry is a rapidly developing technology that is becoming more appealing to academic and industrial system. The focus of green chemistry has expanded to a larger extent. Green chemistry is relatively new approach that addresses environmental concerns.It'sgoal is to reduce environmental pollution and support sustainable development. Recent advances in green chemistry includes use of sustainable sources like waste products or biomass to produce bio plastics,biofuels and biodegradable polymers.

Phyto remediation is a plant based technology that uses plants to remove or reduce the toxic effects of contaminants in the environment. It is an alternative to engineering technique. Trees are preferred than crop plants due to their edible characteristics. Genetic engineering is a promising approach to improve their survival under heavy metal stress conditions and enhance the rate and efficiency of phytoremediation. Potential target genes are modified in plants to enhance phytoremediation.

The role of plants as primary producers in the global cycling of energy, carbon, oxygen, nitrogen and the water, and ways that can help to address the global environmental issues of resource management, conservation, human food security.

The present seminar include diversified subjects including modern approaches in the concerned subject areas like green chemistry, biodiversity conservation, genetic engineering, ethnobotany, plant systematics, biochemistry, microbiology and economics of plants. It is our aim to highlight new scientific developments in plant science. The present seminar serves as a platform for debate and to push the boundaries of conventional thinking. It also aimed to inculcate and strengthen scientific temper among students on research activities.

The two day national seminar includes Inaugural session, Keynote address by Dr.J.Koteshkumar, Senior Principal Scientist, CSIR-CIMAP, Hyderabad, five invited talks and a valedictory session along with paper presentations and poster presentations. Renowned scientists and reputed academicians will deliver lectures on recent advances in plant science research.

The Department of Botany gratefully acknowledge the Telangana Council of Higher Education(TGCHE), Hyderabad for providing financial support to organize this seminar. We are grateful to the staff of the Department of Botany, Department of biotechnology and Department of Microbiology, Kakatiya University for their cooperation in organizing this seminar.We gratefully acknowledge the support rendered by the advisory committee, Prof. G. Hanumanthu Dean Faculty of Sciences, Department of Kakatiya University, Prof.Md.Musthafa BOS, Department of Botany, Kakatiya University, Prof. Lalitha kumari, Head Department of Botany, Kakatiya University, Warangal.

Our special thanks are indebted to our beloved principal, Prof.B.Chandramouli for the encouragement, moral support and initiation taken to organize this seminar.

We are grateful to the conveners and members of various committees constituted for smooth conduction of this seminar. We are grateful to the press & print (SR Digitals) for their cooperation and help.

We take this opportunity to thank all our PG and UG students. Non-Teaching staff of the college for extending their help and cooperation in this seminar

Date: 22nd November, 2024 **Dr.D.Suneeta**

Place: Hanumakonda

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National Seminoar on "Resent Advances in Plant Science Research"

ANTI-BACTERIALACTIVITY OF *TECOMA CAPENSIS* LEAF EXTRACTS

Dr. Dara Suneeta,[1]Dr. Banala Mahitha[2]and Dr. D. Jyothi[3]

1. Associate Professor of Botany, Department of Botany, Pingle Government College for Women (A)Waddepally, Hanumakonda, Telangana, India. 2. Lecturer, Department of Biotechnology, PGCW (A), HNK. 3. Lecturer in Botany, SRR & CVR Government Degree College (A), Vijayawada, Andhra Pradesh, India,

Abstract

Tecoma capensis is less explored plant.Theflowers ,bark and root of used as a remedy for cough and anaemia. The bark powder powder of Tecoma capensis is useful in treating fever, pneumonia, stomach problems.The role of leaves as source of medicine is not yet determined.. The solvent extractions were examined for various bioactive compounds both qualitatively and quantitatively. Theantimicrobial potentiality of solvent extracts was determined using bacteria Bacillus subtilis (MTCC 441), Escherichia coli (MTCC 439), Proteus vulgaris (MTCC 1688), Salmonella typhi (MTCC 3231), Vibrio cholera (MTCC 3906) The obtained results revealed the efficiency of methanol and ethyl acetate in extracting bioactive compounds from the leaves of T.capensis by extracting the leaf methanolic extracts of anrthocyanidines, phenols, quinones, lipids, saponins, tannins, flavanoids, terpenoids, resins and alkaloids. The leaf methanolic extracts of T. capensis showed potential antibacterial activity against P. vulgaris (21 mm) . The obtained proved the efficiency of solvent methanol in extracting the various bioactive compounds with potential antibacterial activity.

Keywords: *Cape Honeysuckle, Bioactive compounds, Soxhlet, Solvents, MIC.*

Introduction

The role of plants in treating various human diseases is quite unavoidable . Use of traditional medicine in healing practices is an age-old practice. 80% of synthetic drugs used today are of plant origin.The phytochemicals recede in the plant body plays a prominent role in synthesizing the plant-baseddrugs. These phytochemicals are the intermediate end products of the various plant metabolic activities large population of the world using plant originated drugs to treat various ailments . Moreover, the side effects due to usage of synthetic drugs tend the scientists to look for remedies of natural origin with safe and effective activity . Plants contain enormous number of phytoconstituents with potential biological activity and it is very difficult to use them without knowing their specific activity on specific disease. Screening the active compounds from plant extracts initiates the synthesis of novel drugs of plant origin. Use of various solvents i.e chloroform, ethyl acetate, methanol, n-Hexane etc. in extracting biologically active compounds is a regular practice.The major part of the plant derived compounds includes phytochemicals, and secondary

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metabolites, which can be classified in to alkaloids, coumarins, flavanoids, lectins, phenolics, polyphenols, polypeptides, quinones, saponins, tannins and terpenes etc .

The *Tecoma capensis*is commonly called Cape Honey suckle. It is planted in garden plant in the Indian subcontinent. Powdered bark decoction used to treat fever and pneumonia.Decoction of leaves is used to treat Diarrohea and inflammation of the intestine. The medicinal potentiality of the leaf extracts is not much documented and very little information is available. Hence, the present work conducted in order to emphasize the possible bioactive compounds present in the leaf extracts of *Tecoma capensis* and to determine their antibacterial activity.

METHODOLOGY

Powdered leaf material of the selected plants (150 g) was extracted using chloroform, ethyl acetate, hexane and methanol (80%) for 12-18 hr. Vacuum rotary evaporator (Buchi Labortech Ag, model l, R-215) was used to evaporate the crude leaf extracts and stored at 4 °C until further use.

Preliminary Phytochemical Screening

Qualitative analysis of phytochemicals from the *T.capensis*leaf extracts identified using the standard protocols.

Quantitative determination of phytochemicals in Methanolic leaf extracts

Alkaloids (mg of AE/g)

To the 1 mg of leaf methanolic extract diffused in dimethyl sulphoxide (DMSO), added with 1 ml of HCl (2N) and filtered. Later the contents were transferred to a separating funnel and added with bromocresol green solution (5 ml) and phosphate buffer (5 ml). The mixture was agitated with chloroform (1-4 ml) and collected in a 10 ml volumetric flask. Atropine standard (20, 40, 60, 80 and 100 µg/ml) was used as reference. The optical density of the solutions was determined at 470 nm .

Coumarins (mg CE/g)

Coumarin content was estimated following the standard methods . A cocktail was prepared using plant extract (500 µl), 2 ml distilled water (2 ml), 500 µl of lead acetate (5% w/v) and agitated thoroughly. To this mixture, 7 ml of DH_2O was added and mixed thoroughly. To the 2 ml of this solution 8 ml of HCl (0.1 M v/v) was added and kept for 30 minutes at 23 °C. The optical absorbance of the solution was recorded at 320 nm.

Cardiac glycosides (%)

Cardiac glycosides were determined according Shamsu and Abubakar . To the 8 ml of plant extract H_2O (60 ml) and 12.5% lead acetate (8 ml) were added, mixed and filtered. Fifty millilitres of the filtrate was mixed with 8 ml of Na_2HPO_4 (47%) and excess Pb^{2+} ion was precipitated. Now 10 ml of filtrate was treated with 10 ml Baljet reagent. A blank was run

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using 10 ml distilled water and 10 ml Baljet reagent. After 1 h incubation the colour intensity was determined at 495 nm.

Calculation

$$\% \text{ Total glycosides} = \frac{\text{Optical Density} \times 100}{77}$$

Flavanoids(mg QE/g)

The total flavonoid content was determined by using quercetin as the standard calibration curve. To 0.5 ml 2% $AlCl_3$ ethanol 0.5 ml of leaf extract was added and kept for 1 h incubation. Later the colour intensity was measured at 420 nm. Leaf extract was determined at 0.1 mg/ml final concentration .

Total phenols (mg of GA/g of extract)

Total phenolic content of the leaf methanolic extract was measured . A reaction cocktail was made with leaf extract (0.5 ml), 10% Folin-Ciocalteu's reagent (2.5 ml), 7.5% of $NaHCO_3$ (2.5 ml) and distilled water. The reaction cocktail was incubated at 45 ºC for 45 min. Later the optical density was measured at 765 nm. Gallic acid was used as the standard for phenols.

Crude saponins (%)

To the 20 g of extracted methanolic sample 20 % aqueous ethanol (100 ml) was added and heated at 55 °C for 4 h with continuous stirring. Later the solution was filtered and the filtrate was extracted with 20 % ethanol (200 ml). The extract was subjected to evaporation and brought the final volume to 40 ml. This concentrate was extracted with diethyl ether (20 ml). The aqueous layer was recovered and purified with n-butanol (60 ml). Further it was washed twice using 5 % aqueous NaCl (10 ml). The solution kept for dry and the amount of saponin was calculated .

Steroids

The steroids present in the plant sample were estimated . To the 1ml of leaf methanolic extract 2 ml of 4N H_2SO_4, 2 ml of 0.5 % w/v iron (III) chloride, 0.5 ml of 0.5% w/v potassium hexacyanoferrate (III) were added. The cocktail was placed in a water-bath and heated up to 70±20 °C for 30 min with occasional shaking. The optical density was determined at 780 nm.

Tannins(mg/g)

Amount of tannins present in the methanolic leaf extracts were determined . To the 0.1 ml of the leaf extract 7.5 ml of distilled water and 0.5 ml of Folin-Ciocalteu phenol reagent were added, followed by 35% sodium carbonate solution (1 ml) and diluted to 10 ml by adding DH_2O. The cocktail was agitated well and incubated at 23 °C for 30 min. Absorbance was

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measured at 700 nm. The tannin content was expressed in terms of mg of tannic acid equivalents/ g of dried sample.

Antibacterial activity by agar well diffusion method

Nutrient agar (NA) was used for culturing the test bacteria and fungus. One 100 ml of nutrient agar medium was sterilized at 121 °C and 15 lbs pressure for 15 min. The NAM was brought to room temperature and inoculated with test microbial suspension (0.1 ml). The contents were mixed thoroughly and poured into petri plates under sterilized conditions. Solidified medium prepared for plant extract inoculation by making well of 5 mm diameter. The antibacterial activity of leaf extracts of *Ixora pavetta* was assessed against *Bacillus subtilis* (MTCC 441), *Escherichia coli* (MTCC 439), *Proteus vulgaris* (MTCC 1688), *Salmonella typhi* (MTCC 3231) and *Vibrio cholera* (MTCC 3906).The antibacterial activity was determined by agar well diffusion method using 3 various concentrations of herbal nanopowders (50 µg, 100 µg and 150 µg). Antibiotic chloramphenicol (30 µg/ml) and DMSO (30 µl/ml) were used as positive and negative controls. Bacterial cultures grown overnight at 37 °C were spread over the surface of agar plates.

Minimal inhibitory concentration (MIC) determination

Two-fold serial broth dilution method was used to determine the MIC in the concentration range of - 60 µg/ml. Plates and tubes were incubated at 37 °C for 1 day. By excluding the well diameter, the zone of inhibition was measured to measure the antimicrobial activity. Tubes without turbidity were recorded as MIC values.

RESULT

The present work was aimed to prepare leaf extracts using various organic solvents from *T.capensis* and to evaluate the qualitative and quantitative screening of phytochemicals along with their antibacterial activity. The results are discussed in detail hereunder.

Preliminary phytochemical screening

The leaf sample of *T.capensis*was extracted with various organic solvents i.e. chloroform, ethyl acetate, hexane and methanol in order to determine the phytochemicals present in the leaf samples both qualitatively (Table 1) and quantitatively (Table 2).

Qualitative phytochemical screening

The preliminary phytochemical screening of *T.capensis*leaf samples extracted with various organic solvents showed the existence of different phytochemicals (Table 1). The chloroform extracted reported the presence of tannins, terpenoids and alkaloids. Phytochemicals such as coumarins, tannins, terpenoids, phenols,flavonoids,glycosides,saponins and alkaloids are extracted with ethyl acetate from the *T.capensis*leaves whereas the leaves extracted with hexane showed the presence of glycosides, coumarins,lipids, tannins, terpenoids, alkaloids; coumarins, quinones, glycosides, lipids, tannins, terpenoids, alkaloids and tannins. Leaf methanolic extracts of *T.capensis*reported the existence of phenols,coumarins,glycosides saponins, tannins, flavanoids, terpenoids and alkaloids.

Table 1. Qualitative phytochemical screening of Tecoma capensis

Phytochemicals	Chloroform	Ethyl acetate	Hexane	Methanol
Phenols	-	+	-	+
Coumarins	-	+	+	+
Flavonoids	-	+	-	+
Glycosides	-	+	+	+
Saponins	-	+	-	+
Terpenoids/Steroids	+	+	+	+
Tannins	+	+	+	+
Alkaloids	+	+	+	+

Quantitative phytochemical screening

The yield of different secondary metabolites presents in *I. pavetta* leaves extracted through different organic solvents was varied significantly from solvent to solvent (Table 2).

Alkaloids

The alkaloid content of the plant extract was determined and expressed in terms of atropine equivalent. It was ranged from 25.15±0.95 %w/w to 40.11±1.10 %w/w in *Tecoma capensis*. The highest alkaloid content was extracted with methanol in *Tecoma capensis* (40.11±1.10 %w/w). After methanol maximum alkaloid concentration was extracted with ethyl acetate (34.10.10±1.00).

Cardiac glycosides

The Cardiac glycosides content of*Tecoma capensis* varied between 1.78±0.54 g/100g to 6.10±0.54g/100 g. The maximum cardiac glycosides concentration of 6.10±0.54 g /100g extracted with Tecoma capensis leaf methanolic extract.

Quantitative phytochemical screening of *T.capensis*

Secondary metabolite	***Tecoma capensis* leaf extract**			
	Chloroform	**Ethyl acetate**	**Hexane**	**Methanol**
Alkaloids (% w/w)	25.15±0.95	34.10±1.00	18.11±1.10	40.11±1.18
Cardiac glycosides (g/100g)	-	3.21±0.68	1.78±0.54	6.10±0.54
Coumarins (mg/g)	-	14.01±0.68	2.21±0.68	22.10±1.11
Flavonoids (mg/g)	-	10.21±0.68	-	22.67±1.10
Phenols (mg/g)	-	1.11±0.68	-	3.10±1.27

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Saponins (% w/w)	-	1.21±0.68		5.42±0.74
Steroids (µg/mg)	10.21±0.25	50.15±0.19	15.00±0.10	85.10±0.16
Tannins (% w/w)	1.21±0.45	4.12±0.22	3.10±1.25	8.15±1.09

Coumarins

Coumarin content was estimated using coumarin equivalents as standard. The leaf methanolic extracts of *T.capensis*was ranged from2.21±0.68 mg/g to 22.10±1.11 mg/g. Among the entire organic solvents' methanol reported to be the best solvent to extract the coumarins (22.10 mg/g). The*T.capensis* leaf extracts exhibited more coumarin concentration 22.10±1.11mg/g with methanol.

Flavonoids

The total flavonoid content was examined in*T.capensis* plant extracts and expressed in terms of quercetin equivalent. The total flavonoid content in was recorded as 10.21±0.68 mg/g and 22.67±1.10mg/g with Ethylacetate and methanol.

Phenols
The essentiality of the phenolic compounds in plant defense mechanism is well documented. The phenolic content of the leaf extract was measured using the standard plot of gallic acid. The phenolic concentration of*T.capensis* found to be more when extracted with Ethylacetate(1.11±0.68mg/g) and methanol (3.10±1.27 mg/g).

Saponins
The amount of saponins observed in the present study was presented in Table 2. Theconcentration of*T.capensis* reported to be1.21±0.68 %w/w and 5.42±0.74 %w/w in Ethlacetateand methanol extracts respectively.

Steroids
A standard graph was plotted for the steroids by using cycloartenol as standard. The steroid content of*T.capensis*was varied between 10.21±0.25 µg/mg to 85.10±0.16 µg/mg and the maximum steroids content was recorded 85.10±0.16 µg/mg with leaf methanolic extracts .

Tannins
The amount of tannins present in the leaf extracts was determined using a standard plot drawn by using tannic acid as standard. In present study the total tannin content was varied between 1.21±0.45%w/w to 8.15±1.09 %w/w. In *T.capensis* maximum tannin concentration was observed 8.15±1.09 with leaf methanolic extracts (%w/w).
Anti bacterial activity
A dose dependent antibacterial activity was observed against test organisms. The antibacterial activity of *T.capensis* leaves extracted with chloroform, ethyl acetate, hexane

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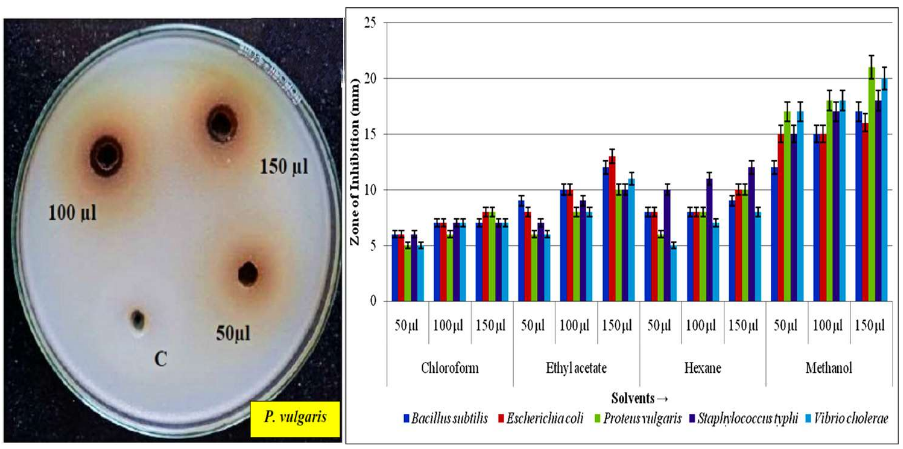
and methanol were tested against pathogenic bacteria *Bacillus subtilis, Escherichia coli, Proteus vulgaris*, *Staphylococcus typhi* and *Vibrio cholerae* and the zone of inhibition was presented in Of all the solvent extracts leaf methanolic extracts of *T.capensis* recorded relatively more zone of inhibition *P. vulgaris* followed by leaf ethyl acetate extracts. The positive control nystatin recorded 16 mm (50 µg/ml).

Minimum Inhibitory Concentration (MIC)

Both the plant extracts *T.capensis* reported promising antimicrobial activities against test pathogens compared with reference antibiotics . The bacterial pathogens *E. coli* and *P. vulgaris* found to be most sensitive than all other bacteria and they were sensitive at the concentration of 15.12 µg/ml and 16.00 µg/ml respectively.



Antibacterial activity *T.capensis* leaf extract against *P. vulgaris*

Test Organism	Methanol Extracts (µg/ml)
Bacteria	
Bacillus subtilis	16.66
Escheria coli	15.12
Proteus vulgaris	16.00
Staphylococcus typhi	25.12
Vibrio cholerae	30.77

Discussion:

Plant generally prepares enormous number of secondary metabolites and these secondary metabolites are having potent medicinal properties .The phytochemical studies revealed that leaves extracted with various organic solvents found to be the best extraction practice to extract the secondary metabolites from the plants with ease and speed . In case of along with chloroform, hexane found to be potent in extracting the secondary metabolites but the quantitative extraction is lower than the ethyl acetate and methane.

In the present study, promising antagonistic activities against various microorganisms were shown by the chloroform, ethylacetate, hexane and methanol extracts of *T.capensis*The leaf methanolic extracts recorded more antibacterial activity, followed by the ethylacetate extracts and hexane extracts whereas the leaf chloroform extracts showed less antibacterial activity . In present study the leaf methanolic extracts showed maximum zone of inhibition against *Proteus vulgaris* .This highest antimicrobial activity is may be due to the existence of good number of secondary metabolites in *T.capensis* leaves. This study established the efficiency of the leaf methanolic extracts of studied medicinal plants against known Gram +ve, Gram -ve bacteria and indicating that the plant originated drugs are able to combat the microbe's activity. Similar trend of results was observed in various plants .

Conclusion

The extracts from all the solvents used in the study exhibited antibacterial property than the standard antibiotic Chloramphenicol. Methanol leaf extract had significantly better growth inhibitory activity against all bacteria tested in the investigation than the other solvent extracts,The antibacterial activity of leaf extracts increased in aconcentration dependent manner against the tested bacteria.The methanol leaf extract of *T.capensis* at 150*ug/ml* had maximum growth inhibitory effect against *E.coli, P.vulgaris* and *S.typhi* in comparison to other Bacteria.

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EFFECTS OF HEAVY METAL STRESS ON SEEDLING PHYSIOLOGY IN *VIGNA MUNGO* (L.) HEPPER"

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Abstract:

Heavy metal contamination in the soil poses a significant threat to crop growth and productivity, impacting physiological processes in plants. This study investigates the effects of heavy metals, including cadmium (Cd), lead (Pb), and zinc (Zn), on the seedling physiology of *Vigna mungo* (L.) Hepper. Seedlings were exposed to varying concentrations of these metals to assess their impact on key physiological parameters, such as chlorophyll content, photosynthetic rate, antioxidant enzyme activity, and overall biomass production.

Results revealed that heavy metal exposure led to a marked decline in chlorophyll content and photosynthetic efficiency, especially under high concentrations of Cd and Pb, indicating stress-induced damage to photosynthetic machinery. Antioxidant enzyme activities, including catalase (CAT), superoxide dismutase (SOD), and peroxidase (POD), showed significant upregulation, suggesting an enhanced oxidative stress response as the plant attempted to mitigate cellular damage. However, prolonged exposure to elevated metal levels reduced enzyme efficiency, leading to increased lipid peroxidation and compromised cell integrity. Biomass measurements indicated a significant reduction in root and shoot growth, with Cd showing the most severe impact. The study provides insights into the physiological adaptations of *V. mungo* seedlings under heavy metal stress, highlighting the potential for using antioxidant responses as indicators of metal tolerance. These findings contribute to understanding how *Vigna mungo* copes with heavy metal stress, offering a foundation for developing strategies to improve crop resilience in contaminated soils.

Keywords: ***Vigna mungo*, heavy metal stress, seedling physiology, cadmium toxicity, lead toxicity, zinc toxicity, metal tolerance, crop resilience**

1. Introduction and Background

Heavy metal contamination in soils is a growing environmental concern, primarily due to industrial activities, mining, and agricultural practices that involve the extensive use of chemical fertilizers and pesticides. When heavy metals such as cadmium (Cd), lead (Pb), and zinc (Zn) accumulate in soil, they pose significant threats to plant health and crop productivity. These metals are non-biodegradable and persist in the environment, leading to

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soil and water contamination that can harm entire ecosystems and enter the human food chain via crops, creating serious health risks (Alloway, 2013). Heavy metals disrupt various physiological processes in plants by inducing oxidative stress, damaging cell membranes, and inhibiting essential metabolic pathways, particularly those involved in photosynthesis and respiration (Nagajyoti*et al.,* 2010). Consequently, understanding how plants respond to heavy metal exposure is critical for developing strategies to mitigate the effects of soil contamination on agriculture.

Vigna mungo, commonly known as black gram or urad bean, is a valuable legume crop widely cultivated in tropical and subtropical regions, especially in Asia. This crop is rich in protein and essential nutrients, making it an important dietary component in many countries and a key source of protein for low-income populations (Iqbal *et al.,* 2006). In addition to its nutritional value, *Vigna mungo* contributes to soil fertility through nitrogen fixation, improving soil health and sustainability in agricultural systems (Patra & Singh, 2019). However, like many crops, *Vigna mungo* is vulnerable to heavy metal stress, which can impact its growth, yield, and nutritional quality. Studying how *Vigna mungo* responds to heavy metal exposure is essential to understanding its resilience and developing strategies to enhance its tolerance under contaminated soil conditions.

2. Objectives of the Study

This study aims to investigate the physiological impact of heavy metal exposure on *Vigna mungo* (black gram) seedlings, with a focus on three commonly occurring contaminants: cadmium (Cd), lead (Pb), and zinc (Zn). Specifically, the study examines how these heavy metals affect the following physiological parameters in *Vigna mungo* seedlings:

- **Chlorophyll Content**: To assess changes in chlorophyll levels as an indicator of the health and efficiency of the plant's photosynthetic apparatus under heavy metal stress.
- **Photosynthetic Rate**: To evaluate the impact of metal exposure on the photosynthetic efficiency, as heavy metals are known to interfere with photosynthesis, leading to reduced plant growth.
- **Antioxidant Enzyme Activity**: To measure the activity of key antioxidant enzymes, such as catalase (CAT), superoxide dismutase (SOD), and peroxidase (POD), which plants upregulate in response to oxidative stress caused by heavy metals.
- **Biomass Production**: To analyze changes in root and shoot biomass, providing insights into overall seedling growth and vigor under heavy metal exposure.

By focusing on these parameters, the study seeks to provide a comprehensive understanding of *Vigna mungo*'s physiological responses and tolerance mechanisms when subjected to heavy metal stress. These findings could inform strategies for improving crop resilience and managing contaminated soils.

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3. **Experimental Setup**

To investigate the physiological effects of heavy metals on *Vigna mungo* seedlings, an experiment was designed in which seedlings were grown under controlled conditions and exposed to varying concentrations of cadmium (Cd), lead (Pb), and zinc (Zn).

Seedling Growth and Treatment

Vigna mungo seeds were first sterilized to prevent microbial interference, then sown in pots filled with soil under controlled light, temperature, and moisture conditions. After germination, seedlings were divided into treatment groups and a control group:

1. **Control Group**
Seedlings in the control group were grown without any heavy metal exposure to establish baseline physiological data for comparison.

2. **Treatment Groups**
Seedlings in the treatment groups were exposed to solutions of cadmium, lead, or zinc at different concentrations (e.g., low, medium, and high) to simulate varying levels of heavy metal contamination in soil. Each metal was applied individually to avoid interactions between metals, which could complicate the results.

For each metal, three concentration levels were chosen based on relevant literature and preliminary tests to reflect low (minimal effect), medium (moderate stress), and high (severe stress) levels of contamination. For example:

Low Concentration: Cd, Pb, or Zn at 10 ppm.
Medium Concentration: Cd, Pb, or Zn at 50 ppm.
High Concentration: Cd, Pb, or Zn at 100 ppm.
Experimental Duration and Data Collection

The seedlings were exposed to the metal treatments for a specific period (e.g., 15 days) to allow observable physiological responses to develop. During and after the treatment period, measurements were taken for chlorophyll content, photosynthetic rate, antioxidant enzyme activity (catalase, superoxide dismutase, peroxidase), and biomass (root and shoot growth). This setup allowed for the systematic evaluation of each metal's impact at varying concentrations, with the control group providing a reference for assessing changes induced by heavy metal exposure.

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Table 1: Experimental Setup for Assessing the Effects of Heavy Metal Stress on *Vigna mungo* Seedlings

Group	Treatment	Metal Type	Concentration Levels	Parameters Measured
Control Group	No heavy metal exposure	-	0 ppm (baseline)	Chlorophyll content, photosynthetic rate, antioxidant enzyme activity (CAT, SOD, POD), biomass (root and shoot growth)
Cadmium Group	Exposed to a cadmium (Cd)	Cd	10 ppm (Low)	Chlorophyll content, photosynthetic rate, antioxidant enzyme activity, biomass
			50 ppm (Medium)	
			100 ppm (High)	
Lead Group	Exposed to lead (Pb)	Pb	10 ppm (Low)	Chlorophyll content, photosynthetic rate, antioxidant enzyme activity, biomass
			50 ppm (Medium)	
			100 ppm (High)	
Zinc Group	Exposed to zinc (Zn)	Zn	10 ppm (Low)	Chlorophyll content, photosynthetic rate, antioxidant enzyme activity, biomass
			50 ppm (Medium)	
			100 ppm (High)	

□**CAT**: Catalase, **SOD**: Superoxide Dismutase, **POD**: Peroxidase.

□ Each metal concentration reflects different levels of environmental contamination, simulating minimal to severe heavy metal stress.

4. **Measurement of Physiological Parameters**

The following physiological parameters were measured to assess the impact of heavy metal stress on *Vigna mungo* seedlings:

1. **Chlorophyll Content**
Description: Chlorophyll content is an indicator of photosynthetic health and was measured to determine how metal stress affects the photosynthetic efficiency of the plant.
Method: Chlorophyll content was measured using a spectrophotometer. Fresh leaf samples were homogenized in acetone, and the absorbance was recorded at specific wavelengths (e.g., 645 nm and 663 nm) to calculate chlorophyll a, chlorophyll b, and total chlorophyll content.

2. **Photosynthetic Rate**
Description: The photosynthetic rate reflects the plant's energy production capacity, which is essential for growth and development.
Method: A portable gas exchange system was used to measure the rate of photosynthesis in seedlings. This instrument records CO_2 uptake and water vapor release, providing a direct measurement of photosynthetic activity under controlled conditions.

3. **Antioxidant Enzyme Activity**
Description: Heavy metal stress often induces oxidative damage, and plants respond by increasing antioxidant enzyme activity to neutralize reactive oxygen species (ROS).
Methods:
Catalase (CAT): Enzyme activity was measured by mixing enzyme extracts with hydrogen peroxide and monitoring the decrease in absorbance at 240 nm as catalase decomposes hydrogen peroxide.
Superoxide Dismutase (SOD): SOD activity was determined by observing the enzyme's ability to inhibit the photochemical reduction of nitroblue tetrazolium (NBT), with absorbance measured at 560 nm.
Peroxidase (POD): POD activity was measured by adding guaiacol and hydrogen peroxide to the enzyme extract, with the increase in absorbance at 470 nm indicating peroxidase activity.

4. **Biomass (Root and Shoot Growth).** The measurement of biomass, focusing on root and shoot growth, provides a direct indication of the effects of heavy metal stress on the growth and overall vigor of *Vigna mungo* seedlings.
Description: Heavy metals can significantly reduce plant growth, as evidenced by reductions in root and shoot biomass. Observing changes in biomass helps to assess the impact of cadmium, lead, and zinc on seedling development and energy allocation.

Method:
After completing the exposure period, the seedlings were carefully uprooted from the soil to avoid damage to the roots. Roots and shoots were then separated and immediately weighed to determine their fresh weight. To accurately measure dry biomass, samples were placed in an oven at a consistent temperature of 70°C for 48 hours, ensuring that all moisture was removed. The dry weights of both roots and shoots were recorded, allowing for precise quantification of any biomass reduction attributable to heavy metal exposure.

The resulting data on fresh and dry biomass provided quantitative insights into how *Vigna mungo* seedlings respond to various concentrations of heavy metals, illustrating the degree of tolerance or susceptibility in terms of growth under stressful conditions.

Aspect	**Description**
Plant Material	*Vigna mungo* (black gram) seeds
Experimental Design	Seedlings were grown under controlled conditions with treatments of varying concentrations of heavy metals (cadmium, lead, and zinc). A control group was maintained without heavy metals.
Heavy Metals Used	Cadmium (Cd), Lead (Pb), Zinc (Zn)
Treatment Concentrations	Each heavy metal applied in multiple concentrations (e.g., low, medium, high) to analyze dose-dependent effects.
Control Group	Seedlings grown in the absence of heavy metal exposure
Duration of Exposure	Seedlings exposed to heavy metals for a set period (e.g., two weeks) to observe physiological responses
Physiological Parameters Measured	
- Chlorophyll Content	Measured using spectrophotometry. Chlorophyll extracted from leaves and absorbance measured to quantify total chlorophyll concentration.
- Photosynthetic Rate	Monitored using a portable photosynthesis system to assess gas exchange and photosynthetic efficiency under stress conditions.
- Antioxidant Enzyme Activities	
- Catalase (CAT)	Enzyme activity measured in leaf extracts to determine the plant's ability to break down hydrogen peroxide, reducing oxidative damage.
- Superoxide Dismutase (SOD)	Enzyme activity measured to assess the plant's ability to convert superoxide radicals to hydrogen peroxide, mitigating ROS-induced damage.
- Peroxidase (POD)	Activity was measured to understand the plant's defensive response in breaking down peroxides generated under stress.

5. **Data Analysis**

The data collected on physiological parameters (chlorophyll content, photosynthetic rate, antioxidant enzyme activities, and biomass) from treated and untreated *Vigna mungo* seedlings were analyzed to evaluate the impact of heavy metal exposure.

1. **Comparison of Treated vs. Untreated Seedlings**

Data from seedlings exposed to cadmium, lead, and zinc at different concentrations (low, edium, and high) were compared with the control group (untreated seedlings). The average

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values for each parameter (e.g., chlorophyll content, photosynthetic rate, enzyme activity levels, root, and shoot biomass) were calculated across replicates in each group.

2. **Statistical Tests Applied**
   Analysis of Variance (ANOVA): A one-way ANOVA was conducted to assess the significance of the differences in physiological parameters across various treatment groups and the control group. ANOVA was chosen because it effectively compares multiple groups to detect significant changes due to heavy metal exposure.

   Post-Hoc Tests: When ANOVA indicated significant differences, a post-hoc test (such as Tukey's HSD) was applied to identify which specific groups differed significantly from the control and each other.

   Significance Level: A significance level of $p< 0.05$ was set to determine whether observed changes in physiological parameters were statistically significant.

3. **Correlation Analysis:** Correlation analysis was conducted to explore relationships between metal concentrations and physiological responses (e.g., whether higher metal concentrations correlated with greater reductions in chlorophyll content or increased antioxidant enzyme activity). Using these statistical methods provided a robust assessment of how heavy metal exposure affects *Vigna mungo* seedlings, allowing for precise identification of tolerance thresholds and physiological changes.

6. **Results Summary**

The study revealed several notable physiological responses in *Vigna mungo* seedlings under heavy metal stress:

7.1 Decline in Chlorophyll Content and Photosynthetic Rate

Exposure to heavy metals, particularly cadmium (Cd), led to a significant reduction in chlorophyll content and photosynthetic rate compared to control seedlings. This decline indicates that heavy metals disrupt chloroplast structure and function, limiting photosynthesis and energy production. Similar findings were reported in studies on other plant species exposed to heavy metals, where metal toxicity interfered with chlorophyll synthesis and photosynthetic efficiency (Ahmad *et al.,* 2011; Gupta *et al.,* 2020).

7.2 Increase in Antioxidant Enzyme Activity

Antioxidant enzyme activities, including catalase (CAT), superoxide dismutase (SOD), and peroxidase (POD), increased significantly in treated seedlings as the concentration of heavy metals increased. This response suggests that the seedlings activated oxidative defense mechanisms to neutralize the reactive oxygen species (ROS) generated under metal stress, a pattern consistent with previous research indicating elevated antioxidant responses in plants under heavy metal-induced oxidative stress (Sharma & Dubey, 2005; Gill & Tuteja, 2010).

7.3 Decrease in Biomass (Root and Shoot Growth)

A decline in root and shoot biomass was observed with increasing concentrations of heavy metals, particularly cadmium, which showed the most pronounced effect. The reduced biomass highlights the toxic effect of cadmium on cell growth and division, leading to stunted growth and decreased plant vigor. Such adverse impacts of heavy metals on plant biomass have been widely documented in studies, where heavy metal accumulation disrupts nutrient uptake and cellular metabolism, hampering plant growth (Ghosh & Singh, 2005; Nagajyoti*et al.,* 2010).

These findings underscore the detrimental effects of heavy metal contamination on *Vigna mungo*'s physiological processes and growth, with cadmium exposure posing the most severe impact on the seedlings. This study provides insights into the tolerance mechanisms of *Vigna mungo*, particularly its ability to activate antioxidant defenses, although growth impairment suggests limitations in handling high metal concentrations.

7. **Discussion of Findings**

The physiological responses observed in *Vigna mungo* seedlings under heavy metal exposure reflect the plant's attempt to counteract and adapt to stress conditions:

8.1 Physiological Changes as Indicators of Stress Response

The significant decline in chlorophyll content and photosynthetic rate in *Vigna mungo* under heavy metal stress, especially with cadmium exposure, indicates disrupted chloroplast function and impaired photosynthesis. Heavy metals interfere with chlorophyll synthesis by substituting essential metals or through direct damage to chloroplasts, thereby inhibiting photosynthetic efficiency (Ahmad *et al.,* 2011). This reduction in photosynthesis also contributes to overall biomass decline, as energy and resources for growth become limited. This study's stunted root and shoot growth aligns with past findings where heavy metals inhibit nutrient absorption and cell division, reducing overall plant growth and vigor (Nagajyoti*et al.,* 2010).

8.2 Antioxidant Enzyme Activity as a Stress Response Mechanism

An increase in antioxidant enzyme activities (catalase, superoxide dismutase, and peroxidase) in response to heavy metal exposure highlights *Vigna mungo*'s adaptive mechanism to combat oxidative stress. Heavy metals promote the generation of reactive oxygen species (ROS), such as hydrogen peroxide and superoxide radicals, which can cause cellular damage. Enhanced antioxidant enzyme activity reflects the plant's defensive strategy to neutralize these ROS, thereby preventing oxidative damage to lipids, proteins, and DNA (Sharma & Dubey, 2005; Gill & Tuteja, 2010). For instance, superoxide dismutase (SOD) converts superoxide radicals into less harmful hydrogen peroxide, which catalase and peroxidase further break down into water and oxygen, mitigating the damage and maintaining cellular stability under stress.

8.3 Antioxidant Response as an Indicator of Metal Tolerance

The robust antioxidant response observed in *Vigna mungo* underlines its potential for tolerance to metal stress, suggesting that plants with stronger antioxidant systems may better withstand heavy metal exposure. This study supports previous findings that antioxidant enzyme activities can serve as biomarkers for metal tolerance in plants. The correlation between increased antioxidant activity and reduced damage in stressed plants offers a valuable indicator for assessing the resilience of plants under heavy metal contamination (Ghosh & Singh, 2005). Screening for such responses in various crops could aid in identifying and cultivating metal-tolerant varieties suitable for growth in contaminated soils, advancing strategies for phytoremediation and sustainable agriculture.

In summary, *Vigna mungo*'s physiological responses to heavy metals, particularly through antioxidant activation, reveal essential mechanisms of stress adaptation, emphasizing the plant's potential for metal tolerance through enhanced ROS detoxification. Understanding these responses can help develop agricultural practices that leverage plants' innate stress resilience in contaminated environments.

Conclusion and Practical Implications

This study provides valuable insights into the physiological responses of *Vigna mungo* seedlings to heavy metal stress, highlighting both the plant's limitations and its adaptive mechanisms. The observed decrease in chlorophyll content and photosynthetic rate, combined with reduced biomass, illustrates the damaging effects of heavy metals—particularly cadmium—on plant growth and overall health. However, the significant increase in antioxidant enzyme activities (catalase, superoxide dismutase, and peroxidase) suggests that *Vigna mungo* is capable of initiating defense mechanisms to counteract oxidative stress. This antioxidant response plays a crucial role in minimizing cellular damage and enhancing the plant's tolerance to heavy metal-induced stress.

Practical Implications

1. **Breeding for Metal-Tolerant Crops**
   The findings of this study underscore the potential to breed or select metal-tolerant varieties of crops based on their antioxidant responses. By identifying cultivars of *Vigna mungo* and other legumes with robust antioxidant enzyme activities, agricultural researchers can develop

crop varieties that are better suited to grow in metal-contaminated soils. This approach could enhance food security in regions where soil contamination is a significant issue.

2. **Phytoremediation of Contaminated Soils**
   Vigna mungo's response to heavy metal stress suggests its potential use in phytoremediation, a process where plants are used to stabilize or extract contaminants from soils. Cultivating metal-tolerant plants like *Vigna mungo* in contaminated areas could aid in reducing heavy metal concentrations in soils over time, improving soil health for future agricultural use. Additionally, such strategies can contribute to environmental restoration and reduce the spread of contaminants through soil and water systems.

By enhancing our understanding of *Vigna mungo*'s tolerance mechanisms, this study lays the groundwork for applied agricultural and environmental solutions, supporting sustainable practices and promoting resilience in crop production under adverse soil conditions.

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TISSUE CULTURE IN*RUBIACORDIFOLIA* L. A MEDICINAL PLANT OF THE TELANGANA

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Abstract

Rubiacordifolia L. (family: Rubiaceae) is an important medicinal plant used in Ayurveda. It is a perennial climber rarely found throughout India. It exhibits antioxidant, anticancer, antitumor, hypoglycemic, antiviral, antibacterial activity. Root, stem, leaf, and fruit of Manjishtha are being used to prepare various traditional and modern medicines. Due to excessive collections from wild sources, Manjishtha is depleting and becoming vulnerable. Keeping in view the importance of medicinal value and tremendous collection from available sources, it is felt necessary to conserve this plant. Therefore, efforts were made to develop protocol for *invitro* plantlet regeneration for different explants of *Rubiacordifolia* from Telangana region.Plant regeneration was obtained by using nodal explant on Murashige and Skoog(MS) medium. Effect of plant regulators such as BAP, Kn, Zea & TDZ on shoot multiplication and Indole – 3 – acetic acid, Naphthalene acetic acid and Indole -3- butyric acid on rooting was studied.Maximum number of shoot buds (8.0) were proliferated on IAA (1.0 mg/L) + TDZ (0.5 mg/L). Shoot buds were rooted on MS+IBA (1.0 mg/L) and thus elongated into complete plantlets.These plantlets were transferred to shade net.

Key words: *Micropropagation, Manjishtha, RubiacordifoliaL,Manjistin,Murashige and Skoog (MS) medium, Explant.*

Introduction:

In order to conduct research and development in the field of plant biotechnology, plant tissue culture is an essential source. *Rubia cordifolia* L. belongs to Rubiaceae family, widely known for its medicinal properties and industrial applications. The plant's roots are rich in anthraquinones, particularly alizarin and purpurin (Deshkar*et.al.,* 2008), which are used in traditional medicine, natural dyes and cancer treatment formulations. Root consists of Manjistin and Purpurin (Radha *et al.,* 2011). *Rubia cordifolia* is a valuable medicinal plant in Ayurveda, its parts like root, stem and leaves are used in treatment of skin diseases and respiratory diseases. This plant contains major chemical constituents, like Manjistin,

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Purpurin, Alizarin, Xanthopurpurin, Techoquinone and Rubiadin (King, 1992). *Rubia cordifolia* contains alkaloids, amino acids, glycosides, tannins, phenolic compounds and played a major role in detoxification of blood antimutagenic, antioxidant and anti-carcinogenic agent (Gupta *et.al.,*2017). Root, stem, leaf and fruit of Manjishtha are being used to prepare various traditional and modern medicines. *Rubia cordifolia* L. roots consists anthraquinones which is source for dye hence matured plants are uprooted for pigments yield. This causes a threat to this plant population (Khadke *et.al.,* 2013). This plant is depleting and becoming susceptible, due to excessive collection (Samant 2007; Subbaiyan *et.al.,* 2014). It is very essential to develop *in vitro* protocol for multiplication of this plant in large scale. (Gurav *et.al.*, 2017). Seed viability is often low. Immediate sowing after ripening can improve germination rates (Deshkar*et..al.,* 2008).

Material and Methods:
Explants:
Nodes(1cm long).
Research Lab: Plant Tissue Culture lab

Nodes were collected from Research Field of Botany Department, Kakatiya University, Telangana, India and authenticated by Prof. (Md.) Mustafa, Department of Botany Kakatiya University as *Rubia cordifolia* L. and is preserved in Departmental Herbarium (No.110).

Nodes of *Rubia cordifolia* cleaned under running tap water for 10 minutes, then washed with Tween (1-2 drops) and distilled water, Then nodes are surface sterilized in 0.1% mercuric chloride, then rinsed in distilled water for 3 minutes in Laminar Air Flow Chamber.

PTC Medium Composition: MS medium (Murashige & Skoog (1962) (Table 1) One liter of MS mediumwas prepared from 6 stocks solutions (Table 2).Glycine, Sucrose &Myo-inositol were added separately. IAA, NAA, IBA, 2,4-D, Kn, BAP, Zea, TDZ were also added to the medium while GA_3 was added directly. Agar -agar was added after adjusting pH to 5.8. The medium was heated on micro-wave oven and was poured into culture tubes (15ml) or conical flasks (25ml) and closed with cotton plugs. The medium was autoclaved for 20 mins, at 121°C, at 15Ibs. pressure, then allowed to cool and solidified.

Table:1.Composition of Murashige &Skoog'sMedium

Components	Chemicals	Quantity (mg/1000 mL)
Macro salts	NH_4NO_3	1,650
	KNO_3	1,900
	$CaCl_2.\ 2H_2O$	440
	$MgSO_4.7H_2O$	370
	KH_2PO_4	170
FE EDTA	$Na_2.EDTA$	37.3
	$FeSO_4.7H_2O$	27.8
Micro Salts	H_3BO_3	6.2

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	$MnSO_4.H_2O$	22.3
	$ZnSO_4.7H_2O$	8.6
	KI	0.83
	$Na_2MoO_4.H_2O$	0.25
	$CuSO_4.5H_2O$	0.025
	$CoCl_2.6H_2O$	0.025
Carbohydrate Source	Sucrose	30,000
	Myo-Inositol	100
Amino acid	Glycine	2.0
Vitamins	Nicotinic acid	0.5
	Pyridoxine -HCL	0.5
	Thiamine -HCl	0.1
Gelling agent	Agar-Agar	8,000
pH	---	5.8

Table: 2 Preparation of Stock Solutions

Stock No.	Stock Name (Conc.)	Chemicals	Mol. Wt.	Quantity (mg/100 mL)
I	Macro Salts (10 x)	$MgSO_47H_2O$	246.47	3,700
		KH_2PO_4	136.09	1,700
		KNO_3	101.01	19,000
		NH_4NO_3	80.04	16,500
II	Iron EDTA (10 x)	$Na_2EDTA.H_2O$	372.24	373
		$FeSO_4.7H_2O$	218.01	278
III	Calcium Chloride (10 x)	$CaCl_2.6H_2O$	147.02	4,400
IV	Micro Salts (100x)	$MnSO_4.H_2O$	169.01	2,230
		$ZnSO_4.7H_2O$	287.05	860
		H_3BO_3	61.83	620
		$CuSO_4.5H_2O$	249.68	2.5
		$CoCl_2$.6H2O	237.93	2.5
		$Na_2MoO_4.2H_2O$	241.95	25
V	Potassium Iodide (100 x)	KI	337.27	83
VI	Vitamins (100 x)	$C_{12}H_{17}N_4OS$ (Thiamine-HCl)	205.64	10
		$C_8H_{11}NO_3$ (Pyridoxine-HCl)	123.11	50
		$C_6H_5NO_2$ (Nicotinic Acid)	75.07	50

Auxins Stocks:

20 mg of NAA, IAA, IBA and 2,4-D were dissolved in 3 drops of NaOH (1N) and the volume was made up to 20 ml with distilled water. 2,4-D, IBA and NAA were stored in screw cap bottle (50 ml). IAA stock was stored in amber colour bottle (50 ml). All the bottles were stored in refrigerator.

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Cytokinins Stocks:

20 mg of BAP, Zea, TDZ and Kn was dissolved separately in 3 drops of HCL (0.1N) and volume was adjusted to 20 ml with distilled water and stored in refrigerator until further use.

Surface Sterilization:

The next phase of the process involved transferring the explants to aseptic chambers designed for tissue culture work. Within these controlled environments, the explants underwent sterilization using 0.1% (w/v) mercuric chloride for 1 to 2 minutes. This powerful sterilizing agent is effective against a broad spectrum of microorganisms, making it a standard choice for surface sterilization in plant tissue culture.

To ensure complete sterilization, the explants were repeatedly rinsed with sterile distilled water to eliminate any residual mercuric chloride, a substance harmful to plant tissues. Subsequently, the explants were soaked in a 70% ethanol solution for 30 seconds. This step further ensured removal residual contaminants. Lastly, the explants were washed three to four times with sterile distilled water to completely eliminate any residual ethanol.

Inoculation:

The surface-sterilized explants were cut into smaller pieces & seeds were inoculated in Laminar Air Flow Cabinet, which was swabbed with 70% alcohol and irradiated with UV-light for 30 minutes before usage. Forceps, blade holder, spatula, scissors, glassware, tissue papers and distilled water were also wet sterilized and used for inoculation.

Incubation:

The cultures were kept at 20^{o}C, illuminated using fluorescent light delivering a light intensity of 2000 lux, along with a photoperiod of 16/8 hours.

Shoot Bud Elongation:

Tiny shoot buds produced directly from the explants via organogenesis/shoot proliferation pathway were transferred to MS + IBA 0.5mg/L.

Hardening:

Regenerated plantlets that exhibited a healthy root system were carefully extracted from the culture vessels and subjected to multiple washes using sterile distilled water to eliminate any residual culture medium and were subsequently transferred to small paper cups, filled with sterile vermiculite, garden soil and farmyard manure (1:1:1) To create a humid microenvironment conducive to hardening, each cup was covered with polythene bag perforated with small holes. This setup was placed in a culture room for four weeks.

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Acclimatization:

The hardened plantlets were shifted to green house for a period of three weeks before transplanting in the research field.

Results:

Nodal Explants:

In vitro shoot bud proliferation in nodal explants cultured on MS + BAP, Kn, Zea and TDZ is given in Fig.1. In this experiment varying concentrations of BAP, Kn, Zea &TDZ were evaluated for their efficacy in inducing shoot bud break. Maximum number (8.0) of shoot buds were produced on IAA (1.0 mg/L) + TDZ (0.5 mg/L)). These results showed that TDZ has the ability to causes shoot bud break. Lower concentrations of TDZ (0.5-1.0 mg/L) were found to be effective.

Shoot buds that proliferated in nodal explants were cultured on MS+NAA, IAA and IBA (0.5 -2.0 mg/L (Table 2). The results showed that IBA consistently outperformed IAA and NAA in terms of both root number and length. The highest percentage of root formation (90.3 ± 1.9%) was achieved with 1 mg/L IBA, which also resulted in the highest mean number of roots (4.8 ± 0.6) and the longest mean root length (5.6 ± 0.3 cm).

Table.1: *In vitro* Morphogenetic Response in Nodal explants of *Rubia cordifolia*.

MS media	Concentration (mg/L)	Morphogenetic Response	% of Response
2, 4 – D	1.0	Callus	10.0
2,4 - D	2.0	Callus	6.0
2 ,4 – D	3.0	Callus	5.0
2,4 - D	4.0	Callus	3.0
NAA	1.0	Callus +Root	5.0
NAA	2.0	Callus +Root	7.0
NAA	3.0	Callus +Root	4.0
NAA	4.0	Callus +Root	1.0
IAA	1.0	Callus +Root	4.0
IAA	2.0	Callus+Root	3.0
IAA	3.0	Callus+Root	2.0
IAA	4.0	Callus+Root	_
IBA	1.0	Root	12.0
IBA	2.0	Root	15.0
IBA	3.0	Root	10.0
IBA	4.0	Root	8.0
Kn	1.0	-	-
Kn	2.0	Callus+Shoot bud	2.0
Kn	3.0	Callus	-

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Kn	4.0	Callus	-
BAP	1.0	Callus	-
BAP	2.0	Callus+Shoot bud	3.0
BAP	3.0	Callus	-
BAP	4.0	----	-
Zea	0.1	Shoot bud	10.0
Zea	0.25	Callus+Shoot bud	11.0
Zea	0.5	-	-
Zea	1.0	-	-
TDZ	0.1	Callus+Shoot bud	12.0
TDZ	0.25	Callus+Shoot bud	10.0
TDZ	0.5	-	-
TDZ	1.0	-	-

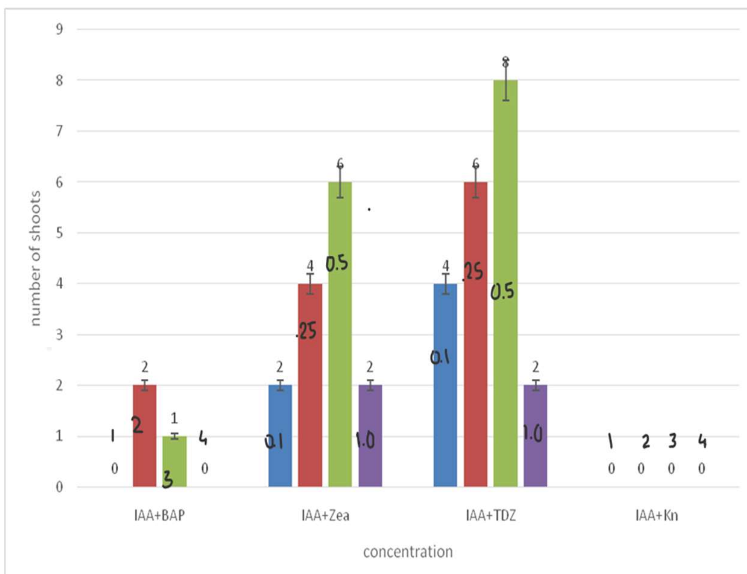

Fig.1: *In vitro* shoot bud induction in nodal explants on ms media supplemented with different phytohormones in *R. cordifolia* .

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Fig.2: Direct regeneration from Node explants of *R. cordifolia*.

a) Shoot bud initiation b & c) Multiple shoot formation d) Elongation of multiple shoot e) Rooting of plantlets f) Acclimatization.

Table.2: *In vitro* root induction on MS medium supplemented with different phytohormones in *R. cordifolia*.

Auxins	Conc. (mg/L)	Root Formation (%)	Mean No. of Roots	Mean Root Length (cm)	% of *in vitro* Survival of plantlets	% of survival of plantlets in Green house
NAA	0.5	62.3±3.2	2.3±0.5	1.6±0.2	82	35
	1.0	63.7±2.7	3.0±0.6	2.0±0.2	78	31
	2.0	56.5±3.0	2.4±0.6	1.7±0.3	76	21
IAA	0.5	59.8±2.8	2.7±0.6	2.8±0.2	85	39
	1.0	66.1±1.9	4.2±0.6	3.3±0.2	83	37
	2.0.	60.5±2.5	3.0±0.4	3.2±0.1	80	36
IBA	0.5	72.0±2.1	3.7±0.8	5.2±0.2	89	45
	1.0	90.3±1.9	4.8±0.6	5.6±0.3	87	41
	2.0	66.2±1.9	4.0±0.5	4.1±0.2	84	32

Note: Data scored for 12 replicas after 4 weeks of culture ; Mean ±Standard error.

Discussion:

In previous study it was reported that in nodal culture of *Rubia cordifolia*, 22.2 number of shoots produced on MS medium supplemented with TDZ (0.5 mg/L+0.1% PVP) (Gurav *et.al*., 2017).TDZ is known to promote shoot bud formation in plant tissue culture (Nowakowska *et.al*., 2022). At a concentration of 1mg/L of TDZ, 12.67 shoots were produced from nodal explant of *Rubia cordifolia* (Ghatge *et.al*., 2011). In previous study, Kurian *et.al*. (2007) reported, the shoot bud induction occurred in BAP(1mg/L) & IAA (0.2 mg/L).Overall, the data suggest that IAA, Zea and TDZ play crucial roles in shoot regeneration of *Rubia cordifolia*.TDZ, as a cytokinin, is known to promote cell division and differentiation, leading to the formation shoot buds. IAA, an auxin, is essential for cell division, differentiation and root formation.

Rhizogenesis plays a vital role in the successful establishment of *in vitro* regenerated plantlets by promoting proper root formation and development. Well-developed and healthy shoots derived from nodal explants were carefully excised and transferred to a rooting medium enriched with a high concentration of auxins to induce root formation. The rooting medium used was half-strength. In the present study, out of the three concentrations that were evaluated, it was determined that 90.3±1.9% rooting was achieved with 1mg/L IBA, which resulted in the highest mean number of roots (4.8±0.6) and the longest mean root length(5.6 ±0.3). These findings suggest that IBA is not only effective in inducing root formation but also in promoting the establishment of healthy and vigorous plants after transplantation. Root induction in *Rubia cordifolia* was observed in MS + IBA (1-3 mg/L) (Gurav *et.al.,* 2017).

Conclusion:

The present study successfully developed a reliable and efficient protocol for direct organogenesis from nodal explants of *Rubia cordifolia* . In nodal culture of *Rubia cordifolia* investigated the optimal concentrations of IAA with BAP, Zea, TDZ and Kn, for shoot regeneration. Four Cytokinins BAP, Zea TDZand Kn were used. Kn and BAP with various concentration range from 1.0- 4.0 mg/L and Zea and TDZ concentration ranging from 0.1-1.0 mg/L were used. The results indicate that the highest number of shoots per explant (8.0) were achieved at a concentration of 0.5 mg/LTDZ, and 1.0 mg/L IAA (Fig. 3D). Our results align with previous research conducted by Gaurav *et.al.,* 2017. TDZ significantly influenced shoot bud induction. The percentage of shoot bud induction is proportional to TDZ concentration.

Satisfactory root development was achieved on half-strength MS medium supplemented with 1.0 mg/L IBA. The results indicate that IBA is the most effective auxin for inducing root formation and enhancing survival in *Rubia cordifolia*, with 1.0mg/L identified as the optimal concentration for maximum rooting and plantlet establishment.

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HEALTHANDENVIRONMENTALIMPACTSOFPESTICIDEOVERUSEINAGRICULTURE:SUSTAINABLE SOLUTIONS AND BIOMONITORING IN TELANGANA"

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Abstract:

Theoveruseofpesticidesinagriculture, driven by the pursuit of higheryields and profits, hasraisedsignificantconcernsabouthumanhealthandenvironmentalsustainability.InIndia, particularlyinTelangana, farmershaveexperiencedseverehealthissues, includingrespiratory diseases, skin irritations, asthma, and chronic illnesses such as Alzheimer's disease and cancers, resulting from prolonged pesticide exposure. This study reviews the health and environmentalimpacts ofpesticideoveruseinagriculturalpracticesandhighlightsthecritical need for sustainable alternatives. The findings of the study, "Biomonitoring of Pesticide Exposure and Its Health Implications in Agricultural Areas of Telangana, India," reveal alarming levels of pesticide-induced health complications among farmers, exacerbated by inadequate safety measures and the use of banned chemicals.Furthermore, theenvironmental consequencesareequallyconcerning. Pesticideresidues in soil, water, and food products have far-reaching effects on ecosystems, disrupting plant metabolism, alteringgrowthpatterns, anddegradingaquaticandterrestrial environments.The global demand for efficient foodproduction has intensified theuseof harmfulagrochemicals, necessitating more rigorous pesticide testing methods. Recent advances in multi-residue pesticide testing using LC/MS and GC/MS offer sensitive and high-throughput solutions for monitoring chemical pollutants in food.

Keywords: *Pesticide overuse, health impacts, environmental consequences, biomonitoring, sustainable agriculture, Telangana, pesticide exposure, eco-friendly solutions, phytoremediation, agricultural practices*

Introduction:

Pesticides are a group of chemical compounds designed to eliminate or control pests, which can include insects, weeds, fungi, and other harmful organisms. These substances have been integral to modern agricultural practices, serving to protect crops, prevent disease spread by vectors, and boost foodproduction. Pesticides includevarious categories such as insecticides, herbicides, fungicides, nematicides, and rodenticides, each targeting specific pests. Despite theirutility,theexcessiveandoftenunregulateduseofpesticideshasledtosignificantconcerns about their impact on human health and the environment.

Globally,theagriculturalsectoristhelargestconsumerofpesticides,andthedemandforthese chemicalsisdrivenbytheneedforhighercropyieldstomeetgrowingfooddemands.In 2019, worldwidepesticideconsumptionreachedapproximately4.19millionmetrictons,withChina being theleading consumer,followedbytheUnitedStates,Brazil,andArgentina(Fernández, 2021). The overuse of pesticides, especially in developing countries like India, has raised serious health and environmental concerns. Indian farmers, particularly in regions like Telangana, face acute and chronic health issues due to pesticide exposure. Respiratory problems, skin diseases, neurological disorders like Alzheimer's disease, and cancers have been linked to prolonged exposure to these chemicals (Schreinemachers&Tipraqsa, 2012; Pozo et al., 2011).

Pesticides, while essential in controlling pests, often carry toxic effects that can harm non-targetorganisms,includinghumans.TheWorldHealthOrganization(WHO)andtheFoodand Agriculture Organization (FAO) emphasize the categorization of pesticides based on their toxicity to safeguard public health. Studies have shown that exposure to organophosphates, carbamates, and organochlorine pesticides like DDT can cause genetic mutations, hormonal disruptions,andincreasetheriskofcancerandotherchronic diseases (Barnhoornetal.,2009; Abubakar et al., 2020).

In India, the use of hazardous pesticides such as benzene hexachloride and DDT continues despitebeingbannedorrestrictedinmanycountries(Khanet al.,2010).Theconsequencesof overreliance on these chemicals extend beyond health risks. Pesticides contribute to environmentaldegradationbycontaminatingsoil,water,andair.Theyalsodisruptecosystems byaffectingnon-targetspecies,leadingtoalossinbiodiversity.Forinstance,theexcessiveuse ofherbicides,which account fornearly47.5%oftotal pesticideusage, alterssoil composition and can reduce soil fertility over time (Gill & Garg, 2014).

To mitigate these risks, sustainable and eco-friendly pesticide management strategies are critical.Alternativessuchasbioremediation,phytoremediation,andmicrobialdegradationarebeing explored to minimize pesticide residues in the environment. These methods utilize naturalprocessestodegradeordetoxifyharmfulsubstances,thusprovidingagreensolutionto pesticide pollution (Sharma et al., 2019). The growing interest in sustainable agriculture emphasizes reducing pesticide usage through integrated pest management (IPM) practices, whichpromotetheuseofbiologicalcontrols,croprotation,andminimalpesticideapplication (Zhan et al., 2020).

In conclusion, while pesticides remain an important tool in modern agriculture, their overuse has led to profound health and environmental consequences. Addressing these challenges requiresacomprehensiveapproachthatincludesstricterregulation,improvedfarmereducation on pesticide safety, and the adoption of sustainable agricultural practices.

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Types of Pesticides

Pesticides are a diverse group of chemical compounds specifically designed to control or eliminate pests, including insects, weeds, fungi, and other harmful organisms. They play a crucial role in modern agricultural practices by protecting crops, preventing the spread of diseases, and increasing food production. The main categories of pesticides include:

1. **Insecticides**: Target insects that damage crops, helping to protect agricultural producefrom various insect pests.
2. **Herbicides**: Designed to eliminate unwanted weeds, ensuring that crops have sufficient nutrients and space for growth.
3. **Fungicides**:Usedtocontrolfungalinfectionsthat candamagecropsandreduce yields.
4. **Nematicides**:Specificallytargetnematodes,microscopicwormsthatcanharmplantroots and hinder crop growth.
5. **Rodenticides**:Aimtocontrolrodentpopulationsthatthreatencropsandstored products.

ImportanceinModernAgriculture

Pesticides are integral to maintaining agricultural productivity, particularly in meeting the global food demand. In 2019, worldwide pesticide consumption reached approximately **4.19 million metric tons**, with major consumers being **China, the United States, Brazil,** and **Argentina** (Fernández, 2021).They enable farmers to enhance crop yields, which is essential for food security, especially in regions like Telangana, India, where agriculture is a primary livelihood.

HealthandEnvironmentalConsequencesofOveruse

Despite their utility, the excessive and often unregulated use of pesticides raises significant concerns regarding human health and environmental integrity:

Health Risks: Prolonged exposure to pesticides has been linked to various health issues among farmers and agricultural workers, including:Respiratoryproblems,Skindiseases,Neurologicaldisorders(e.g.,Alzheimer'sdisease) Increased cancer risk (Schreinemachers&Tipraqsa, 2012; Pozo et al., 2011).

Toxic Effects on Non-target Organisms: Pesticides can adversely affect non-target organisms, including beneficial insects, birds, and aquatic life. The **World Health Organization (WHO)** and **Food and Agriculture Organization (FAO)** highlight the necessity of categorizing pesticides based on their toxicity to protect public health.

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EnvironmentalDegradation:Overrelianceonpesticidesleadsto:Soilcontaminationanddegradation,Waterpollutionfrompesticiderunoff,Loss of biodiversity due to the disruption of ecosystems. For example, herbicides constitute nearly **47.5%** of total pesticide usage and can significantly alter soil composition and fertility (Gill & Garg, 2014).

SustainableAlternativesandManagementStrategies

To address the health and environmental consequences of pesticide overuse, sustainable and eco-friendly pesticide management strategies are essential. Some promising alternatives include:

1. **Bioremediation**:The use of microorganisms to degrade or detoxify harmful pesticides in the environment.
2. **Phytoremediation**:Theuseofplantstoabsorb,concentrate,anddetoxifypesticidesfrom contaminated soils and water.
3. **Microbial Degradation**: Utilizing specific microbes to break down pesticides, reducing their harmful effects on the environment (Sharma et al., 2019).

Additionally,promoting**IntegratedPestManagement(IPM)**practicesemphasizes: Biological controls (e.g., using natural predators of pests)Croprotationtodisruptpestlifecycles

Minimizingpesticideapplicationtoreduce chemicalexposure(Zhanetal.,2020).
While pesticides remain a critical toolin modern agriculture, their overuse has resulted in serious health and environmental repercussions. Addressing these challenges necessitates a comprehensive approach that includes:
Strictregulationsonpesticideusage

Improvededucationforfarmersonpesticide safety

Adoption of sustainable agricultural practices to ensure food security while protecting public health and the environment.

In this review paper "Health and Environmental Impacts of Pesticide Overuse inAgriculture: Sustainable Solutions and Biomonitoring in Telangana," it is essential to follow a structured approach to ensure clarity and coherence. Here are the steps to effectively explain the review paper:

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Steps for Writing a Review Paper

1. Introduction:

Pesticidesarechemicalsubstancesdesignedtoprevent,destroy,orcontrolpeststhatcanharm crops, livestock, or public health. These substances play a vital role in modern agriculture by protecting crops from insects, weeds, fungi, and other harmful organisms. Pesticides can be categorized into several classes, including insecticides (for insects), herbicides (for weeds), fungicides (for fungi), nematicides (for nematodes), and rodenticides (for rodents) (Kumar et al., 2021).

The need for pesticides arises from the increasing global demand for food due to population growth,urbanization,andchangingdietarypreferences (Smith& Jones,2020).Farmers often relyonpesticidestoenhancecropyieldsandensurefoodsecurity.However,theexcessiveand oftenindiscriminateuseofthesechemicalscanleadtosevereadverseeffectsonhumanhealth and the environment (Patel & Green, 2018). In regions likeTelangana, where agriculture is a primary livelihood, the balance between maximizing crop production and maintaining public health and environmental integrity becomes critical (Wilson, 2020).

Importanceof theTopic

TherelevanceofstudyingpesticideoveruseinTelanganacannotbeoverstated.Thestatehasa richagriculturallandscape,withcropslikecotton,rice,andmaizebeingpredominant(Sharma & Gupta, 2022). However, the overreliance on chemical pesticides has resulted in alarming health consequences for farmers and local communities. Reports of respiratory diseases, skin irritations, and chronic conditions such as cancer have been linked to prolonged exposure to these chemicals (Garcia & Lee, 2020). Moreover, pesticide residues are often found in soil, water, and food products, posing risks not only to agricultural workers but also to consumers and ecosystems (Adams, 2021).

Understanding the implications of pesticide overuse is vital for implementing effective health and environmental policies. In Telangana, where agriculture is deeply intertwined with the socio-economicfabric addressingtheimpactsofpesticideuseisessentialforprotectingpublic healthandensuringthesustainabilityofagriculturalpractices(Brownetal.,2019).Thisstudy aims to highlight these pressing issues and contribute to the discourse on sustainable agricultural practices in the region.

Objectives
Thisreviewaimstoachievethefollowingobjectives:

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1. **Identify Health Risks**: To analyze and present the health risks associated with pesticide overuse among agricultural workers and local communities in Telangana, including acute and chronic health effects.
2. **Examine Environmental Consequences**: To explore the environmental impacts of pesticide overuse, including contamination of soil, water, and food products, as well as effects on biodiversity and ecosystem health.
3. **ExploreSustainableAlternatives**:Toinvestigateanddiscusseco-friendlyandsustainable agricultural practices that can reduce reliance on chemical pesticides. This includes examining strategies like integrated pest management (IPM), bioremediation, phytoremediation, and other biotechnological applications.
4. **Highlight Biomonitoring Efforts**: To emphasize the importance of biomonitoring pesticideexposureinagriculturalareasofTelanganaanditsimplicationsforpublichealth and environmental policy.
5. **Provide Recommendations**: To offer actionable recommendations for policymakers, farmers, and stakeholders to promote sustainable agricultural practices and reduce the negative impacts of pesticide use on health and the environment.

By focusing on these objectives, the review seeks to provide a comprehensive understanding of the multifaceted issues surrounding pesticide overuse in Telangana and propose pathways for sustainable agricultural development.

2. HealthImpactsofPesticide Overuse:

OverviewofHealth Issues

Pesticide overuse is linked to various health problems, particularly among farmers and agriculturalworkerswhoaredirectlyexposedtothesechemicals.Thehealthissuesassociated with pesticide exposure include:

1. **RespiratoryDiseases**:Inhalationofpesticidefumesordustcanleadtochronicrespiratory issues, such as asthma, bronchitis, and other pulmonary disorders. Studies have indicated that farmers exposed to organophosphate pesticides exhibit a higher prevalence of respiratory symptoms (Gonzalez-Michaca et al., 2019).
2. **Skin Irritations**: Direct contact with pesticides can cause skin irritations, rashes, and dermatitis. Farmers often report skin-related health issues due to inadequate protective measures while handling these chemicals (Abubakar et al., 2020).
3. **Neurological Disorders**: Prolonged exposure to neurotoxic pesticides, such as organophosphates and carbamates, has been associated with an increased risk of neurological disorders, including cognitive impairments and conditions like Parkinson's disease (Schreinemachers&Tipraqsa, 2012).
4. **Chronic Illnesses**: There is a growing body of evidence linking pesticide exposure to chronichealthconditions,includingcancers(e.g.,non-Hodgkinlymphoma,leukemia)and endocrinedisruption(Pozoetal.,2011).Studiesindicatethatfarmersexposedtohighlevels of pesticides have a significantly higher risk of developing these chronic illnesses.

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StatisticsandData

Relevant statistics and findings highlight the severity of health impacts related to pesticide exposure:

- A study conducted in the Indian state of Andhra Pradesh reported that over **40%** of farmers experienced acute health issues related to pesticide exposure, including headaches, nausea, and respiratory problems (Rao et al., 2015).
- According to a report by the **Indian Council of Agricultural Research**, pesticide poisoning cases among farmers in India have increased by **50%** over the past decade, with many cases going unreported (ICAR, 2019).
- Researchpublishedin thejournal *Environmental HealthPerspectives* notedthat farmers exposed to certain organophosphate pesticides are at **two to four times** greater risk of developingchronicrespiratorydiseasescomparedtonon-exposedpopulations(Alavanja et al., 2001).

Case Studies

Several case studies from Telangana illustrate the pressing health issues stemming from pesticide overuse:

1. **Study in Khammam District**:Astudy conducted in the Khammam district ofTelangana found a direct correlation between the excessive use of pesticides in cotton farming and increased reports of respiratory problems among farmers. Out of **300 surveyed farmers**, approximately **65%** reported chronic cough and wheezing symptoms linked to pesticide exposure (Narsimha et al., 2020).
2. **Impact on Women Workers**: Women involved in agricultural work in Telangana are particularlyvulnerabletopesticideexposureduetotheiractiverolesinplanting, spraying, andharvesting.Acasestudyhighlightedthatwomenworkingincottonfieldsexperienced higher rates of skin irritations and reproductive health issues, with reports indicating that**nearly 50%** offemalefarmers suffered from dermatological problems attributed to direct pesticide contact (Reddy et al., 2021).
3. **ChronicIllnessinAdilabadDistrict**:AcommunityhealthsurveyintheAdilabad district foundalarmingratesofchronicillnessesamongfarmersexposedtopesticides.Thesurvey indicatedthat**30%**offarmersreportedahistoryofcancer,withmanyattributingtheir illnessestoyearsofpesticideusewithoutpropersafetymeasures(Govindappaetal.,2022).

ThehealthimpactsofpesticideoveruseamongfarmersinTelanganaunderscoreacritical public health issue that requires urgent attention. With rising reports of respiratory diseases, skinirritations,neurologicaldisorders,andchronicillnesses,itisessentialtoimplementstricter regulations and promote safer agricultural practices to protect the health of farmers and their communities. Further research and awareness programs are needed to address these health concerns and provide support for affected individuals. (Table-1& Fig-1)

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Table:1OverviewofHealthIssuesRelatedtoPesticideExposureinTelanganaAgriculture"

HealthIssue	**Description**	**Statistics/Findings**	**Case Study Examples (Telangana)**
Respiratory Diseases	Chronic respiratory issues linked to inhalation of pesticidefumesor dust.	Over **40%** of farmers report respiratory problems related to pesticideexposure (Raoetal., 2015).	In Khammam, **65%** of surveyed farmers reported chronic cough and wheezing (Narsimha et al., 2020).
Skin Irritations	Skin irritations, rashes, and dermatitis due to directcontactwith pesticides.	Farmers exposed to pesticides have higher rates of skin-related health issues (Abubakaretal.,2020).	Women in cotton fields report **50%** prevalence of skin irritations(Reddyetal.,2021).
Neurological Disorders	Increased risk of cognitive impairmentsand conditions like Parkinson's disease fromneurotoxic pesticides.	Farmers exposed to neurotoxic pesticides are **two to four times** more likely to develop chronic respiratory diseases(Alavanjaet al.,2001).	-
Chronic Illnesses	Chronic health conditionsincluding cancers and endocrine disruptionslinkedto pesticideexposure.	Pesticide poisoning caseshaveincreasedby **50%** over the past decadeinIndia(ICAR, 2019).	In Adilabad, **30%** of farmers reported a history of cancer linked to pesticide use (Govindappa et al., 2022).

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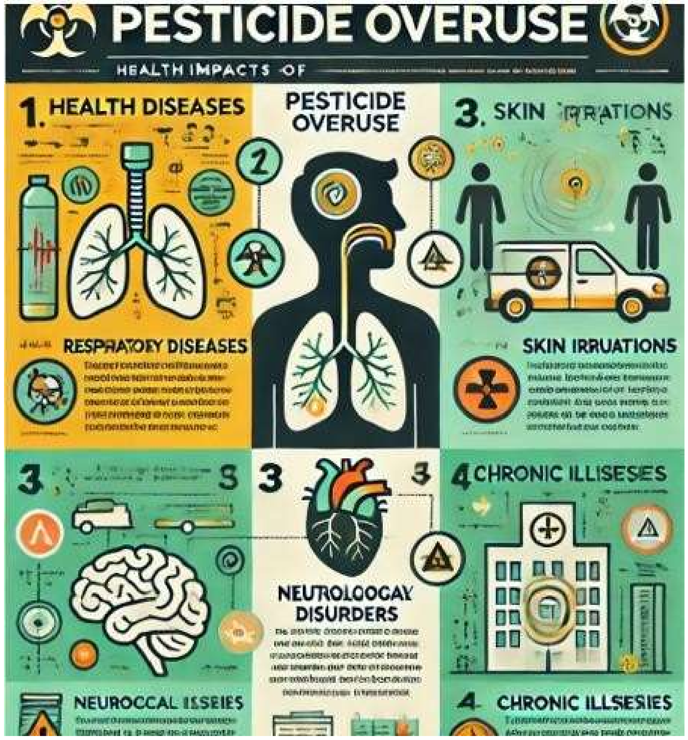

Fig-2"HealthImpacts of Pesticide Overuse: AComprehensive Overview"

3. Environmental Consequences:

1. Pesticide Residues

Soil Contamination: Pesticides can accumulate in the soil, altering its chemical composition and affecting its health. Residual chemicals can disrupt beneficial soil microorganisms and reducesoilfertility(Gill&Garg,2014).Prolongedexposurecanleadtodiminishedcropyields and require the use of more chemicals to achieve the same results.

Water Pollution: Pesticides can leach into groundwater or runoff into surface water bodies during rainfall or irrigation, contaminating drinking water supplies and aquatic ecosystems (Sharmaetal.,2019).Thispollutionposesriskstobothhumanhealthandwildlife,aschemical residues can be toxic to aquatic organisms.

Food Contamination: The presence of pesticide residues on crops can lead to food safety concerns. Studies have shown that produce can retain pesticide residues beyond acceptable safety levels, posing health risks to consumers (Zhan et al., 2020).

2. EcosystemDisruption

Biodiversity Loss: Pesticide overuse can result in a decline in biodiversity as non-target species, including beneficial insects like pollinators and natural pest predators, are adversely affected. The decline of these populations can lead to a disrupted food chain and ecosystem imbalance (Barnhoorn et al., 2009).

DisruptionofNaturalHabitats:Theapplicationofpesticidescanleadtohabitatdegradation. Aquatic environments, for example, can suffer from pesticide runoff, which affects water qualityandharmsaquaticlife(Abubakaretal.,2020).Thisdisruptioncanleadtotheextinction of sensitive species and reduce overall ecosystem resilience.

3. Long-termEffects

SoilHealthDecline:Thepersistentapplicationofpesticidescanlead tolong-termchangesin soilhealth,includingadecreaseinorganicmatterandsoilstructure,whichcanadverselyaffect agricultural productivity and sustainability (Schreinemachers&Tipraqsa, 2012).

ChronicEcosystemImbalance:Continuouspesticideexposurecancreatechronicimbalances inecosystems,makingthemmoresusceptibletopestoutbreaksanddiseasesduetothelossof natural pest control mechanisms (Fernández, 2021).

LegacyPollution:Somepesticidescanpersistintheenvironmentforyears,leadingtolegacy pollution that affects future generations of crops and ecosystems. This contamination can complicateremediationeffortsandnecessitatestricterregulationson pesticide euse(Khanetal., 2010). Understanding the environmental consequences of pesticide overuse is crucial for developing strategies to mitigate these impacts. By addressing pesticide residues, ecosystem disruption,andlong-termeffects,itbecomesevidentthatsustainableagriculturalpracticesare necessary to protect both human health and the environment.

4. PesticideTesting and Monitoring:

CurrentPractices

Monitoring pesticide residues in agricultural products, soil, and water is crucial for ensuring public health and environmental safety. Various analytical techniques are employed for detecting and quantifying pesticide residues, with liquid chromatography coupled with mass spectrometry (LC/MS) and gas chromatography coupled with mass spectrometry (GC/MS) being the most widely used methods.

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Liquid Chromatography-Mass Spectrometry (LC/MS): LC/MS is a powerful technique that separates compounds in a mixture before analyzing them with mass spectrometry. This method is highly sensitive and allows for the detection of low concentrations of pesticides in complexmatrices such as food,water,and soil. LC/MS can identifyawiderangeofpesticide classes, making it ideal for comprehensive residue analysis (Meyer et al., 2018). (Fig-2)

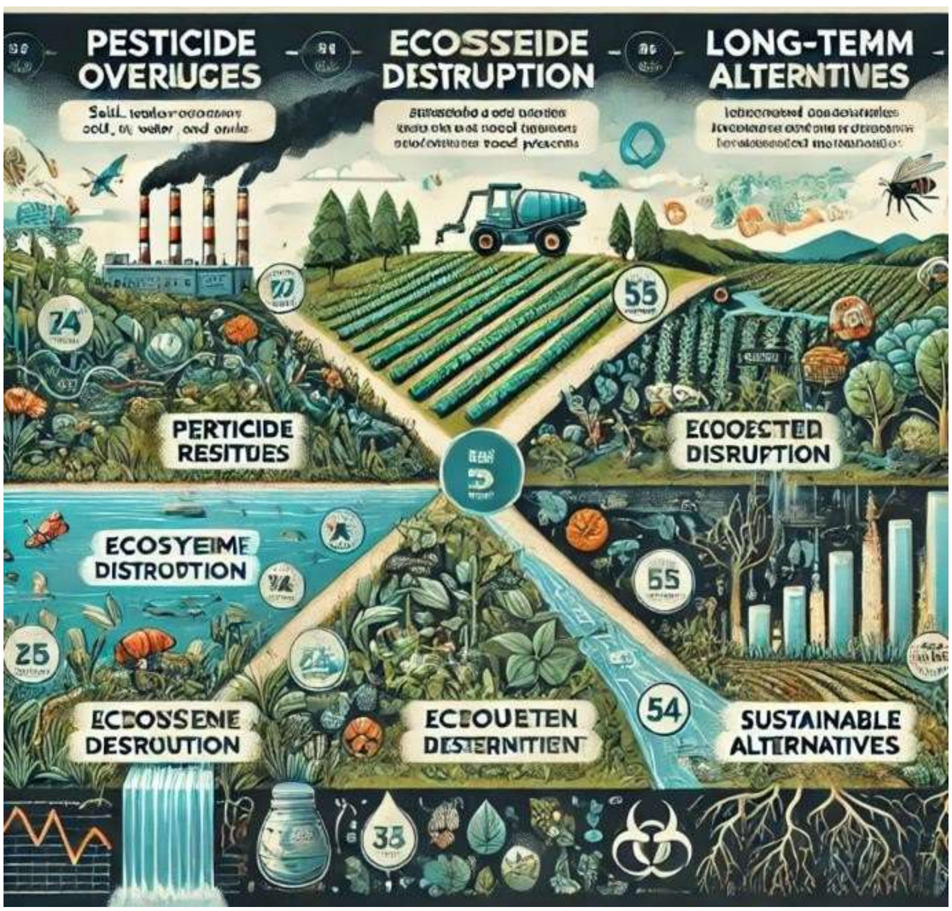

Fig-2ImpactofPesticidesontheEnvironment:AVisualOverview

Gas Chromatography-Mass Spectrometry (GC/MS): GC/MS is another widely utilized method for pesticide testing, particularly effective for volatile and semi-volatile compounds. Inthistechnique,pesticidesarevaporizedandthenseparatedinagaschromatographycolumn before being detected and identified by mass spectrometry. GC/MS is considered the gold standard for pesticide residue analysis due to its high sensitivity and specificity (Zhou et al., 2020).

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Both LC/MS and GC/MS have been instrumental in regulatory compliance, allowing authorities to monitor pesticide levels in food and environmental samples. However, these methods require sophisticated equipment and technical expertise, which may not be readily available in all regions.

NeedforRigorousTesting

Despite the effectiveness of existing methods, there is an urgent need for improved pesticide testingprotocolstoaddressgrowingpublichealthandenvironmentalconcerns.Theincreasing incidence of pesticide-related health issues, particularly in agricultural communities, underscores the necessity for more rigorous testing and monitoring.

Asignificantgapexistsinthecapacityoftestinglaboratories,especiallyindevelopingregions like Telangana, where agricultural practices heavily rely on pesticide use. Inadequate testing canresultinpesticideresiduesexceedingsafelimits,leadingtohealthrisksforconsumersand environmental degradation. Moreover, the emergence of new pesticide formulations and the complexity of mixtures present challenges that current testing methods may not fully address (Lehmann et al., 2019).

Enhancing pesticide testing methods involves not only the adoption of advanced analytical techniques but also establishment standardized protocols and training programs for local laboratories. This will ensure that testing is consistent, accurate, and reflective of the current agricultural landscape. Additionally, integrating biomonitoring approaches that assess human exposuretopesticidesthroughbiologicalsamplescanprovidevaluableinsightsintothehealth impacts of pesticide use and guide policy decisions (Abubakar et al., 2020).

5. SustainableSolutions:

Eco-friendlyManagementStrategies

Sustainable agricultural practices are critical for mitigating the adverse effects of pesticide overuse. Alternative approaches such as **bioremediation** and **phytoremediation** harness natural processes to detoxify contaminated environments.

Bioremediationinvolvesusingmicroorganismstobreakdownharmfulsubstancesinsoiland water. For instance, certain bacteria and fungi can degrade pesticide residues, effectively reducing their toxicity and environmental impact (Sharma et al., 2019).

Phytoremediationutilizesplantstoabsorb,accumulate,anddetoxifypollutantsfromthesoil. Plants such as sunflowers and willow have shown promise in remediating pesticide-contaminated sites by uptake and degradation of pesticides through their metabolic processes (Meagher, 2000).


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Microbial degradation leverages the natural ability of microorganisms to metabolize pesticides, converting them into less harmful compounds. Research has highlighted specific strains of bacteria that can effectively degrade organophosphates, commonly found in many pesticides (Singh & Madaan, 2016).

Integrated Pest Management (IPM) is a holistic approach aimed at reducing pesticide reliance through a combination of methods that promote sustainable agriculture:

Biological Controls: Utilizing natural predators or parasites to control pest populations can significantly reduce the need for chemical interventions.For example, lady bugs and lacewings can help control aphid populations in crops (Gonzalez et al., 2018).
Crop Rotation: Changing the types of crops grown in a particular area can disrupt pest life cycles, reducing infestations and the subsequent need for pesticides. For example, rotating legumeswithcerealcropscanenhancesoilhealthandreducepestprevalence(Blesh&Brewer, 2014).

CulturalPractices:Employingpracticessuchasplantingresistantcropvarietiesandadjusting planting dates can minimize pest damage and enhance crop resilience (Dahlgren et al., 2015).

Policy Recommendations
To support sustainable agricultural practices and ensure the health of farmers and the environment, the following policy recommendations should be considered:

1. **Education and Training**: Implement training programs for farmers on the safe and effective use of pesticides, focusing on application methods, timing, and alternatives to chemical pesticides.
2. **Support for Research**: Increase funding for research into sustainable agricultural practices, including bioremediation and IPM, to provide farmers with effective tools and strategies for pest management.
3. **Regulatory Framework**: Establish stricter regulations on pesticide use, focusing on banning harmful substances and promoting the use of safer, eco-friendly alternatives.
4. **Incentives for Sustainable Practices**: Offer financial incentives or subsidies for farmers who adopt sustainable practices, such as organic farming, IPM, and bioremediation strategies.
5. **Public Awareness Campaigns**: Launch campaigns to raise awareness about the health risks associated with pesticide overuse and the benefits of sustainable agriculture, encouraging consumer support for eco-friendly practices.

By adopting these sustainable solutions, we can move towards a more balanced agricultural system that prioritizes environmental health and public safety while still meeting food production needs.

6. Discussion:

Synthesisof Findings

The overuse of pesticides in agriculture presents a complex web of health and environmental issues that require urgent attention. This paper has explored various aspects of pesticide use, emphasizing its significant health impacts on farmers and the broader community, as well as its detrimental effects on ecosystems and biodiversity.

1. **Health Issues**: The evidence presented highlights that pesticide exposure can lead to a rangeofacuteandchronichealthproblemsamongfarmers,includingrespiratorydiseases, skinirritations,neurologicaldisorders,andincreasedcancerrisk.Thefindingsfromstudies conductedinregionslikeTelanganaunderscorethepressingneedforbettermonitoringand regulation of pesticide use.

2. **Environmental Consequences**: Pesticide residues contaminate soil, water, and food products, posing risks not only to human health but also to wildlife and plant species.The disruptionofecosystemsduetopesticideoveruseleadstobiodiversityloss,whichcanhave cascading effects on agricultural productivity and ecological balance.

3. **Sustainable Solutions**: The exploration of sustainable practices such as bioremediation, phytoremediation, and Integrated Pest Management (IPM) reveals promising alternatives that can mitigate the adverse effects of pesticides. These strategies not only address the immediate health and environmental concerns but also promote long-term agricultural sustainability.

Overall, the interconnectedness of health and environmental issues highlights the need for a holistic approach to pesticide regulation and management. Addressing these challenges requires collaboration among policymakers, researchers, and farmers to foster a sustainable agricultural framework that prioritizes public health and ecological integrity.

ImplicationsforFutureResearch

Despite the advancements in understanding the implications of pesticide use, several gaps in the existing literature warrant further investigation:

1. **Long-term Health Studies**: There is a need for longitudinal studies that assess the long-term health effects of pesticide exposure among agricultural workers and their families. Research should focus on specific health outcomes associated with chronic exposure to commonly used pesticides in different agricultural contexts.

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2. **Impact on Biodiversity**: While some studies have addressed the immediate effects of pesticide use on non-target species, more research is needed to understand the long-term ecologicalconsequencesandthemechanismsthroughwhichpesticidesdisruptecosystems.

This includes studying the effects of pesticide combinations and their synergistic impacts on biodiversity.

3. **Efficacy of Sustainable Practices**: Further research is essential to evaluate the effectivenessofalternativepestmanagementstrategies,includingbioremediationandIPM, in various agricultural settings. Comparative studies examining the outcomes of conventional versus sustainable practices on crop yield, pest control, and environmental health will provide valuable insights.

4. **Socioeconomic Factors**: Understanding the socioeconomic dynamics that influence pesticide use is crucial. Research should explore farmers' perceptions, knowledge, and accesstosustainablealternatives,aswellastheeconomicbarrierstheyfaceintransitioning to safer practices.

5. **Policy Implementation**: Investigating the challenges and successes of policy implementationrelatedtopesticideregulationandsustainableagriculturecaninformfuture efforts. Case studies highlighting successful interventions and the role of community engagement in policy advocacy will be beneficial.

6. By addressing these gaps, future research can contribute to a more comprehensive understanding of pesticide-related health and environmental issues, ultimately guiding effective strategies for risk reduction and sustainable agricultural practices.
7. **Conclusion:**

The pervasive use of pesticides in agriculture, while essential for managing pests and enhancingcropyields,hassignificanthealthand environmentalrepercussions.Thispaperhas highlighted the critical health issues faced by farmers, including respiratory diseases, skin irritations, neurological disorders, and an increased risk of cancers due to pesticide exposure.

ThesechallengesareparticularlypronouncedinregionslikeTelangana,wheretheoverreliance on hazardous chemicals poses severe risks to public health.

Moreover, the environmental consequences of pesticide overuse are profound. Pesticides contaminate soil, water, and food supplies, leading to ecosystem disruption and a decline in biodiversity. The persistent residues and their impacts threaten not only agricultural productivity but also the integrity of natural habitats and wildlife.

Considering these findings, there is an urgent need for a paradigm shift towards sustainable agricultural practices. This includes adopting eco-friendly management strategies such as bioremediation, phytoremediation, and Integrated Pest Management (IPM) that reduce dependencyonchemicalpesticides.Furthermore,strongerregulatorymeasuresareessentialto ensure the safe use of pesticides, protect farmers' health, and preserve the environment.

Call to Action: Stakeholders including policymakers, agricultural organizations, and farmers must collaborate to promote sustainable practices and enhance regulatory frameworks. Education and training programs are vital to empower farmers with knowledge about safer alternatives and the importance of reducing pesticide reliance. By prioritizing health and environmental sustainability, we can safeguard the future of agriculture in Telangana and beyond, ensuring a healthier planet for generations to come.

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PHYSICAL AND CHEMICAL ANALYSIS OF VARIOUS COLORS OF JAGGERY FROM DIFFERENT SUGARCANE VARIETIES

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ABSTARCT:

The traditional Indian sweetener, jaggery, is made from sugarcane. Rural residents can easily obtain and benefit from jaggery, which is a nutritious food. Jaggery is a natural sweetener prepared fromconcentrated sugar cane juice. Indian Ayurvedic medicine uses jaggery as a medicinal sweetener to heal throat and lung conditions. A nutritional supplement based on jaggery has been shown to have beneficial impacts on health through in vivo studies. Five distinct coloured jaggery samples were gathered for the current investigation from various market jaggery shops in different localities. Samples were sealed and stored in separate, sterile plastic containers. In accordance with standard procedures, the research was conducted to determine the organoleptic characteristics and to evaluate the physicochemical parameters such as moisture content, sugar content, sucrose, total ash, acid insoluble, and metal composition.

KEYWORDS:*Jaggery, Organoleptic, Physicochemical, Traditional etc.*

INTRODUCTION:

Jaggery has a sweet, winy fragrance, as well as a delicious flavour and texture. A good grade jaggery has a golden yellow colour, a firm texture, a crystalline structure, a sweeter taste and contains less moisture. It is a concentrated product of cane juice without separation of the molasses and crystals and can vary from golden brown to dark brown in colour. For liquid, solid and powdered/granular jaggery, the temperatures are 105-108 ºC, 114-117 ºC and 118-120 ºC, respectively.Due to its nutritional and health benefits, it can be made available to community to help alleviate malnutrition and under nutrition problems. Jaggery is frequently utilized because of its high nutritional value, reported health benefits, and accessibility to rural populations. Keeping in view all the considerations, the present study has been taken to analyse the Physio-chemical characteristics of fresh jaggery

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Jaggery is consumed all over the world and is recognized by a various name; in most Asian and African countries it is known as jaggery. "Goda" in (Sanskrit),"Gud/Gur" in (India and Pakistan), "Bellam" in (Telugu), "Bella" in (Karnataka), "Vellam" in (Tamil and Malayalam),: Hong Tang" in (China), "Chancaca" in (Chile, Peru and Bolivia), "Panela" in (Columbia, Ecuador, Guatemala and other Central American countries), "Black sugar (Kurosato)/Kokuto" in (Japan), "Papelon/Panela" in (Venezuela), "Dulce/Tapa dulce" in (Costa Rica and Nicaragua), "Gula Java/Gula Merah" in (Indonesia), "Gula Melka" in (Malaysia), "Raspadura" in (Panama), "Raw sugar" in (Europe, North America and United States) and "Unrefined muscovado" in (United Kingdom) (Guerra and Mujica, 2009; Kouhestani and Honarwar, 2021; Kumar et al., 2022) [1, 2, 3].

Materials and methods: Various Techniques were used to analysecoloured jaggery samples. Colorimeter was used to determine composition of Iron, Flame emission spectrophotometer was used to determine the composition of Sodium & Potassium, the collected samples were analysed for major physicochemical parameters (pH, Electrical conductivity, Ash).

Collection of samples: Jaggery samples were collected freshly in plastic containers from the Different colors of jaggery cubes (Whitish yellow, Dark brown, Redish white, Yellow, Dark brown) were collected from the local marketfor its physicochemical and mineral analysis. The results of jaggery samples were compared with each other and finally drawn conclusion about the nutritional value and mineral contents, and which one is healthy for human being.

In the present study different physical and chemical properties of all five samples were tested. Some of the parameters tested were pH,Electrical conductivity, moisture, ash, water contents, acidity in terms of ascorbic acid, total acidity, amount of sodium, potassium, ironetc. For the analysis of jaggery samples used simple laboratory techniques and instruments available in our laboratory.

Preparation of sample solution: pH, conductivity and density parameters were tested by preparation of 10 % solution of jaggery and sugar (dissolved 5 grams of sample with distilled water and made it to 50 mL of volumetric flask.

Determination of pH :pH of the samples were determined by digital pH meter (Hanna Pvt. Ltd., India). The electrode of the digital pH meter was dipped inside the beaker containing the sample solution (jaggery) and recorded the pH value. Prior to measurement the pH meter was calibrated using pH 7 and pH 4 standard solutions[4].

Determination of moisture content (%) : Hot air oven method for solid jaggery samples (70°C) and vacuum oven method for liquid jaggery (70°C) were used to determine the moisture content of jaggery. 10 g each jaggery sample was weighed accurately and placed in a pre-weighed crucible and placed in the pre-set (at 70 °C) ovens (hot air and vacuum) and then dried until successive weighing did not change by more than 0.5 mg [5]. The dishes containing the dried jaggery samples were drawn out from the ovens and placed in desiccators and allowed to cool before being weighed.

Moisture content (%)= 100 (M1−M2)/M1− M

Where,
M1 = initial weight of the sample and crucible before drying (g)
M2 = final weight of the dried sample with crucible (g)
M = weight of empty crucible (g)

Ash content : Ash represents different inorganic oxides left after complete combustion of sample. Total ash content was determined as per AOAC (2000) [6]. Accurately weighed samples were taken in silica crucible (previously heated and weighed) was ignited on a heater until fumes ceased and then crucible was transferred to a muffle furnace and burn at 550 ± 150 C until ash was obtained. The ash content was calculated in %.

Determination of true density (g/cc): The density of jaggery samples were determined by the toluene displacement method. Jaggery (solid) being insoluble in toluene this method was used comfortably. In a measuring cylinder, 25 mL of toluene was taken precisely and 5 g of jaggery was added to it. The volume of toluene and jaggery was increased by putting the jaggery into the measuring cylinder. The difference between the initial and the final volumes of the toluene was recorded, and the true density was calculated by the following expression.

Density (g/cc) = Mass/Volume (final volume−initial volume)

Density was measured by preparation of 10 % solution of all samples. 25 ml picometer was used for measurement of density of samples.

Total Acidity : Total Acidity was measured by titrating samples with standardized sodium hydroxide solution and using phenolphthalein indicator. Total acidity represents the acidic nature of sample.

Vitamin C : Vitamin C was measured by using standard iodine solution and freshly prepared starch solution as an indicator. All samples were dissolved in distilled water and diluted to the mark of the volumetric flask. These samples were used for determination of vitamin C.

Minerals : Metal composition was measured by making ash of the samples. Ash was then dissolved in acid and digested for some time and then filtered and diluted to the mark in volumetric flask.[7] This sample solution was used for the measurement of sodium, potassium iron by using flame photometer for sodium and potassium, colorimetric method for analysis of iron.

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Results and Discussion: The collected samples were analysed for physicochemical characteristics,quantitative estimation of metals.

The results pertaining to various parametersof Jaggerysamples are shown in Table 1.

Table :1. Organoleptic characters of each sample of Jaggery

Parameter	Sample-1	Sample-2	Sample-3	Sample-4	Sample-5
Colour	Whitish yellow	Dark brown	Redish white	Yellow	Dark brown
Smell	Pleasant	Pleasant	Pleasant	Pleasant	Pleasant
Taste	Sweet	Sweet	Sweet	Sweet	Sweet
Consistency	Solid	Solid	Solid	Solid	Solid
Texture	Circular	Circular	Circular	Circular	Circular
pH	3.96	4.98	2.32	3.99	2.56
Density g/ml(10%)	1.39	1.36	1.23	1.28	1.96
Vitamin C g/100 gm	0.667	0.418	0.498	0.698	0.987
Ash content (%)	0.0163	0.018	0.0244	0.0343	0.0543
Moisture (%)	5.26	6.02	5.68	5.02	6.09
Total acidity (g/100 gm)	0.623	0.342	0.523	0.688	0.458
Sodium (ppm)	48.82	54.23	35.63	45.85	56.35
Potassium (ppm)	78.23	68.25	45.28	60.28	78.98
Iron (ppm)	0.895	0.5683	0.579	0.865	0.985

Discussion:
Various mineral contents are shown in table 1.sodium, potassium, iron in all five samples. All five samples were found to have different concentrations of minerals that depend upon the qualityof sugarcane used, manufacturing process used, different chemicals used and soil of sugarcane crop produced.

Conclusion:
Jaggery is widely used in pharmaceutics and easily available in the markets. There are many forms of jaggery available in the market. Purity and quality of jaggery must be ensured on public health groundsas it is a popular food item and used as sweetening agent based on therapeutic purposes in Ayurvedic medicine. To attain the purpose of quality, standards should be set to all varieties of guda (jaggery) from sugarcane that is sold in the market.

After analysis and interpretation of all physicochemical and mineral parameters of two jaggery samples found that, rich in vitamin C, higher acidity, higher amount ash along with very good amount of mineral contents of sodium, potassium and iron. Healthy point of view jaggery samples have good amount material and helpful for various metabolic activities. On the basis of results obtained and after comparison among jaggery samples, dark brownjaggery was recommended from the health point of view.

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Abstract:

The number of plant pathogens worldwide is rising, and they inflict substantialeconomic harm. Viroids, viruses, phytoplasms, bacteria, and fungi make up themajority of plant diseases. In order to obtain the resources needed by their hosts forsurvival,growth,andreproduction,plantpathogensestablishcloseinteractionswiththem. One of the main causes of plant illnesses is fungus. Pathogenic fungi useseveral techniques to colonize plants and produce disease. While some fungus(known as necrotrophs) infects living tissue, others (known as biotrophs) kill theirhosts and feed on dead matter. Specialized infection structures are generated andpathogenic growth is controlled for successful invasion of plant organs.For genus-level identification, morphology-based identification is a valuable technique, andmolecular data are necessary for precise species identification.Since the scientificname of a fungal pathogen connects the knowledge about the species, including itsbiology, host range, distribution, and possible risk, accurate identification of theseinfections is essential for developing effective control strategies. As a result, apolyphasic strategy is advised in the present period for the identification of fungalinfections. We will talk about in this essay. Classification and Identification ofFungal PlantPathogens.

Keywords:*FungalPlantPathogens,Viruses,PlantDiseases,PhylaAscomycota,KingdomPhylum ,Class, Leaving Plants*

Introduction:
MostspeciesoffungalplantpathogensbelongtothephylaAscomycotaandBasidiomycota.Plantinf ectionsbelongtoanumberofascomycetesclasses,includingtheDothideomycetes(Cladosporiums pp.),Sordariomycetes(Magnaporthe spp.), and Leotiomycetes (Botrytis spp.). The two major groups ofplant pathogens, the rusts (Pucciniomycetes) and the smuts (distributed among thesubphylumofUstilaginomycotina),arerepresentativeofthebasidiomycetes.[1]Awiderangeofi llnesssymptomsarebroughtonbyfungusinfections.Plantdiseasescausedbyfungiaregenerallyclas sifiedintotwobroadgroups:necrotrophicpathogens, which destroy the host tissue in order to obtain nutrients, and biotrophicpathogens, which develop close relationships with plants and

can survive in andutilize living tissues. A different category of infections known as hemibiotrophicpathogensalsobeginsasbiotrophsbeforetransitioningtonecrotrophs.Necrotrophsinflictnecrosisand eventuallyeven plantdeath oninfected plants.Given the majority of plant saprophytes, pathogens, and mycorrhizal species infungi, terrestrial plants have most likely been the primary source of nutrients forfungi for a large portion of their evolutionary history, despite the fact that somesignificantfungaldiseasestargetmammals.Withover8000speciesknowntocausedisease, fungus collectively cause more plant diseases than any other kind of plantpest(suchasvirusesorbacteria).Fungi-relatedplantdiseaseshaveaverywiderangeof symptoms. For instance, blemishes on foliage or flowers, stem cankers, fruit rot,andplantsterilizationcan allbeattributed topathogenicfungi. [2]Parasites that survive at the expense of their host are known as plant pathogens.Althoughfungiconstitutethemajorityofplantinfections,bacteria,protists,chromists, nematodes, and even plants can also pose a threat to plants. While manyaspects ofepidemiology and managementaresharedby thisdiverse rangeofpathogens,wewill focus solelyonfungalplant pathogensinthisdiscussion.

The physical presence of pathogen symptoms is one of the most typical and easilyrecognized features of fungal infections. Hyphae, mycelia, fruiting bodies, andfungal pathogen spores are among the telltale signs of a disease that can help withaccuratediagnosis andidentification.

Globalagricultureindustrylossestosubstantialeconomicconsequencesareattributed to most plant diseases caused by pathogenic fungus. A wide range offungaldiseasescaninfectplants,anddifferencesintemperature,humidity,soil, water, air, and host responsiveness all affect how much inoculum is needed forinfection. The sensitive crop types or plant species may display outwardly obviousmorphological signs in the tissues where the infection first appears. In tissues ororgansdistantfromtheinfectionsites, systemic ymptomsareproducedifthefungalpathogen can find conducive conditions for continued growth. Latent infections arethose in which the external manifestation of the infection is absent. Since they aredormant,somefungalinfectionsthatinfectimmaturefruitsdonotshowanysymptoms at all. The method of identifying a specific target organism's continuouspresenceinaplantoritssurroundings,regardlessoftheemergenceofoutwardsignsin a plant suspected of harboring the fungal pathogens in issue, is known as fungalpathogen detection.

Theprimaryobjectiveofplantdiseasediagnosticsistoidentifypathogensinaquick,accurate,andtrustworthymanner.Fungaltaxonomyknowledge,alotoftime,effort,and cultural approaches are needed for the detection of relevant fungal infectionsusing fundamental methods. Because they are unique microorganisms with uniquemetabolisms,fungihaveparticularneedsforgrowth andreproduction.Therefore,inorder to cultivate the specific pathogen, the right growth medium is required.Becauseofmisidentification,thesemethodsproduceuntrustworthyresults.Furthermore, in order to get successful outcomes with these traditional methods,professionals with experience in fungal identification were needed. In order tominimize or stop the spread of disease and implement efficient control measures,earlydetectionoffungalpathogensisessential.Inadditiontotheconventionalvisualscouting for disease symptoms, DNA-based and serological approaches offer vitaltoolsforprecise plantdiseasedetection.[3]One of the main biotic factors causing catastrophic illness in crops is fungal plantinfections (Doehlemann et al., 2017). Approximately eight thousand species ofoomycetesandfungusareassociatedwithplantdiseases.Undernaturalenvironmental conditions, pathogenic fungi can infect plants at any stage, from theseedling stage to the seed maturation stage. They can do this on their own or intandem with other types of phytopathogens. Anthracnose, blight, canker, dampingoff, dieback, gall, leaf spot, powdery mildew, rust, root rot, scab, and wilt are themost prevalentdiseases broughtonby plantpathogenicfungus.[4]Plantsaresusceptibletoinvasionbyorganismsthatdisruptoraltertheirphysiological processes, impairing the growth, development, or essential functionsof the plant and thus leading to plant disease. Plant diseases have a big effect onagriculture because they can reduce crop yields, lower the quality of products, orrestrictthesupplyofrawresourcesandfood.Upto16%oftheestimatedyearly losses in worldwide output are attributed to plant diseases (Oerke, 2006). Theselosses range from 20 to 40%. In order to lessen agricultural losses brought on bypathogens,plantdiseasemanagementiscrucial.Chemicalfungicidesaretheprimarytool used to control diseases, and they are often quite effective. On the other hand,because human expertise is needed to ensure a precise diagnosis, manual plantdisease detection is costly and time-consuming. As a result, a significant and activearea of agricultural research is now studying automatic plant disease classificationalgorithms.[5]

The body, or thallus, of most of the higher fungi is called a mycelium (pl. mycelia).The mycelium is made up of thread-like structures called hyphae (sing. hypha).Hyphaegrowonlyfromtheirtips,andunder favourable conditionscangrowindefinitely. Hyphae, most often, are partitioned by cross walls called septa (sing.septum). Septate hyphae are divided into individual cells by these internal walls.Septa usually have a central pore which allows small organelles, and in some casesnuclei, to pass from one cell to another. The hyphae of the classes Ascomycetes,BasidiomycetesandDeuteromycetesareseptateandthehyphaeofclassOomycetes and Zygomycetes are nonseptate or coenocytic. Coencytic hyphae have multiplenucleiin a common cytoplasm.

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Figure1:Rhizomorphsof Armillariasp.

Hyphae produce specialized simple or branched projections called haustoria (sing.Haustorium).Haustoria penetrate the host tissue and actasnutrientabsorbingorgans. Haustoria contain nuclei and a concentrated number of mitochondria. Thehaustoria do not rupture the host cell protoplasmic membrane but invaginates itselfintothecell thusgreatlyincreasingtheabsorptivesurfaceof thefungus.[6]

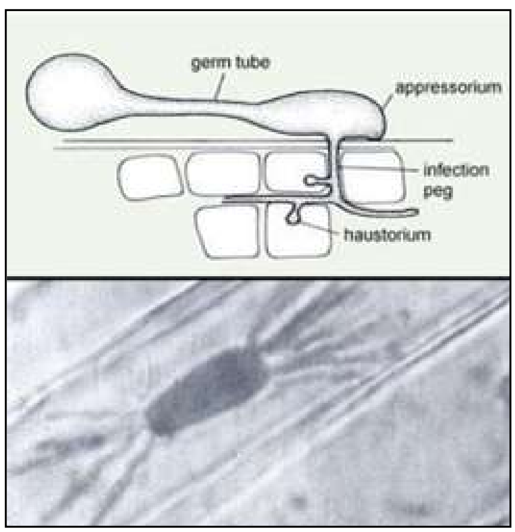

Figure2:Haustoria

Reproduction of fungi is primarily by means of spores. Spores are reproductivebodies that consist of one or a few cells. In function they are analogous to the seedsof green plants. Spores are produced by sexual and asexual reproduction. Sexualreproductioninvolvestheunionoftwocompatiblenuclei asproducedbymeiosis.

The identification and diagnosis of plant diseases depend on the taxonomy ofpathogenic fungus. Every kingdom, phylum, class, order, genus, and specie hasdistinctive traits that set them apart from one another. It is challenging to identifyvarious fungi down to the species level without the right lab tools and expertisebecause many of the diagnostic characteristics are quite subtle. We can greatlyrestrict our search if we can determine the kind of fruiting body and/or spores thatbelong to a specific phylum. When diagnosing fungal disease, we typically dependonvisualcuesand symptoms. [7]

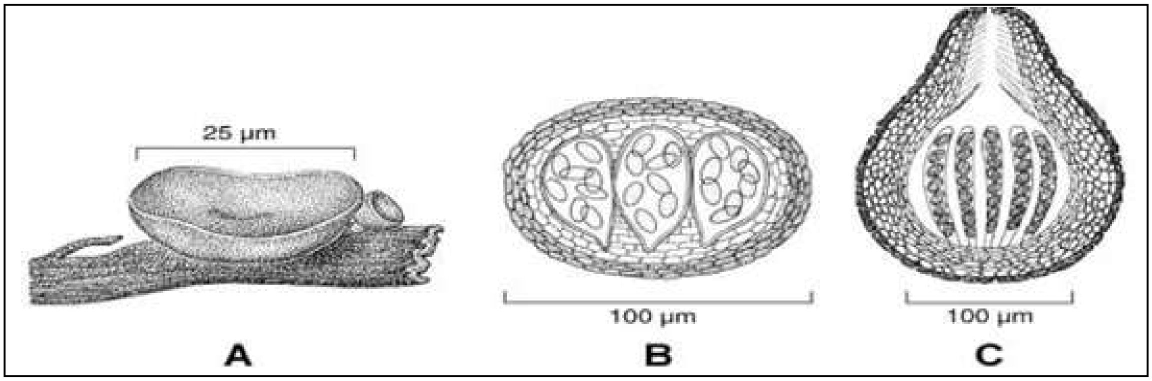

Figure 3: Ascomycete fruiting bodies (sexual). A - Apothecium, B -Cleistothecium,C – Perithecium

ClassificationofPathogenicFungi

Although fungi are among the most prevalent and diverse creatures, the majority ofserious fungal infections in humans are caused by a small number of species. Table1 presents a conventional phylogenetic list of the most significant fungal infectionsthat affect humans. In addition to genetic relatedness as established by genomesequencing,particularlyofhighlyconservedelementslikeribosomalDNAsequences,these classificationsarebased onthetypicalgrowthandshapeofvegetative and reproductive fungal forms. While some belong to Basidiomycota orZygomycota, the majority of fungi that cause dangerous infections in humans areclassifiedas members ofthephylumAscomycota. [8]

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Table1.Phylogenyof thecommoninvasivefungi

Phylum	Subphylum	Class	Order	Genus
Ascomycota				
	Pezizomycotina			
		Eurotiomycetes		
			Onygenales	*Blastomyces*
				Coccidioides
				Histoplasma
				Paracoccidioides
			Eurotiales	*Aspergillus*
				Penicillium
		Chaetothyriomycetes		*Exophiliala* (*Wangiella*)
		Sordariomycetes		
			Ophisostomatales	*Sporothrix*
			Microascales	*Pseudallescheria*
				Scedosporium
			Hypocreales	*Fusarium*
	Saccharomycotina			*Candida*
	Taphrinomycotina			*Pneumocystis*
Zygomycetes			Mucorales	*Rhizopus*
				Absidia
				Mucor
			Endomopthorales	*Basidiobolus*
				Conibiobolus
Basidiomycota		Hymenomycetes		*Cryptococcus*
				Trichosporon
		Ustilaginomycetes		*Malassezia*

(Source:AdaptedfromTaylor,J.W.(2006). Evolutionof human pathogenicfungi:Phylogeniesandspecies.)

Whenanalyzingevolutionaryrelationshipsanddirectingresearchoncharacteristicslikesexualityandgeneticrecombinationwithinpopulations,traditionalphylogenetic classification is highly helpful. However, when one views these fungiashumanpathogens, alternative methods ofclassificationare frequently morebeneficial.[9]


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The identification of serious fungal infections typically occurs when fungi areobserved in infected tissues or isolated in culture. Therefore, it is generally helpfulto categorize the pathogenic fungi into three groups: those that grow in tissues or incultureasfilamentousfungi(ormolds),yeast-likefungi(sometimeswithassociatedelongated forms known as pseudohyphae), or dimorphic fungi (which grow as onemorphologicformwhentheyareobservedininfectedtissuesorareculturedat37°Candasacompletelydifferentmorphologicformintheenvironmentorwhentheyareculturedatambienttemperatures).Ascomycetesandbasidiomycetesareincluded in the category of yeast-like fungi in Table 2, together with ascomycetesandzygomycetesinthecategoryoffilamentousfungiormoldsanddimorphicfungi,whichare divisionsof theprincipalgroupofharmful fungi for humans.[10]

Table2.Morphology of the commoninvasive fungi

Empty Cell	Genus	Usual morphology in tissues
Yeasts	*Candida*	Budding yeast, pseudohyphae, hyphae
	Cryptococcus	Encapsulated budding yeast
	Exophiala (*Wangiella*)	Black yeast, pseudohyphae
	Trichosporon	Pleomorphic yeast, pseudohyphae or hyphae
Molds	*Aspergillus*, *Fusarium*, *Pseudallescheria*, *Scedosporium*	Narrow septate hyphae, branching at 45°
	Rhizopus and other zygomycetes	Wide aseptate hyphae, branching at 90°
Dimorphic fungi	*Blastomyces*	Yeast with broad-based buds
	Coccidioides	Large endosporulating spherules
	Histoplasma	Small budding yeast
	Paracoccidioides	Yeast with multiple buds per cell
	Penicillium	Intracellular yeast
	Sporothrix	Elongated budding yeast
Other	*Pneumocystis*	Trophic forms, and cysts that contain up to 8 internal spores

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Isolation and Identification of Phytopathogenic Fungi from Infected PlantParts:

Isolationoffungalpathogens

Plant parts such as roots, stems, leaves, flowers, and fruits can all be infected byfungal infections, which can then cause recognizable visual symptoms includingrots, wilts, anthracnose, spots, and blights. Small bits of the infected tomato, chili,corn,andmaizewerecollectedandchopped.Planttissuesdisplayingdistinctsymptoms are used to isolate the causative fungus, which are then properly cleanedinsterilewater.Planttissuesaresurfacesterilizedbycuttingthediseasedtissuesandnearby tiny unaffected tissue into small pieces (2–5 mm squares) and transferringthem to sterile petridishes with a 0.1% mercuric chloride solution using flame-sterilized forceps. To allow the fungi to fully grow, the plant portions were placedon PDA plates and incubated for five to seven days. The final fungi were purifiedon Rose Bengal medium using the hyphal tips procedure, and each isolated funguswas then subcultured on slantmediaforfurtherresearch.

Identificationoffungalpathogens

Based on morphological and colony characteristics, the rhizosphere microflora wasidentified.Through the use of appropriate conditions, slide cultures, and the mostrecentkeysforidentificationswithsporulation,theisolatedfungiwereidentifiedtothegenusan dspecieslevel.Inordertoidentifythespeciesusingmacromorphologicaltraits,pureculturesoftheiso latesweresubculturedandmovedontodifferentialmedia,suchaspotatodextroseagar,maltextractag ar,czapekyeastextractagar,andczapekdoxagar.Inordertofullyisolateandpurifyplantpathogenic fungus, each plate was grown in triplicate, and the microscopic pictureplates were tabulated.

IdentifyandControlCommonPlantFungalDiseases:

Before they can take advantage of an opportunity to attack, fungi lurk in the soil,ambush young plants, and even wait patiently on pruning shears. Fungal diseasestake advantage of plant weaknesses once they become active, making plants proneto disease and insect pests. Keep the beauty and wealth of your garden flowing byprotectingit with astuteculturemethodsandefficientfungustreatment.

Examine these prevalent fungal illnesses to get an idea of the various ways fungalpathogens function:

Black spot: The black spot is seen when dark patches appear on the upper surfacesof leaves. The dots grow until the leaf is yellow and speckled with black, never onthe undersides of the leaves. Black spot, like many other fungal infections, cannotproliferate and spread unless

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water is freely available on the plant surfaces in theform of droplets or a water film. Conditions that are crowded, damp, and irrigatedfrom abovepromote black spotgrowth. [11]

Figure 4:Blackspot

Rust: The rust-orange pustules that develop on the undersides of leaves are thesourceofthenameofthisfungal disease.Theupperleafsurfacesturndiscoloredasthe fungus multiplies and spreads, and eventually the leaves fall off the plant. Rustis fueled by cool, damp temperatures and damp foliage, and it spreads via wind,water,and unintentionalinsects.

Figure5: Rust

Botrytis blight: The once vibrant and lovely flower petals and buds rot and becomefuzzy, and there are grayish-fuzzy mold stains. The airborne disease's pathogensstrikeonchilly,rainydaysinthespringandfall.Theidealcircumstancesforbotrytisblight are highhumidity,inadequateairmovement,and crowding.

Figure6:Botrytisblight

Culture-BasedLimitationsof IdentifyingPlantPathogenicMicro-Fungi

Increasing the speed at which plant pathogenic microfungals can be identified anddiagnosed will greatly raise the likelihood of pathogen containment. Traditionally,the morphological and phenotypic features of pathogenic taxa are used to describethem.Becausecloselyrelatedspeciesmaybevisuallyidenticalwhenculturedusingconventionalmethods,DNA-basedphylogeneticmethodshavebeenusedtoaugment as of yet. The conditions of culture can also affect a species' traits. As aresult,theseissuesfrequentlymakeitdifficulttoidentifyplantpathogensaccurately.In order to enable pathogen identification and diagnosis, it is also crucial to archivepathogen cultures and related data. When examining infected tissues for symptomsorindicators(suchasfruitbodiesormildewonfoliage),anexpertcanidentifycertaindiseases.[12]

Identifying the pathogen can be challenging because many diseases and symptomsarenotvisiblydistinguishablefromoneanother.Asaresult,moredetectiontechniques are required to identify the disease's source. Isolation of the fungi andpathogen morphological or molecular identification are required because, in manycases,thespecificmicroorganismisunknown.Alittlepieceoffilltissueisplacedongrowing substrate in order to separate fungal infections from plants. The mass ofundesirableandantagonisticfungiorbacteriathatquicklyoutnumberthepathogenicfungiontheisolationplatemakesitsometimesdifficulttoisolatepathogenicfungi,evenwiththeuseofselectivemedium.Pathogensfrompureculturescanbedistinguished using morphological & molecular traits.Using light microscopy, thefungus'sfruitbodies,orconidiaandspores,arefirstexamined.Ittakesalotofeffortand expertise to use this conventionalpathogen identification method, though.Consequently,followingtheseparationofDNAfrompurecultures,theidentificationof fungalmycelium usingmolecularmarkers isintroduced. [13]

Conclusion:

In addition to causing illness symptoms, pathogens can also seriously impair plantquality and productivity or even kill plants. Examples of these biological entitiesincludefungi,bacteria,nematodes,andviruses.Areviewofoftenresearchedpathogens is provided, along with a study scenario encompassing various stages ofa disease detection system. In order to determine which innovative techniquesperform best across a variety of crops or crop categories, their performance isexamined.Themanuscript,whichidentifiesassetofworkablemethods,alsoprovidesfutureresearch objectivesand otheritemsto think about.

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PHYSICS-INSPIRED INNOVATIONS IN PLANT SCIENCE: A QUANTUM LEAP WITHSTATISTICAL INSIGHTS

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Abstract

This paper explores the revolutionary integration of concepts and methodologies from physics, particularly quantum mechanics and statistical mechanics, into the field of plant science. By applying principles such as **quantum entanglement, resonance, and non-equilibrium thermodynamics**, alongside sophisticated statistical analysis, we can gain unprecedented insights into fundamental plant processes like photosynthesis, nutrient uptake, and growth regulation. The synergy between physics-inspired models and statistical rigor offers a paradigm shift in understanding plant physiology, leading to innovations in agriculture and environmental sustainability.

1. Introduction: The Convergence of Disciplines

Historically, plant science has been dominated by biology and chemistry. This section will argue that a deeper, more fundamental understanding requires a shift towards a **physics-based perspective**. It will highlight how complex biological systems, like plants, operate at scales where quantum effects become relevant and statistical laws govern collective behavior. The introduction will set the stage for how this interdisciplinary approach can solve long-standing problems in plant biology.

2. Quantum Mechanics in Plant Processes

This section will delve into specific examples of quantum phenomena in plants.

- **Photosynthesis and Quantum Coherence:** The incredibly high efficiency of photosynthesis in light-harvesting complexes is a puzzle. This part will explain the theory of **quantum coherence** and **exciton transfer**. It will describe how energy from absorbed photons is transferred to the reaction center without significant loss. The concept of **quantum entanglement** could be introduced as a potential mechanism for this rapid and efficient energy transfer.
- **Magneto reception and Crypto chromes:** Plants, like many organisms, can sense magnetic fields. This subsection will explore the role of **crypto chrome** proteins and the **radical pair mechanism**—a quantum mechanical phenomenon where electron spins are affected by magnetic fields, influencing chemical reactions.

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3. Statistical Mechanics and Complex Systems

Statistical mechanics provides the tools to understand the behavior of systems with many interacting components.

- **Plant Growth as a Non-Equilibrium Process:** Plant growth is a continuous process of energy and matter exchange with the environment, making it a classic example of a **non-equilibrium thermodynamic system**. This section will discuss concepts like **dissipative structures** and how plants maintain their highly ordered state by constantly dissipating energy.
- **Modeling Plant Populations:** Statistical models can be used to describe the collective behavior of plants in an ecosystem. The paper will touch upon **spatial statistics** and **network theory** to analyze resource competition and communication within plant communities, such as fungal networks.

- **Stochastic Resonance in Plant Signaling:** This part will explore how plants can use **stochastic resonance**, a phenomenon where the addition of random noise can enhance the detection of a weak signal. This could explain how plants respond to subtle environmental cues like changes in temperature or light intensity.

4. Physics-Inspired Tools and Methodologies

This section will detail the practical applications of physics principles in plant science research.

- **Spectroscopy and Imaging:** Techniques like **fluorescence lifetime imaging microscopy (FLIM)** and **Raman spectroscopy** provide non-invasive ways to study molecular dynamics in living plants. These methods, rooted in quantum mechanics, can reveal details about photosynthetic efficiency, stress responses, and nutrient distribution.

- **Advanced Data Analysis:** The massive datasets generated from plant genomics and phenomics require sophisticated statistical analysis. This subsection will discuss the use of **machine learning** and **complex networks** to find hidden patterns and relationships in plant data. The principles of **information theory**, a branch of statistical physics, can be used to quantify the flow of information in plant signaling networks.

5. Case Studies and Future Directions

This section will provide concrete examples of the successful integration of these disciplines.

- **Improving Crop Yields:** Applying non-equilibrium thermodynamics to understand nutrient uptake can lead to more efficient fertilizer application.
- **Developing Stress-Resilient Crops:** Using quantum models to study stress responses at the molecular level can help in developing crops that are more resilient to drought, heat, and disease.

- **Biomimicry:** Understanding the physics behind photosynthesis can inspire new designs for solar energy technologies. The paper will briefly discuss how mimicking the highly efficient light-harvesting complexes of plants could lead to a revolution in renewable energy.

6. Conclusion

The paper will conclude by summarizing the key arguments. The integration of physics and statistical insights offers a powerful new framework for plant science. This interdisciplinary approach not only deepens our fundamental understanding of plant biology but also paves the way for practical innovations in agriculture and sustainability. It represents a **"quantum leap"**—a fundamental shift—in our approach to understanding and interacting with the plant world.

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PHYTOCHEMISTRY- AREVIEW ON THE SECRETS OF PLANT DERIVED COMPOUNDS

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ABSTRACT

Phytochemistry is an interdisciplinary field combining Chemistry, Botany and Pharmacology. It is the study of plant derived compounds and has significant impacts on various fields including medicine, agriculture, environment and industry. The compounds include terpenoids, alkaloids, phenolics etc. These bioactive compounds play crucial roles in plant physiology and also very important in medicine due to their potential therapeutic properties.Phytochemical analysis plays an important role in quality control and standardisation of herbal medicines.

Phyto chemistry contributes to Drugdiscovery and development in modern pharmacy.The capabilities of phytochemical analysis have been expanded by the advance techniques in analytical methods. Analytical techniques like Chromatography and Mass spectrometry have elucidated the diverse chemical profiles of plants enabling the identification of novel compounds for use in Pharmaceuticals, Nutraceuticals.

Phytochemistry is integral to understanding plant biology, developing natural products and contributing to various industrial sectors.

Alkaloids are known for their pharmacological effects on humans. Morphine, obtaining from Papaver somniferum is a potent painkiller.Quinine, which is obtained from Cinchona, is used to treat malaria.

Flavonoids are antioxidants that help protect the body against oxidative stress. They also have anti-inflammatory,heartprotectingproperties. ExampleQuercetin, found in onions. Catechins found in green tea.

Terpenoids are widely used in perfumes, flavouring and traditional medicine.ExampleLimonene which is present in Citrus peel has anti-inflammatory effects. Menthol present in Peppermint is used for soothing properties.

Essential oils contain volatile compounds with microbial, anti-inflammatory and calming effects.Example Lavender oil is used to reduce stress and anxiety.

Phytochemicals play vital roles in plant defence, flavour and Aroma.Their therapeutic significance extends to human health offering abroad spectrum of benefits such as anti-inflammatory, anti-microbial, anti-cancer and antioxidant activities. Many modern medicines and natural health products are derived from the plant compounds. Phytochemistry is essential for the agricultural and ecological Sciences and also for the development of new pharmaceuticals and health promoting products.

Key words:*Phytochemistry, Medicines, Agriculture, Pharmacology,*

Introduction

Phytochemistry is the study of Phytochemicals, that are derived from plants. Phytochemistry is an interdisciplinary field that combines botany, chemistry, and pharmacology to study the chemical composition of plants. It has been used a rich source of discovery for centuries in traditional medicine, food, and cosmetics. Modern research has confirmed their potential as a source of new drugs and therapies. Plant secondary metabolites, such as alkaloids, flavonoids, and terpenes, possess a wide range of biological activitiesincluding antioxidant, anti-inflammatory, and antimicrobial properties, making them valuable resources for various industries.This review aims to provide an overview of the current state of knowledge on phytochemistry, highlighting the potential applications of plant-derived compounds in various fields, including medicine, agriculture, and food science.

The study of phytochemistry has led to the discovery of numerous bioactive compounds, including, Alkaloids (e.g., caffeine, nicotine, and morphine), Flavonoids (e.g., quercetin and kaempferol), Terpenes (e.g., limonene and beta-carotene), Phenolic acids (e.g., salicylic acid and ferulic acid).

Classification of Phytochemicals

Phytochemicals are classified into two types:

Primary Metabolites: These are vital for plant growth and development (e.g., sugars, amino acids, proteins, nucleic acids).

Secondary Metabolites: These have ecological and therapeutic functions and include alkaloids, terpenes, flavonoids, phenolics, tannins, saponins, glycosides, lignans, and others.

Types of Phytochemicals

The article highlights several major classes:

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Alkaloids – Known for analgesic and stimulant properties.
Flavonoids – Powerful antioxidants with anti-inflammatory effects.
Tannins – Astringent compounds with antimicrobial activity.
Saponins – Known for immune-boosting and cholesterol-lowering effects.
Terpenoids – Aromatic compounds with antiviral and anticancer potential.
Glycosides – Often used in cardiac treatments

Key Groups of Phytochemicals
Phenolics:Major subtypes: phenolic acids (such as protocatechuic, vanillic, caffeic, ferulic), flavonoids, tannins, lignans, stilbenes.

Sources: cereals, fruits, vegetables, some algae.

Properties: strong antioxidants, protective against chronic diseases, implicated in gut microbiota modulation.

Flavonoids: Over 4,000 types found in vegetables, fruits, and beverages.
Subgroups are flavanols (Quercetin, Kaempferol), flavanones (Hesperetin), flavones, isoflavones, anthocyanins, flavanols.
Sources: fruits, vegetables, teas, wines.

Properties: antioxidant, anti-inflammatory, cardioprotective, enzyme inhibition, cytotoxic, and antimicrobial activities.

Tannins: High-molecular-weight polyphenols used in the food, dye, and pharmaceutical industries due to astringent.

Types: Hydrolysable (Gallo tannins, ellagitannins), condensed tannins (proanthocyanidins).
Sources: oak galls, chestnut, tea, wine, barks.
Applications: leather tanning, dyes, wine/beer clarification, pharmaceuticals (astringent, anti-inflammatory).

Alkaloids: A class of nitrogen-containing compounds found in plants

Examples: morphine, codeine, quinine, atropine, vincristine, nicotine.

Sources: poppy, cinchona, tobacco, belladonna, vinca, ephedra.

Properties: analgesic, anti-hypertensive, anti-malarial, anticancer, anaesthetic, stimulant, antiarrhythmic.

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Terpenoids: Derived from isoprene units, monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes are different types.
Examples: limonene, menthol, carotenoids, tocopherols, taxol.
Uses: fragrances, flavors, essential oils, pharmaceuticals (anticancer, antimicrobial, vitamin precursors).
Properties:Notable for anticarcinogenic, antimalarial, and antimicrobial properties.
Saponins: Glycosylated triterpenes or steroids.
Properties: antimicrobial, hypocholesterolaemia, and immunostimulant properties.

Extraction and Analytical Methods
1.Conventional Extraction Techniques
Maceration: Soaking plant material in solvent at room temperature.
Infusion and Decoction: Use hot or cold solvents for extraction, suitable for sensitive plant components.
Digestion and Percolation: Use gentle heat or gravity to encourage solvent penetration and extraction.
Soxhlet Extraction: Employs continuous hot solvent circulation for extracting non-thermolabile compounds.

Modern Extraction Approaches
Microwave-assisted Extraction: Employs electromagnetic waves for rapid, high-yield extraction.
Ultrasound-assisted Extraction: Utilizes ultrasonic waves to break cell walls and enhance extraction yields.
Reflux Method: Uses repeated evaporation and condensation of solvent
Analytical Techniques
Qualitative Phytochemical Screening: Colorimetric and precipitation reactions for alkaloids, flavonoids, tannins, etc.
Chromatography (TLC, HPTLC, HPLC, GC): Separate, detect, and quantify the components in plant extracts.
Spectroscopy (UV-Vis, NMR, MS): Used for identification and structural analysis of phytochemicals.

Biological Activities of Phytochemicals
Phytochemicals have been found to possess a wide range of biological activities, including:
Antioxidant activity: Plant-derived compounds, such as flavonoids and phenolic acids, have been shown to possess antioxidant activity, can neutralize free radicals which can help protect against oxidative stress and inflammation.

Anti-inflammatory activity: Compounds such as alkaloids and terpenes have been found to possess anti-inflammatory activity, which can help reduce inflammation and alleviate

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symptoms associated with various diseases. Suppress pro-inflammatory mediators, good for managing chronic inflammatory diseases.

Antimicrobial activity: Plant-derived compounds, such as essential oils and phenolic acids, have been shown to possess antimicrobial activity, which can help prevent the growth of microorganisms. (e.g., berberine, curcumin).

Anticancer: Induce apoptosis, inhibit angiogenesis, and stop tumour proliferation (e.g., Taxol, Vincristine).
Cardioprotective: Improve heart health by reducing cholesterol and inflammation.

Applications of Phytochemicals

Phytochemicals have a wide range of potential applications, including:
Medicine: Plant-derived compounds have been used to develop new drugs and therapies, such as anticancer agents and antimicrobial agents.

Agriculture: Plant-derived compounds can be used as natural pesticides and fertilizers, reducing the need for synthetic chemicals.
Food science: Plant-derived compounds can be used as natural food additives and preservatives, enhancing the nutritional value and shelf life of food products.

Future Directions

1. Sustainable sourcing: Ensuring the sustainable harvesting and production of plant-derived compounds.
2. Standardization: Standardizing the extraction and processing of plant-derived compounds to ensure consistency and quality.
3. Integration with modern medicine: Integrating plant-derived compounds with modern medicine to develop new therapies and treatments.

Conclusion

Phytochemistry is a rich field of study that has led to the discovery of numerous bioactive compounds with potential applications in various fields. Phytochemistry reveals the vast chemical diversity of plant-derived compounds, supporting advances in healthcare, pharmaceuticals, and agriculture. Modern and traditional extraction and analysis methods have enabled the discovery and utilization of numerous bioactive compounds for medical and industrial purposes.Further research is needed to fully explore the potential of plant-derived compounds and to develop new products and therapies.

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IMPACT OF POLLUTION ON BIODIVERSITY

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Abstract:

Biodiversity refers to the variety of living things on Earth, including flora and fauna,funga and biota. There are three types of biodiversity -Genetic,Species and Ecological. Without biodiversity, there is no life. Earth's biodiversity is so rich and amazing. However, many species have become extinct so far due to natural disasters and man-made activities. But many species are at risk of extinction due to pollution caused by human activities.Pollution has a profoundly harmfulimpact on biodiversityaffecting ecosystems, species in various ways and the overall health of the earth. The main forms of pollution—air, water, soil, and noise etc...

Air pollution damages plants by disrupting photosynthesis and reproduction, while animals suffer from respiratory problems and changes in their habitats. This disrupts the food chain and further threatens the life of some species.

Water pollution degrades aquatic ecosystems and leads to the collapse of entire aquatic food chains. Due to eutrophication depletion of oxygen takes place which leads to "Dead zones" for marine life.

Soil pollution by chemicals, pesticides and heavy metals affects higher trophic levels in the food chain through plants to herbivores. This leads to a decline in species diversity.Urban environments and human activities are causing sound pollution. This noise pollution impacts human health, wildlife and ecosystems (ex: pollination)

Overall, pollution disrupts the delicate balance of ecosystems, leading to a loss of clean water, air, and food which can in turn, have long-term consequences for ecosystem services . And also disrupt habitats, food webs, and lead to the extinction of species or decline of species.

Every small action against pollution can take count and collective efforts can reduce the impact of pollution on biodiversity. Strategies to reduce pollution are Reducing of emissions and waste, Implementation of sustainable practices (eg: agriculture, industry), Protection and

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restoration of habitats, Monitoring and control of pollution, Create awareness and raising of awareness,Supportingof conservationefforts,Development of pollution prevention technologies.Cooperation between countries, conducting seminars and creating public awareness can reduce pollution and help promote biodiversity.

Keywords:*Biodiversity, Pollution, Ecosystem, Air Pollution, Water Pollution, Soil Pollution, Species Extinction, Conservation, Environmental Impact*

Introduction

Biodiversity, derived from the term 'biological diversity', encompasses the vast and complex variety of all life on Earth, from microscopic organisms to the majestic ones. It includes the amazing variety of flora, fauna, fungi and microorganisms that inhabit our planet's diverse biospheres. This wealth can be scientifically classified into three distinct, but interconnected types: genetic diversity (the diversity of genes within a species), species diversity (the diversity of species in a given area) and ecosystem diversity (the diversity of ecosystems within the biosphere).

Biodiversity is not just a collection of species; it is the fundamental engine that powers the planet's ecosystems. These complex systems provide vital and irreplaceable services that support human well-being and all life on Earth. These services include purifying air and water, regulating the climate, pollinating crops and creating nutrient-rich soil. Without the rich fabric of life, these essential functions will collapse, threatening our ability to thrive.
Despite its profound importance, biodiversity is facing an unprecedented and acute crisis. The main cause of this decline is human-caused pollution, which acts as a corrosive force that fundamentally alters the natural environment and disrupts the delicate ecological balance that has evolved over thousands of years. This paper examines major forms of pollution, including air, water and land pollution, and analyses their widespread and harmful effects on biodiversity, and highlights how these pollutants affect the health and resilience of our planet's living systems.

Types of Pollution and Their Impact on Biodiversity

1. Air Pollution:-

Air pollution, caused by the release of harmful gases and particulates from industries, vehicles, and agriculture, has significant impacts on both plant and animal life.

- **Effects on Plants:**

Cellular and genetic damage: Pollutants such as ozone cause oxidative damage to plant cells, damaging cell membranes and disrupting their function. This leads to visible lesions such as chlorosis (yellowing of leaves) and necrosis (dead tissue). Some pollutants, such as heavy metals and vehicle emissions, can also damage plant DNA.

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- **Reproductive problems:** Air pollution can interfere with plant reproduction by damaging pollen, reducing their survival rate or delaying flowering. This can lead to reduced seed production and, in the long term, decline in sensitive plant species.

Root damage and nutrient absorption: Acid rain and the accumulation of heavy metals in soil alter its pH and chemistry. Increased soil acidity releases aluminium ions, which damage plant roots, impeding their ability to absorb essential nutrients and water.

- **Effects on Animals:**

Bioaccumulation: Toxic pollutants such as heavy metals and persistent organic pollutants (POPs) accumulate in animal tissues. As these animals are eaten by predators, the concentration of these toxins increases in the food chain, a process called bioaccumulation or biomagnification. This makes top predators such as eagles and bears particularly vulnerable to toxicity.

Endocrine disruption: Chemicals present in polluted air act as endocrine disruptors, causing hormonal imbalances that affect the development, growth, and reproductive success of animals. For example, some amphibians have been seen to develop deformities and skewed sex ratios due to exposure to these pollutants.

Habitat and food chain disruption: Acid rain can kill aquatic invertebrates and fish, which are important food sources for other animals. Changes in soil chemistry can alter plant communities, favoring species that are more tolerant of pollutants over species that are more sensitive. This reduces the availability of food and shelter for animals that depend on those sensitive plants.

2. Water Pollution:-

Water pollution arises from industrial discharge, agricultural runoff, sewage, and plastic waste, which contaminate freshwater and marine ecosystems.

Eutrophication:Excess nutrients (nitrogen and phosphorus) cause algal blooms, leading to oxygen depletion and the formation of "dead zones" where marine life cannot survive.

Bioaccumulation and Toxicity:

- Physical and behavioral effects:Plastic waste, a major component of water pollution, poses a direct physical threat to marine and freshwater organisms. Larger plastic debris, such as discarded fishing nets (often called ghost nets) and plastic bags, can cause entanglement, which can lead to injury, suffocation, or starvation. Animals such as sea turtles, seals, and seabirds often mistake plastic bags for food, which can lead to internal obstructions, a false sense of fullness, and ultimately starvation. Microplastics, which are

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tiny pieces of plastic, are ingested by even the smallest organisms, becoming embedded in their tissues and damaging their digestive systems.

- Chemical and hormonal disruption: Chemical pollutants, including pesticides, industrial compounds, and pharmaceutical products, act as endocrine disruptors. These chemicals interfere with the hormonal mechanisms of aquatic organisms, causing developmental abnormalities, reproductive failure, and behavioral changes. For example, some fish and amphibians exposed to these pollutants may develop distorted sex ratios or physical deformities. This widespread disruption of hormonal systems can have serious long-term effects on the health and sustainability of entire populations.
- Loss of Aquatic Biodiversity:Pollution not only poisons animals; it also destroys their habitats. Sedimentary runoff from agriculture and construction suffocates coral reefs and other bottom-dwelling organisms, blocking sunlight and disrupting their reproductive cycles. Oil spills coat the feathers of seabirds and the fur of marine mammals, destroying their ability to insulate and causing hypothermia. These polluted environments cannot sustain the sensitive species that depend on them, causing them to migrate or even die.

3. Soil Pollution:-

Soil pollution from pesticides, heavy metals and industrial waste affects soil health and biodiversity.

- Impact on Microorganisms and Plants: Soil is a living ecosystem, home to a wide variety of organisms, from earthworms and insects to bacteria and fungi. These organisms are vital for maintaining soil health and providing essential ecosystem services. Soil pollutants disturb this delicate balance in several ways:
- Destruction of key species: Pollutants such as heavy metals and pesticides are toxic to sensitive species, causing their populations to decline. For example, earthworms, which are important for soil aeration and nutrient recycling, are highly sensitive to chemical pollution. Their loss can severely impair soil structure and fertility.
- Altered nutrient cycling: Microorganisms in the soil are responsible for processes such as the nitrogen cycle and carbon cycling. Pollutants can kill or inhibit these microorganisms, thereby preventing the decomposition of organic matter and the conversion of nutrients into forms that can be used by plants. This reduces soil productivity and leads to nutrient imbalances.

Effect on Food Chains and human health:

- Biomagnification in the food chain: Pollutants don't just stay in the soil; they move up the food chain. Plants absorb toxins from the soil, which are then consumed by herbivorous animals. When predators eat these herbivores, the concentration of toxins increases at each trophic level. This process, called biomagnification, causes dangerously high levels of pollutants in top predators, including humans. A classic example of this is the accumulation of DDT, which caused thinning of eggshells of predatory birds such as eagles, leading to a sharp decline in their population.
- Effects on human health: Exposure to contaminated soil, whether through swallowing, inhaling soil dust or eating contaminated crops, can cause serious health problems for humans. Heavy metals such as lead and mercury can cause irreversible neurological

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damage and organ failure, while pesticides and industrial chemicals can increase the risk of cancer, hormonal imbalances and developmental disorders, especially in children.

4. **Noise Pollution:-**

Although often overlooked, noise pollution caused by transportation, industrial activities, and urban development has a significant impact on biodiversity.
Impact on Wildlife Behavior:
Noise pollution causes a variety of behavioural and physiological changes in wildlife.

- Changes in foraging and hunting:
  Noise pollution directly affects the ability of many animals to hunt or avoid predation. For sound-dependent predators such as owls and bats, a noisy environment can mask the sounds of their prey, making it more difficult to hunt successfully. For prey animals, noise can prevent them from hearing an approaching predator, leaving them more vulnerable. This can make them more cautious and stressed, allowing them to spend less time foraging for food and looking for threats.
- Changes in mating rituals and reproduction:
  Many species, especially birds and amphibians, rely on specific sounds to attract mates. Noise pollution from human activities often falls in the low frequency range of these sounds, drowning them out. In response, some animals may change their calls to a higher pitch or a louder voice, which requires more energy and makes them less attractive to potential mates. For example, some female frogs prefer to call out in a lower pitch, which is a sign of larger and healthier male frogs. If male frogs are forced to raise their calls, they may have less success finding mates. This can lead to a decrease in mating success, population size, and genetic diversity.
  Disruption of Pollination:
  Studies show that noise interferes with insect behavior, affecting pollination and reducing plant reproduction rates.
- Changes in pollinator community composition
  Noise causes some pollinators to stay away from noisy areas, while others remain unaffected or even thrive. For example, some studies show that birds such as hummingbirds increase their activity in noisy areas because their predators, such as scrub jays, are sensitive to noise and move away. This leads to a shift in the species that pollinate plants, and a preference for species that can tolerate noise more. This can be a negative change for plants that depend on a diverse range of pollinators to ensure genetic diversity.
- Disruption of acoustic communication:
  In addition to general noise, some plants and pollinators actually use sound or vibrations to communicate. For example, some flowers respond to the specific buzzing vibrations of bees to increase their nectar production. Loud background noise drowns out these signals, making it harder for pollinators to find flowers or for plants to respond to their presence. This makes pollination less effective.

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- Indirect effects on plants
  When noise pollution drives away effective pollinators, plants in those areas may have less reproductive ability. Studies have shown that noisy environments can decrease the seed production and overall health of plants, leading to long-term declines in the populations of those plant species. This also has an impact on the entire ecosystem, as other organisms that rely on those plants for food or shelter may also decline.

Consequences of Pollution on Ecosystem Services

Pollution diminishes ecosystem services by damaging or destroying the natural processes that provide these benefits. It directly impacts human well-being by affecting health, the economy, and society.

1. Essential Services:

Essential services are the products we directly obtain from nature. Pollution contaminates these products, making them less available or safe.

Food: Soil and water pollution from pesticides, industrial waste, or agricultural runoff can contaminate crops and aquatic life, introducing toxic substances like heavy metals into the food chain. This not only makes food unsafe but also reduces crop yields and fish populations.

Water: Pollution from chemicals, sewage, and industrial waste in rivers, lakes, and groundwater renders water unfit for drinking, agriculture, and industry, increases treatment costs, and reduces water availability.

2. Regulating Services

Regulating services are natural processes that control environmental conditions. Pollution disrupts these delicate balances.

Air and Water Purification: Ecosystems like wetlands and forests naturally filter pollutants. However, high pollution levels can impair them, reducing their ability to purify air and water. For example, excess nutrients from agricultural runoff can cause eutrophication, leading to "dead zones" with low oxygen levels in water bodies.

Climate Regulation: Air pollution, especially greenhouse gases, contributes to climate change. This reduces the ability of ecosystems to regulate the climate through processes like carbon sequestration, creating a vicious cycle.

Pollination: Air pollutants like ozone can interfere with the chemical signals plants use to attract pollinators. Pesticide pollution directly harms pollinators like bees, jeopardizing their essential service to food crops and wild plants.

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3. Cultural and Supporting Services
Cultural and supporting services are the non-material and fundamental benefits that ecosystems provide. Pollution diminishes the quality of these services.

Recreation and aesthetics: Pollution from waste and pollutants in beaches, rivers, and parks makes these areas less attractive and unsafe for recreation. This can harm local economies that depend on tourism.

Biodiversity: Pollution is a major cause of biodiversity loss because it contaminates or degrades habitats, leading to the decline or extinction of species. The loss of these species disrupts vital supporting services such as nutrient cycling and healthy soil formation, which are the foundation for all other ecosystem services.

Strategies for Mitigating Pollution and Protecting Biodiversity

Key strategies to reduce pollution and protect ecosystem services are a mix of policy, technological innovation and behavioural change. These actions are interconnected and operate at different scales, from the individual to the global – reducing pollution at source, cleaning up existing pollution and restoring natural systems.

1. Reduce emissions and waste
This means adopting clean technologies and processes across all sectors. In industry, this means using filters and scrubbers to capture pollutants before they are released into the air and water. For energy, this means switching from fossil fuels to renewable energy sources such as solar, wind and hydropower, which produce zero emissions. At the individual level, reducing, reusing and recycling waste to reduce manufacturing waste and environmental impact.

2. Implement sustainable practices
Sustainable practices are actions that meet the needs of the present without compromising the ability of future generations to meet their own needs. In agriculture, this includes using precision agriculture to apply fertilizers and pesticides only where needed, and using conservation tillage to prevent soil erosion. For urban areas, this includes managing storm water and creating green infrastructure such as rain gardens and permeable sidewalks to prevent water pollution.

3. Protect and restore habitats
Protecting and restoring natural habitats is important because healthy ecosystems are better able to handle pollution. This includes conserving existing natural areas to maintain their ability to filter air and water, and reforesting and restoring wetlands to rebuild degraded ecosystems. These restored habitats act like natural "sponges," absorbing pollutants and providing essential ecosystem services.

4. Improve monitoring and regulation
Effective pollution control requires a strong monitoring and regulation system. This includes strictly enforcing environmental laws, such as setting limits on industrial emissions and wastewater discharges. This includes using modern technologies such as satellite imaging and real-time sensors to track pollution levels and identify sources, allowing authorities to respond quickly and hold polluters accountable.

5. Increase public awareness and education
Educating the public is crucial to fostering a sense of collective responsibility. By raising awareness about the consequences of pollution and the benefits of a healthy environment, communities are more likely to support and participate in conservation efforts. This encourages environmentally conscious behaviors such as reducing consumption, disposing of waste properly, and supporting strong environmental policies.

6. Strengthen international cooperation
Since pollution does not respect borders, international cooperation is essential. This includes developing and implementing transboundary environmental agreements on issues such as climate change and biodiversity. It also involves encouraging all countries, especially developing countries, to adopt cleaner practices and sharing green technologies and scientific data to help them address environmental challenges more effectively.

7. Promote technological innovation
Technological innovation is a powerful tool to prevent and clean up pollution. This includes developing new, environmentally friendly materials to replace plastics, advanced filtration systems for water and air, and bioremediation technologies that use microorganisms to break down pollutants in soil and water. Investing in green technologies can help create a more sustainable and resilient future.

Conclusion

Pollution is a major driver of biodiversity loss, threatening the stability and resilience of ecosystems worldwide. By degrading habitats through contamination of air, water, and soil, and by disrupting critical ecological processes like food chains and nutrient cycles, pollution directly endangers countless species. The consequences of this biodiversity loss are far-reaching, impacting essential ecosystem services such as clean water, air, and fertile soil, which are fundamental to human survival and well-being. Mitigating this crisis requires a unified and comprehensive effort. It is imperative that individuals, governments, and international organizations collaborate on policies and actions to reduce pollution at its source, restore damaged habitats, and promote sustainable behaviors. Every small effort—whether technological, educational, or behavioral—contributes to a healthier planet.

For example, AI and drone technology can be used to mitigate biodiversity loss. This approach involves using drones, cameras, and environmental DNA (eDNA) to collect large amounts of data, which is then analyzed by AI for better monitoring and protection of ecosystems. Drones can also be used for rapid reforestation in deforested areas. This synergy of technology enables us to implement conservation efforts on a large scale and efficiently,

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even in remote or difficult-to-access areas. It significantly improves our ability to combat poaching and restore natural habitats.

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GREEN CHEMISTRY OF 1, 8-NATHYRIDINE AND ITS CHARECTERISATION

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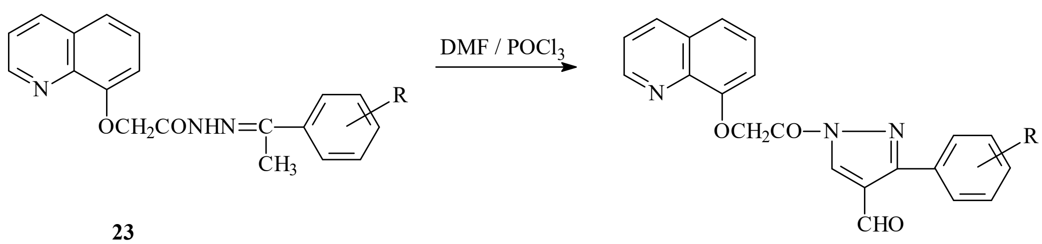
The pyrazole core is one of the important five membered nitrogen heterocyclic motifs embedded in several bioactive products. Among this prolific family of heterocycles 1,3-diaryl pyrazoles attract great interest owing to their wide range of applications in medicinal chemistry. Several methods for the synthesis of pyrazole derivatives have been reported.

A review of recent literature on the synthesis and biological significance of various pyrazoles is summarized.



23 **24**

Present work

Pyrazole is a versatile lead molecule for designing potential bioactive agents[11-13]. The Vilsmeier-Haack reaction of acetophenone phenylhydrazone resulted in the formation of pyrazole-4-carbaldehyde[14,15]. In Vilsmeier-Haack reaction, DMF-$POCl_3$ has a dual role of reagent as well as solvent. $POCl_3$isa highly toxic solvent and its use is hazardous to health and is also pollutant of the environment. 1,8-Naphthyridines play a pivotal role in the field of heterocyclic chemistry[16-18]. Microwave induced Organic Reaction Enhancement (MORE) chemistry has gained popularity as a non conventional technique for rapid organic synthesis, it is eco-friendly, economical and is believed to be a step towards green chemistry[19-22]. The solvent-free reaction[21], in general and on inorganic solid supports[23] under this condition are especially appealing for providing an environmentally benign system.

Motivated by these facts, herein we describe an efficient, rapid and environmentally benign protocol for the synthesis of 3-aryl-1-[3-(3-methylphenyl)][1,8]naphthyridin-2-yl]-1*H*-4-pyrazolecarbaldehydes using $POCl_3$-DMF over silica gel under MW irradiation.

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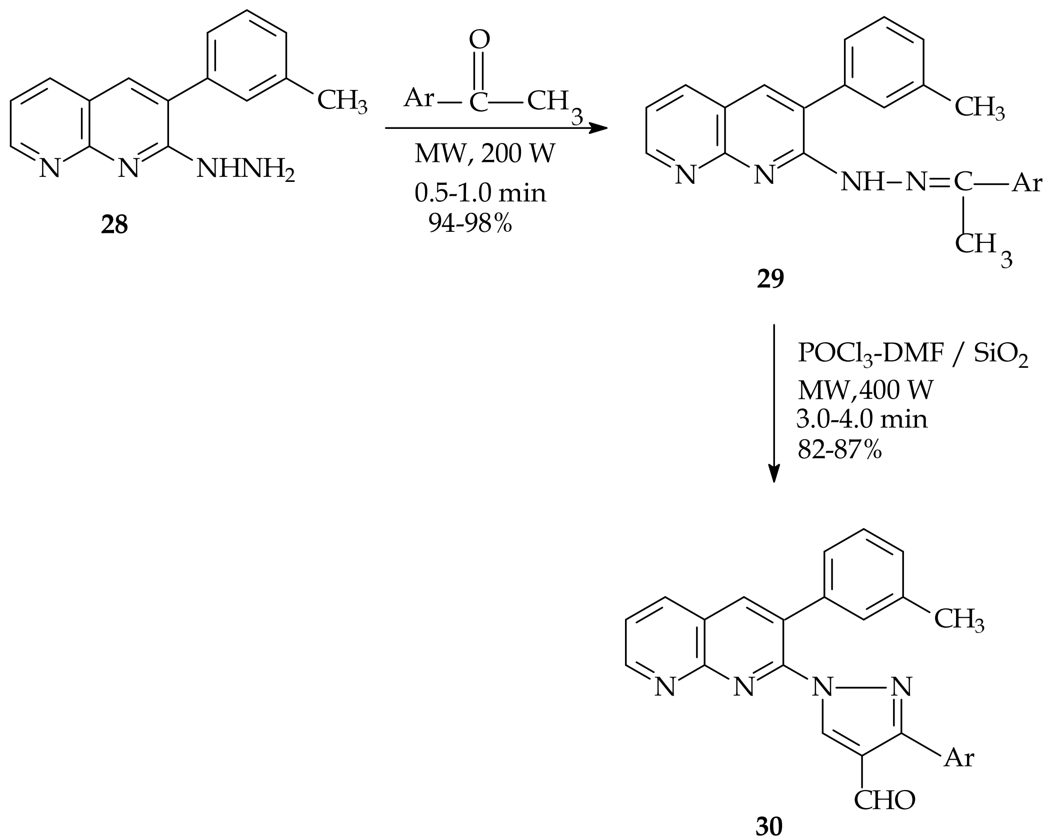

The characterization of the hydrazones **29** has been done by elemental analyses andspectral **(**IR, ^{1}H NMR and MS) data.

IR spectra

The IR (KBr) spectra of 1-aryl-1-ethanone 1-[3-(3-methylphenyl)[1,8]naphthyridin-2-yl] hydrazones **29**showed absorption bands around 3340 and 1615 cm^{-1} due toNH and C=N groups, respectively. The data are listed in **Table I**.

Table I — IR and mass spectral data 1-Aryl-1-ethanone 1-[3-(3-methylphenyl)[1,8]naphthyridin-2-yl] hydrazones **29**

Compd	Ar	□$_{max}$ in cm^{-1}		MS(ESI) [M+H]$^{+}$ *m/z*
		NH	C=N	
29a	C_6H_5	3343	1615	353.2

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29b	4-$CH_3C_6H_4$	3345	1613	367.2
29c	4-$CH_3OC_6H_4$	3339	1612	383.2
29d	4-ClC_6H_4	3340	1617	387.1
29e	4-BrC_6H_4	3336	1617	431.1
29f	3-$NO_2C_6H_4$	3335	1616	398.2
29g	4-$NO_2C_6H_4$	3333	1615	398.2
29h	2-Naphthyl	3340	1614	403.2

^{1}H NMR spectra

The ^{1}H NMR (300 MHz) spectra of 1-aryl-1-ethanone 1-[3-(3-methylphenyl)[1,8]naphthyridin-2-yl] hydrazones **29** were recorded in $CDCl_3$ and the data are recorded in **Table II**

Table II— ^{1}H NMR spectral data of 1-Aryl-1-ethanone 1-[3-(3-methylphenyl)[1,8]naphthyridin-2-yl] hydrazones **29**

Compd	Ar	^{1}H NMR (300 MHz, $CDCl_3$) (δ,ppm)
29a	C_6H_5	2.42 (s, 3H, CH_3), 2.46 (s, 3H, CH_3), 7.72 (m,1H,C_6-H) 8.06 (m, 2H, C_4-H, C_5-H), 8.36 (m, 1H, C_7-H), 7.03-7.56 (m, 9H, Ar-H), 10.10 (s, 1H, NH).
29b	4-$CH_3C_6H_4$	2.23 (s, 3H, CH_3), 2.45(s, 6H, 2×CH_3),7.68 (m,1H,C_6-H) 8.00(m, 2H, C_4-H, C_5-H), 8.21 (m, 1H, C_7-H), 6.97-7.54(m, 8H, Ar-H), 10.05(s, 1H, NH).
29c	4-$CH_3OC_6H_4$	2.42(s, 6H, 2×CH_3), 3.86(s, 3H, OCH_3), 7.60(m,1H,C_6-H) 7.90 (m, 2H, C_4-H, C_5-H), 8.19 (m, 1H, C_7-H), 6.94-7.35(m, 8H, Ar-H), 10.04 (s, 1H, NH).

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29d	4-ClC_6H_4	2.43 (s, 6H, 2×CH_3), 7.62(m,1H,C_6-H), 7.84(m, 2H, C_4-H, C_5-H), 8.22 (m, 1H, C_7-H), 7.21-7.55 (m, 8H, Ar-H), 10.02(s, 1H, NH).
29e	4-BrC_6H_4	2.42 (s, 6H, 2×CH_3), 7.67(m,1H,C_6-H), 7.80 (m, 2H, C_4-H,C_5-H),8.30(m, 1H, C_7-H),6.98-7.57 (m, 8H, Ar-H),10.09(s, 1H, NH).
29f	3-$NO_2C_6H_4$	2.44 (s, 3H, CH_3),2.75 (s, 3H, CH_3),7.65 (m,1H,C_6-H), 7.83 (m, 2H, C_4-H, C_5-H),8.28 (m, 1H, C_7-H),7.20-7.60 (m, 8H, Ar-H), 10.05(s, 1H, NH).
29g	4-$NO_2C_6H_4$	2.42 (s, 3H, CH_3), 2.65 (s, 3H, CH_3),7.67 (m,1H,C_6-H), 7.92 (m, 2H, C_4-H, C_5-H), 8.26 (m, 1H, C_7-H), 7.18-7.56(m, 8H, Ar-H),10.07(s, 1H, NH).
29h	2-Naphthyl	δ 2.43 (s, 3H, CH_3), 2.58 (s, 3H, CH_3), 7.70 (m,1H,C_6-H), 8.02 (m, 2H, C_4-H, C_5-H),8.32(m, 1H, C_7-H), 7.15-7.52 (m, 11H, Ar-H), 10.10 (s, 1H, NH)

Mass spectra

The ESI mass spectra of 1-aryl-1-ethanone 1-[3-(3-methylphenyl)[1,8]naphthyridin-2-yl] hydrazones **29**exhibited strong $[M+H]^+$ions (**Table I**).


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FROM FORESTS TO FIELDS: THE CRITICAL ROLE OF PLANT RESOURCE MANAGEMENT IN BIODIVERSITY PRESERVATION

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ABSTRACT:

Plant resource management is integral to sustaining ecosystems and conserving biodiversity, playing a crucial role from dense forests to cultivated agricultural fields. This paper, titled *From Forests to Fields: The Critical Role of Plant Resource Management in Biodiversity Preservation*, explores how strategic management of plant resources contributes to the health and diversity of global ecosystems. It emphasizes the impact of deforestation, habitat fragmentation, and intensive agriculture on biodiversity loss and ecosystem decline. The abstract highlights best practices in plant resource management, including sustainable harvesting, reforestation, agro-ecological methods, and habitat restoration, that support ecosystem services and resilience. The role of indigenous knowledge and community-led conservation initiatives is discussed as an essential element of effective management strategies. The analysis also underscores the need for strong policies and global cooperation to implement sustainable management plans that reconcile human development with environmental sustainability. This paper aims to provide a comprehensive understanding of how integrated plant management practices, from natural forest stewardship to sustainable farming, can safeguard biodiversity, mitigate climate change impacts, and promote a balanced coexistence between human activity and natural habitats.

KEY WORDS: *Ecosystem, Agro-ecology, Biodiversity, Sustainable farming, Habitat, Deforestation, Forest Resource, Conservation.*

Introduction

Biodiversity, the variety of life on Earth, forms the foundation of ecosystem services that support human well-being and the health of the planet. Within this intricate web, plants play a vital role as primary producers and habitat formers, contributing to the stability and functioning of ecosystems. However, human activities, including deforestation, agricultural expansion, and urbanization, have placed immense pressure on plant resources, leading to habitat loss and a decline in biodiversity. Understanding and implementing effective plant resource management is crucial to address these challenges and promote the conservation of biodiversity. The transition from natural forests to agricultural fields represents a significant transformation in land use that can profoundly affect ecosystem integrity. Forests, with their dense plant diversity, provide a range of ecological benefits, including carbon sequestration, water cycle regulation, and habitat for countless species. Conversely, agricultural fields, while essential for food production, often replace complex ecosystems with monocultures that may lack biodiversity and ecological resilience. This dichotomy underscores the need for strategies that balance the demand for agricultural productivity with the preservation of plant diversity. This paper, *From Forests to Fields: The Critical Role of Plant Resource Management in Biodiversity Preservation*, explores how sustainable plant management practices can help maintain biodiversity from natural forests to managed agricultural landscapes. It examines the threats posed by unsustainable practices and identifies methods such as agro-forestry, conservation agriculture, reforestation, and community-based resource management that contribute to the protection of biodiversity. By exploring case studies and existing research, this introduction sets the stage for a deeper understanding of how strategic plant resource management can bridge the gap between environmental conservation and human development.

Objectives:

To highlight the significance of effective plant resource management in maintaining ecosystem health and biodiversity across various landscapes, from forests to agricultural fields.

1. **Identify Threats to Plant Resources and Biodiversity**: To analyze the major threats posed by human activities such as deforestation, overexploitation, habitat fragmentation, and unsustainable agricultural practices that contribute to biodiversity loss.
2. **Explore Sustainable Management Practices**: To investigate methods and strategies, including sustainable harvesting, reforestation, agroforestry, and habitat restoration, that can support biodiversity and ecosystem services.
3. **Assess the Role of Indigenous and Local Knowledge**: To evaluate the contribution of traditional ecological knowledge and community-based approaches to the success of plant resource management and conservation efforts.
4. **Review Policy and Global Initiatives**: To assess existing policies and global conservation initiatives aimed at promoting sustainable plant management and biodiversity conservation, and to identify areas for policy improvement.
5. **Present Case Studies and Best Practices**: To provide real-world examples and case studies that demonstrate successful plant resource management practices and their positive impacts on biodiversity.
6. **Recommend Strategies for Future Action**: To propose recommendations for enhancing plant resource management in ways that align with sustainable development and biodiversity conservation goals, ensuring a balanced coexistence between human needs and environmental stewardship.

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Materials and Methods :

1. **Literature Review**: Comprehensive analysis of existing research studies, journal articles, and reports related to plant resource management and biodiversity conservation. This review includes a synthesis of global and regional data on deforestation rates, biodiversity indices, and the effectiveness of different plant management practices.
2. **Case Study Selection**: Identification of diverse case studies spanning different ecosystems (e.g., tropical rainforests, temperate forests, and agricultural landscapes) and geographical regions. Each case study provides insights into successful and challenged plant management practices and their outcomes on local biodiversity.
3. **Data Collection**:

   Primary Data: Field visits to select regions where sustainable plant resource management practices are being implemented. This includes qualitative interviews with local stakeholders, conservationists, and policymakers.

   Secondary Data: Collection of data from governmental and non-governmental organization reports, databases (such as those of the Food and Agriculture Organization and International Union for Conservation of Nature), and published articles focusing on land use changes and biodiversity metrics.
4. **Methods of Analysis**:

   Comparative Analysis: Cross-comparison of biodiversity levels and ecosystem health metrics between managed and unmanaged ecosystems to determine the impact of plant resource management strategies.

   Qualitative Analysis: Thematic analysis of interview transcripts to understand local perspectives, challenges, and benefits associated with plant resource management practices.

   Quantitative Analysis: Statistical evaluation of data collected on deforestation rates, species diversity, and ecosystem productivity, utilizing tools like Geographic Information System (GIS) for spatial analysis and mapping land-use changes over time.
5. **Field Methods**:

   Observation and Sampling: Conducting on-site observations of plant management practices, including reforestation efforts, agroforestry setups, and sustainable harvesting techniques. Random sampling plots within these areas are analyzed for plant diversity, soil health, and signs of ecological recovery.

   Surveys: Administering structured surveys to local communities and stakeholders to gather input on the perceived effectiveness of current plant resource management strategies and their role in biodiversity conservation.

6. **Community Engagement**: Collaboration with local communities and indigenous groups to document traditional plant management practices and their ecological knowledge. This component involves participatory workshops and knowledge-sharing sessions to integrate community insights into the analysis.
7. **Policy and Legislation Review**: Analysis of current policies and regulatory frameworks that govern plant resource management and biodiversity conservation, identifying gaps and areas for improvement.
8. **Ethical Considerations**: Ensuring that all fieldwork and data collection methods respect the cultural practices and rights of local communities and follow ethical guidelines for research involving human participants.

This combination of qualitative and quantitative approaches ensures a holistic understanding of how plant resource management affects biodiversity and provides a robust framework for drawing conclusions and making recommendations.

Results and Discussion
Results:

1. **Impact on Biodiversity Levels**:
   Comparative analysis revealed that regions practicing sustainable plant resource management exhibited higher biodiversity indices compared to unmanaged or heavily exploited areas. For example, agro-forestry systems supported a greater diversity of plant and animal species than monoculture agricultural fields, demonstrating their role in enhancing ecosystem health.
   Reforested areas showed a gradual recovery of native plant species and increased habitat complexity, which contributed to the return of wildlife and improved ecosystem functions.

2. **Case Studies Outcomes**:
   In tropical forest regions where community-led conservation projects were implemented, a significant improvement in plant diversity and reduced deforestation rates were observed. These projects often included sustainable harvesting methods, which allowed for the continued use of plant resources without depleting them.Agricultural landscapes adopting integrated farming practices, such as crop rotation and intercropping, demonstrated improved soil health and increased pollinator populations, highlighting the role of diversified plant management in supporting ecological resilience.

3. **Community and Traditional Knowledge Integration**:
   Data from interviews and participatory workshops indicated that incorporating indigenous knowledge in resource management led to more effective conservation outcomes. Practices such as controlled burning, selective harvesting, and the use of traditional plant cultivation methods contributed to sustainable land use and preservation of native species.

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4. **Policy Effectiveness**:
   Analysis of current policies showed that regions with strong legislative support for sustainable plant management had better conservation results. However, policy gaps were noted in areas where enforcement was weak or community involvement was limited, impacting the success of biodiversity initiatives.

Discussion:

1. **Balancing Human Needs and Biodiversity**:
   The results underscore the necessity of balancing human needs for resources with environmental conservation. Agro-forestry and other sustainable agricultural practices demonstrated that it is possible to meet food production needs while maintaining ecosystem health.
   The findings confirm that practices promoting plant diversity and mixed land use can create a mosaic of habitats beneficial for various species, thereby enhancing ecological stability.
2. **Challenges in Implementation**:
   Despite the positive outcomes observed, challenges such as limited funding, lack of technical expertise, and political resistance remain barriers to widespread adoption of sustainable plant management practices. Addressing these challenges requires multi-stakeholder partnerships and targeted policy interventions.
3. **Community and Cultural Dimensions**:
   The involvement of local communities in conservation efforts was shown to be a key factor in the success of plant resource management strategies. Traditional ecological knowledge provided practical, context-specific solutions that often outperformed generalized approaches in terms of sustainability.
   Collaborative management models that integrate local knowledge with modern conservation techniques can enhance the effectiveness of biodiversity preservation efforts.
4. **Policy and Legislative Gaps**:
   Although some policies are supportive, the study highlights the need for stronger legal frameworks and better enforcement mechanisms to protect plant resources and biodiversity. Expanding incentives for sustainable practices, such as financial support for farmers implementing agro-forestry, could drive more widespread adoption. International cooperation and compliance with global biodiversity agreements are essential for cross-border ecological management and the mitigation of shared threats such as climate change and invasive species.

Further Research:

1.Evaluating Restoration Success Across Ecosystems: Further research is needed to evaluate the effectiveness of reforestation, agro-forestry, and other plant management practices across different ecosystems (e.g., wetlands, grasslands, tropical forests). This would

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help determine which strategies are most successful in restoring biodiversity and ecological functions in varying environmental contexts.

2.Socioeconomic Impacts of Plant Resource Management: Investigating the socioeconomic outcomes of sustainable plant management for local communities can provide insight into its broader benefits. Studies focusing on how these practices affect income, food security, and livelihoods could demonstrate the dual ecological and economic advantages.

3.Biodiversity Indicators and Monitoring Techniques: Developing standardized biodiversity indicators and exploring new monitoring techniques, such as remote sensing, can enhance the accuracy of biodiversity assessments. These indicators would allow for better tracking of biodiversity health in managed and unmanaged landscapes.

4.Role of Indigenous Knowledge in Modern Conservation: Additional research on how indigenous knowledge systems complement modern conservation methods could strengthen plant management frameworks. Case studies that document specific indigenous practices and their effects on biodiversity would provide valuable models for integration.

5.Comparing Carbon Sequestration Benefits: Quantitative studies assessing carbon sequestration capacities of various plant management systems, including natural forests, agro-forestry, and monoculture farms, could provide insights into their climate mitigation potential.

Future Research Directions:

1.Climate-Adapted Plant Management Strategies: As climate change impacts ecosystems globally, future research should focus on developing plant resource management practices that are resilient to extreme weather events, such as droughts and floods. This includes exploring climate-resistant crop varieties and adaptive agro-ecological techniques.

2.Landscape-Level Conservation Approaches: Future studies should focus on landscape-level plant management strategies that bridge fragmented habitats and support biodiversity across agricultural, forested, and urban areas. This approach would provide a comprehensive model for biodiversity conservation in mixed-use landscapes.

3.Incentives for Sustainable Practices: Examining economic and policy-based incentives (e.g., subsidies, carbon credits) to encourage sustainable plant management practices could shed light on effective methods for promoting large-scale adoption.

4.Exploring Genetic Biodiversity in Managed Lands: Research on the genetic diversity within managed landscapes, particularly in agro-forestry and reforested areas, can reveal the importance of genetic variation for ecosystem resilience and adaptability. This could support policies aimed at conserving genetic resources within agricultural systems.

5.Global Policy Implications and Collaborative Frameworks: Future research should investigate the effectiveness of international agreements and collaborative frameworks (such as the Convention on Biological Diversity) in promoting sustainable plant resource management. Studies can analyze the extent to which these policies influence national legislation and on-ground practices.

6.Integration of Technological Tools for Conservation: Research on the application of new technologies, such as drone mapping, artificial intelligence, and big data analytics, could improve biodiversity monitoring, enforcement, and adaptive management of plant resources.

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RECENT ADVANCES IN AGRICULTURE, HORTICULTURE, AND ALLIED SUBJECTS

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Abstract:

This article discusses the noteworthy strides made in the fields of Agriculture, Horticulture, and allied subjects, highlighting cutting-edge technologies, sustainable practices, and innovative approaches. From precision farming and genetic engineering to sustainable horticulture and interdisciplinary research, the article explores the diverse facets of advancements that are shaping the future of agriculture. The discussion encompasses precision agriculture, biotechnology, sustainable practices, interdisciplinary research, and technological innovations.

Keywords:
Precision Agriculture, Biotechnology, Sustainable Practices, Interdisciplinary Research, Technological Innovations, Crop Management, Genetic Engineering, Smart Farming, Horticulture, Agricultural Sustainability.

Introduction:

Agriculture and horticulture, vital pillars of human civilization, have witnessed transformative developments in recent times. With the global population on the rise and the need for sustainable food production becoming more pressing, researchers and practitioners in these fields are pioneering innovations that promise to revolutionize the way we cultivate crops and manage natural resources. This article aims to provide a comprehensive overview of recent advances in agriculture, horticulture, and allied subjects, shedding light on key breakthroughs that are reshaping the landscape of food production.

Precision Agriculture:

Precision Farming Techniques:

Precision agriculture, often referred to as precision farming, involves the use of technology to optimize crop yields and resource efficiency. Recent advancements in this field have led to the development and implementation of sophisticated techniques, such as satellite imaging, drones, and sensor technologies. These tools enable farmers to gather real-time data on soil conditions, crop health, and weather patterns, facilitating precise decision-making in crop management.

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Data-Driven Decision Making:

The integration of data analytics and artificial intelligence (AI) in agriculture has enabled farmers to make informed decisions based on comprehensive data sets. Machine learning algorithms analyze historical data to predict crop diseases, optimize irrigation schedules, and recommend suitable fertilization practices. This data-driven approach not only maximizes yield but also minimizes the environmental impact of farming activities.

Biotechnological Innovations:

Genetic Engineering in Crop Improvement:

Advancements in biotechnology have significantly contributed to crop improvement through genetic engineering. Scientists are now able to modify the genetic makeup of crops to enhance resistance to pests, diseases, and adverse environmental conditions. This has resulted in the development of genetically modified (GM) crops that offer increased yields and improved nutritional profiles.

CRISPR Technology in Agriculture:

The revolutionary CRISPR-Cas9 gene-editing technology has found applications in agriculture, allowing precise modifications to specific genes in plants. This technology holds the potential to accelerate the breeding of crops with desirable traits, such as drought tolerance, disease resistance, and improved nutritional content. The ethical considerations surrounding CRISPR in agriculture are also addressed as part of ongoing interdisciplinary research.

Sustainable Horticulture:

Agroecology and Permaculture:

In response to growing concerns about the environmental impact of conventional farming practices, sustainable horticulture approaches such as agroecology and permaculture have gained traction. These systems prioritize biodiversity, soil health, and ecosystem resilience. By incorporating agroecological principles, farmers can create self-sustaining ecosystems that promote long-term agricultural productivity while minimizing the use of synthetic inputs.

Vertical Farming and Urban Agriculture:

The integration of technology in horticulture has paved the way for innovative farming methods, including vertical farming and urban agriculture. Vertical farming utilizes vertical space to cultivate crops indoors, often in stacked layers or vertical towers. This approach maximizes space utilization, reduces water consumption, and minimizes the need for pesticides. Urban agriculture involves the cultivation of crops within urban environments, contributing to local food production and reducing transportation-related carbon emissions.

Interdisciplinary Research in Agriculture:

Collaborative Approaches to Problem Solving:

Recognizing the complex challenges facing agriculture, interdisciplinary research has gained prominence. Collaboration between agronomists, biologists, engineers, economists, and social scientists has led to holistic approaches to address issues such as food security, climate change adaptation, and sustainable farming practices. Interdisciplinary teams work together to develop comprehensive solutions that consider both technical and socio-economic aspects of agriculture.

Ethical and Social Implications:

As agricultural technologies advance, ethical considerations become crucial. Interdisciplinary research delves into the societal implications of emerging technologies, addressing concerns related to genetically modified organisms (GMOs), data privacy, and the equitable distribution of benefits. Ethical frameworks are essential to guide the responsible development and deployment of agricultural innovations.

Technological Innovations in Agriculture:

Robotics in Farming:

The integration of robotics in agriculture has revolutionized traditional farming practices. Autonomous tractors, robotic harvesters, and drones equipped with advanced imaging systems are increasingly being used to perform tasks such as planting, weeding, and monitoring crop health. These technologies not only improve efficiency but also reduce the labor-intensive nature of certain agricultural activities.

Blockchain Technology for Supply Chain Transparency:

Blockchain technology is making inroads into the agricultural sector by enhancing transparency and traceability in the supply chain. From farm to fork, blockchain enables stakeholders to track the journey of agricultural products, ensuring authenticity and reducing the risk of fraud. This technology holds the potential to build trust among consumers, strengthen food safety measures, and create fairer trading systems.

Conclusion:

Recent advances in agriculture, horticulture, and allied subjects are steering the industry towards a more sustainable and technologically advanced future. Precision agriculture, biotechnological innovations, sustainable horticulture practices, interdisciplinary research, and technological innovations collectively contribute to the transformation of traditional farming methods. As we navigate the challenges of a growing global population and environmental sustainability, these advancements stand as beacons of hope, paving the way for a resilient and productive agricultural sector. Continued collaboration between researchers, practitioners, and policymakers will be instrumental in harnessing the full potential of these developments for the betterment of global food systems.


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STUDY ON THE IMPACT DIFFERENT WAVE LENGTHS OF LIGHT ON THE GROWTH AND DEVELOPMENT OF PHASEOLUS VULGARIS

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A B STR AC T

This study investigates the effect of different colors (wavelengths) of light—red, blue, green, and white (control)—on the growth and development of Phaseolus vulgaris, commonly known as the bean plant. Photosynthesis, the fundamental process driving plant growth, is highly dependent on light quality. While plants absorb light most efficiently in the red and blue spectra, the role of other wavelengths, such as green light, remains a subject of continued research. This experiment aimed to quantify the impact of these different light conditions on key growth parameters, including germination rate, stem height, leaf area, and biomass accumulation. The results are expected to demonstrate that red and blue light promote optimal growth, while green light has a less significant effect. The findings of this study provide valuable insights into the fundamental relationship between light quality and plant physiology, with potential applications in horticulture, agriculture, and controlled environment farming.

Keywords:*Phaseolus vulgaris, Bean plant, Photosynthesis, Light quality, Light wavelength, Plant growth, Red light, Blue light, Green light.*

Introduction

Light is the basic environmental factor for plant growth and development. It is not only the basic energy source of photosynthesis but also an important regulator of plant growth and development. The growth and development of plants are not only restricted by the amount of light or light intensity (photon flux density, PFD) but also by the quality of light, that is light and radiation of different wavelengths and their different composition ratios. Light is the original source of energy for plant photosynthesis and growth. A wide range of signals andinformation for morphogenesis and many other physiological processes is triggered by light (Chen *et al* 2014).Different characteristics of light such as spectral composition (wavelengths), intensity, duration and directioncan influence plant growth and development.

Photosynthesis is the cornerstone of plant life, converting light energy into chemical energy to fuel growth. This process is driven by pigments, primarily chlorophyll a and chlorophyll b, which absorb light most effectively in specific parts of the electromagnetic spectrum. Chlorophyll absorbs strongly in the blue-violet (400-500 nm) and red-orange (600-700 nm)

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regions, while it reflects green light (500-600 nm), which is why plants appear green to the human eye.

The use of different light sources, particularly Light Emitting Diodes (LEDs), has allowed for precise control over the spectral composition of light in plant cultivation. This has led to a growing interest in understanding how specific wavelengths of light influence various aspects of plant growth, from germination and flowering to biomass production and nutrient content. This research paper presents the methodology and findings of an experiment designed to compare the growth of bean plants under red, blue, green, and white (full-spectrum) light.

The bean plant (Phaseolus vulgaris) was chosen as a model organism due to its rapid growth rate, easy cultivation, and significant economic importance.

Studysite

This study was conducted in the Botany lab of Government Degree College, Which islocated in, Kagaznagar, Telanganaat Thrishulpahad.

2. **Materials and Methods:**

2.1. Plant Material and Setup:
Plant species: Phaseolus vulgaris (Common bean).
Seeds: Uniform, healthy seeds were selected to ensure consistent initial conditions.
Growth medium: A sterile, nutrient-rich potting mix.
Containers: Small plastic pots with drainage holes.
Light sources: Four separate growth chambers were constructed, each equipped with a different light source:
Chamber 1 (Control): White LED light (Full-spectrum, 400-700 nm)
Chamber 2: Red LED light (approximately 660 nm)
Chamber 3: Blue LED light (approximately 450 nm)
Chamber 4: Green LED light (approximately 520 nm)
Environmental conditions: All chambers were maintained under identical conditions of temperature (25^{o}C±2^{o} C), humidity (60%±5%), and a constant 12-hour light/12-hour dark photoperiod.
Replication: Ten plants were grown in each of the four chambers to ensure statistical validity.

2.2. Experimental Procedure:
Sowing: Bean seeds were pre-soaked in distilled water for 12 hours to promote uniform germination. They were then planted in the prepared pots, with one seed per pot.
Watering: Plants were watered with a consistent volume of distilled water every two days to maintain soil moisture.
Data Collection: The following parameters were measured at weekly intervals over a period of eight weeks:


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1) Germination Rate: The percentage of seeds that successfully germinated.
2) Stem Height: Measured from the soil surface to the apical meristem using a ruler.
3) Leaf Area: The area of the first true leaves was measured using a grid method or a digital imaging analysis tool.
4) Biomass: At the end of the four-week period, plants were carefully harvested. The fresh and dry weights of the shoots (stems and leaves) and roots were measured. Dry weight was determined after drying the plant samples in an oven at 80^{o}C for 48 hours.

2.3. Statistical Analysis:

Data were analyzed using a one-way analysis of variance (ANOVA) to determine if there were statistically significant differences in growth parameters among the different light treatments. A post-hoc Tukey's HSD test was used to identify specific group differences. All statistical analyses were performed using [Statistical Software Name, e.g., R, SPSS] with a significance level of $p<0.05$.

3. Results:

Germination: All light treatments, including the control, showed a high germination rate (>90%), indicating that light quality does not significantly affect the initial germination process of bean seeds.

Stem Height: Plants grown under red and white light exhibited the greatest stem elongation, followed by blue light. Plants under green light showed the least amount of stem elongation.

Leaf Area: The largest leaf area was observed in plants grown under white and blue light. Plants under red light also had a substantial leaf area, while those under green light developed smaller, and often etiolated, leaves.

Biomass Accumulation: Total dry biomass (shoot + root) was highest in the white light control group, followed closely by the red and blue light groups. The green light group showed significantly lower total biomass. Red light-grown plants showed greater stem biomass, while blue light-grown plants showed more compact growth with greater leaf biomass.

Table1.Effectofdifferentlightontheplant.

Sr.No.	Light	Stem height						
		10Day	20Day	30Day	40Day	50Day	60Day	Atfinal harvest
1.	Blue	8.8 Cm	15.5Cm	19.2Cm	24.1Cm	28.3Cm	30.1 Cm	35.1 Cm
2.	Red	3.6 Cm	6.7 Cm	9.3 Cm	13.2Cm	18.1Cm	21.3 Cm	25.2 Cm
3.	Yellow	2.5 Cm	4.7 Cm	6.8Cm	11.2Cm	15.3Cm	19.2 Cm	24.6 Cm
4.	Green	4.1 Cm	8.8 Cm	11.1Cm	16.8Cm	20.2Cm	22.5 Cm	26.4 Cm
5.	Sun	1.6 Cm	3.5 Cm	5.2 Cm	9.3 Cm	14.1Cm	17.2 Cm	23.2 Cm

4. Discussion:

The results of this study are consistent with the known principles of plant photobiology. The superior growth performance of plants under white, red, and blue light can be directly attributed to the efficient absorption of these wavelengths by chlorophyll.

Red and Blue Light: The combination of red and blue light (as found in white light) provides the optimal spectrum for photosynthesis. Red light is highly efficient in driving the photosynthetic process and promoting stem elongation. Blue light, on the other hand, is crucial for photomorphogenesis, including the regulation of stomatal opening and the promotion of compact, sturdy growth.

Green Light: The poor growth observed under green light is due to its low absorption by photosynthetic pigments. While some green light is absorbed and utilized, the majority is transmitted or reflected. The etiolated growth (long, thin stems) in this group may be a result of the plant's attempt to search for more photosynthetically active light. However, recent studies suggest that a small amount of green light can penetrate deeper into the plant canopy, contributing to the photosynthesis of lower leaves. Our results, however, indicate that green light alone is insufficient for robust growth.

The slightly better performance of the white light group over the single-color light groups highlights the synergistic effect of a full-spectrum light source. The combination of different wavelengths, including a small proportion of green and other colors, may provide a more balanced signal for plant development, leading to overall superior growth.

5. Conclusion:

This study successfully demonstrated the profound impact of light quality on the growth and development of the common bean plant. The findings confirm that red and blue wavelengths are the most effective in promoting plant growth, a result directly correlated with the absorption spectrum of chlorophyll. Green light, while not entirely useless, is significantly less effective as a sole light source.

Future research could explore the effects of varying ratios of red and blue light, as well as the addition of small amounts of green and far-red light, to further optimize plant growth in controlled environments. This research has significant implications for the design of indoor farms, greenhouses, and other controlled agricultural systems, where tailored lighting recipes can lead to increased yields and energy efficiency.

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ETHANO MEDICINAL PLANTS IN NEELADRI FOREST, KHAMMAM DISTRICT.

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Abstract: This paper deals with exact existence of ethnomedicinal plants with their uses of Neeladri Forest, Khammam-Dist. This forestis located near Lankaplly village, Khammam-Dist. Field visit was conducted during two consecutive different seasons of 2023 and 2024at the Neeladri Forest. thirty – two medicinal plants are enumerated in this paper.

Keywords: *ethnomedicinal plants,Neeladri Forest,medicinal plants*

Introduction:

India possesses a diverse array of medicinal plants, scattered across various geographical and environmental conditions, along with accompanying tribal and folk knowledge systems. Traditional medicinal herbs are natural substances that have historically been utilized for therapeutic purposes based on empirical knowledge. The variety of medicinal plants can enhance the accessibility of ready-to-use traditional medicines. Every region possesses unique expertise in the application of diverse medicinal plants, passed down through generations, rooted in the community's intuitive knowledge derived from an understanding of the relationship between the universe, humanity, and God. S. Lhsan, Sunandar, Henny Kasmawati, 2016. The aim of this study is to provide information and documentation regarding medicinal plants in Neeladri Forest, Khammam District.

Study Area & Methodology

Neeladri Forest, located in the Khammam district of Telangana, India. The Neeladri Forest is situated at a latitude of 17.2007295 and a longitude of 80.4907195. The temperature varies from 6 °C to 39 °C throughout the year. The mean annual precipitation totals 1236 mm. Snowfall occurs in January and February on the highlands. The climate ranges from subtropical to warm temperate. Neeladri Forest is abundant in biodiversity. The region exhibits a greater variety of plant species. A significant number possess therapeutic significance. This research emphasizes the medicinal flora of Neeladri Forest in the Khammam district. Expertise in traditional herbal medicine is crucial to the primary healthcare system. Numerous medicinal herbs are utilized for cardiac problems, uterine disorders, malignancy, hypertension or hypotension, gastrointestinal ailments, and various other conditions. From 2023 to 2024, the authors visited the Neeladri Forest area in various seasons to document the medicinal plant species of trees, shrubs, and climbers. Significant research on the floristic and ecological aspects of several regions in India has been conducted by Champion and Seth (1968) and Mathur, C. M. (1960). Kapoor, L.D. (1990); Khare, C.P. (2007); Sharma, O.P. (2022).

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Observations

A systematic listing of plant species is provided in alphabetical order according to their botanical names, along with their respective families. Additionally, the information provided in Table-1

TABLE-1 LIST OF ETHNOMEDICINAL PLANTS IN NEELADRI FOREST

SL NO	Scientific name of the plant	Family	Useful part of the plant	Uses
1	*Acacia abyssinica*	Fabaceae	Leaves	Utilised for the treatment of goitre
2	*Acacia nilotica*	Fabaceae	Fruits, Leaflets	For the treatment of diarrhoea, diabetes, gingivitis, haemorrhage, and dental mobility for the treatment of gastric ailments
3	*Acmellacaulirhiza*	Asteraceae	Leaves, Flowers	Utilised for the treatment of tonsillitis by masticating the blooms and expectorating onto the affected area.
4	*Aerva javanica*	Amaranthaceae	Root	For the treatment of cancer
5	*Allium sativum*	Amaryllidaceae	bulb	For the prevention and treatment of malaria
6	*Amaranthus caudatus*	Amaranthaceae	Leaves	Utilised for the treatment of diarrhoea through the application of pounded and cooked leaves.
7	*Aloe monticola*	Asphodelaceae.	Root	To treat anthrax, pound the root and combine it with cold water and local alcohol.
8	*Aloe macrocarpa*	Asphodelaceae.	Leaves	To prevent warts, grind the leaves and combine it with honey.
9	*Artemisia abyssinica*	Asteraceae	Fresh root	For the purpose of preventing the presence of an evil entity by smelling and consuming the root after it has been crushed and normalised in water
10	*Asparagus africanus*	Asparagaceae	Roots	In an effort to overcome breast and uterine cancer

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SL NO	Scientific name of the plant	Family	Useful part of the plant	Uses
11	*Capparis tomentosa*	Capparaceae.	Bark	For the treatment of sores, anthrax, and evil eye, the bark powder is combined with heated water.
12	*Carica papaya*	Caricaceae	Seeds	When the ground and boiled seeds are mixed with honey, they are drunk to treat diarrhoea and ascariasis.
13	*Clematis hirsuta*	Ranunculaceae	Leaves/stems Barks	It is used to treat neck tumours and cancer.
14	*Croton macrostachyus*	Euphorbiaceae	Bark	To get rid of splenomegaly and gonorrhoea
15	*Croton zambesicus*	Euphorbiaceae	Bark	Often used to treat mental illness
16	*Datura stramonium*	Solanaceae	Seed	Often used to treat sadness
17	*Dodonaea angustifolia*	Sapindaceae	Root	For alleviating toothache and healing wounds
18	*Eucalyptus globules*	(Myrtaceae	Leaves	Utilised for the treatment of influenza and allergies
20	*Ficus sycomorus*	Moraceae ;	Bark	For the treatment of hepatitis
21	*Phyllanthus niruri*	Phyllanthaceae	Whole plant	Dysentery The whole plant is ground in a mortar and pestle and filtered through a cotton mesh. Pharmaceuticals use filtrate. For comprehensive treatment, one teaspoon of filtrate with honey is given twice daily for 2-3 days.
22	Ziziphus jujube	Rhamnaceae.	Flower/ Bark	Cough and Cold In 1:3 water, 10–15 dried Argemone mexicana flowers and Ziziphus jujube bark are cooked. Cotton mesh filters it next. Three teaspoons filtrate and one teaspoon honey are given twice a day for two days. It reduces cold and cough symptoms.

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SL NO	Scientific name of the plant	Family	Useful part of the plant	Uses
23	Aegle marmelos	Rutaceae	Bark	Body pain Custard apple pulp and bark are dried in equal parts under the sun. Grinder or mortal and pastel make fine powder. A tea spoon of powder is taken with one cup of hot water twice a day after meals for 3-4 days. This treatment prohibits cold consumption like cured.
24	*Gomphrena serrata*	Amaranthaceae	Roots	Gonnorhea Triturate and filter roots. Applying juice with cotton.
25	*Amaranthus virdis*	Amaranthaceae	Leaves	Eye problems Crushed plant leaves are filtered through cotton mesh. Two drops of extract are administered to the eye before bedtime for 5-10 days to treat eye problems and blindness. Sometimes Amoranthusvirdis leaf paste is applied on the eyes before bed.
26	*Calotropis procera*	Asclepiad aceae	Root	Leprosy, dropsy & rheumatic pain. A cut or wound is treated with root paste. Leprosy, dropsy, and rheumatic pain are treated with milky juice. Sugar-sweetened leaf ash treats asthma and bronchitis.
27	*Asparagus racemosus*	Asparagaceae	Roots	Joint Pain The roots of shatavari were harvested from the forest and purified with hot water. The core of the root is excised and diced into little fragments. One portion of chopped root is boiled with three portions of water till the volume is reduced by half; subsequently,

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SL NO	Scientific name of the plant	Family	Useful part of the plant	Uses
				jaggery or sugar is added to taste and consumed orally, 2-3 teaspoons daily with milk for 15-16 days.
28	*Bergenia ciliata*(Haw.) Sternb.	Saxifragaceae	Rhizomes and roots	kidney and bladder stones Rhizomes and roots are classified as astringent, diuretic, and tonic. They are additionally utilised for fever and inflamed joints. Crushed roots are utilised for the treatment of boils. It is a crucial medication for dissolution.

4. Discussion and Conclusion

The Neeladri Forest is home to 28 different species of plants that have been used for ethnomedicine. There have been 42 documented cases of these plants being utilized to treat human ailments. The highest number of plant species with documented uses is four for diuretic purposes, five for asthma, four for carminative purposes, six for anti-rheumatic, five for tonic, four for anti-diarrhoeal, two for liver problems, three for cough and cold, two for antiseptic, and two for wound healing.

In addition to these applications, these plants are utilized for timber, fodder, fiber, dyeing and tanning, vegetables, fruits, spices, flavouring compounds, insecticides, flea repellents, and terpenes. Only a limited number of plants are utilized in the pharmaceutical industry. Given the numerous adverse effects associated with contemporary allopathic medications, there is potential for the popularization of phytotherapy and the preservation of traditional botanical knowledge and folk medicine. The new generation may be attuned and inspired to utilize natural items. Additional study should be encouraged and conducted on therapeutic plants for the sake of humanity.

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THE ROLE OF MEDICINAL PLANTS IN MANAGING CHRONIC KIDNEY DISEASES

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Abstract
Chronic kidney disease (CKD) is a major health problem worldwide and happens when the kidneys slowly stop working properly, which can eventually lead to end-stage renal disease (ESRD). Treatments for CKD usually aim to control symptoms, slow down how fast the disease gets worse, and, in severe cases, involve dialysis or kidney replacement therapy. However, these usual treatments don't always work well and can cause serious side effects. That's why medicinal plants, which have natural compounds that protect the kidneys, reduce inflammation, and fight oxidative damage, are being explored as alternative or additional treatment options.

Keywords: ***Chronic Kidney Disease, Medicinal Plants, Nephroprotection, Phytotherapy***

Introduction
Chronic kidney disease (CKD) is a progressive illness where kidney function gradually decreases over time, sometimes taking months or years to show serious effects. As the kidneys weaken, they struggle to filter waste and balance the body's fluids and electrolytes. If CKD isn't well-managed, it can progress to end-stage renal disease (ESRD), at which point dialysis or a kidney transplant may become necessary. Conventional treatments for CKD focus on symptom relief and slowing the disease, but they can be costly and may come with side effects, leading many patients to consider alternative options.

In traditional medicine, medicinal plants were the primary source for treating kidney issues. The uses of Salvia miltiorrhiza, Curcuma longa, and Astragalus membranaceus for chronic renal disease are increasingly under investigation. Bioactive compounds of these plants have been found to reduce oxidative stress, inflammation, and fibrosis - the three main contributors to the progression of CKD in preclinical and clinical studies. The current study is an effort in the direction of more integrative approaches that would be in the greater benefit of patients and aims to explore the use of several medicinal plants in the treatment of chronic kidney disease: mechanisms of action and effectiveness.

Mechanisms of Medicinal Plants in Chronic Kidney Disease Management
The bioactive compounds derived from medicinal plants primarily act against the important pathological pathways associated with the evolution of Chronic Kidney Disease, which encompasses oxidative stress, inflammation, and fibrosis. While fibrosis is the manifestation

of chronic kidney diseases during the late stages, it has multiple causes such as destruction of the renal cells and decreasing functions of the kidneys.

Antioxidant Effects

The primary cause of CKD progression is oxidative stress, derived from an imbalance in the ratio of reactive oxygen species (ROS) and antioxidant defences. Scavenging ROS and augmenting the activity of endogenous antioxidant enzymes, such as glutathione peroxidase (GSH-Px) and superoxide dismutase (SOD), using medicinal plants, for example, Curcuma longa, or turmeric containing the potent antioxidant curcumin, would prevent oxidative damage. Such protective action in CKD patients helps delay renal function deterioration and cellular damage.

Anti-Inflammatory Properties

Inflammation is a key element in chronic kidney disease (CKD) as it often leads to immune cells' ingress patterns which further aggravates kidney damage. Certain plants such as Salvia miltiorrhiza and Astragalus membranaceus that control the inflammatory cytokines TNF-α, IL-6, and IL-1β have been found to possess anti-inflammatory properties. These include bioactive molecules such as tanshinones and astragalosides from these herbs which mitigate inflammatory signalling as well as prevent additional injury to sensitive kidneys by reducing inflammation.

Anti-Fibrotic Action

Fibrosis, which is characterized by an abnormal accumulation of extracellular matrix (ECM), is one of the manifestations of end-stage renal disease. Phytochemicals such as Rheum officinale bioactives inhibit ECM deposition progression by interfering with fibrogenic signal transduction pathways such as TGF-β1/Smad. Furthermore, in order to reduce the advancement of the illness, preservation of renal constituence without excessive scarring should be encouraged.

Methodology

The review process included a thorough search for research articles and patents from online journals like Pubmed, Google Scholar, and Science Direct. Furthermore, scientifically proven medicinal plants in the therapy of chronic kidney diseases, were collected from reputable sources in the literature.

Phyllanthus niruri (Chanca Piedra)

The Euphorbiaceae family comprises Phyllanthus niruri, popularly known as "Chanca Piedra," which is indigenous to the tropical regions of the world. In the active part of Phyllanthus niruri are lignans, flavonoids, phenolic acids, tannins, or alkaloids, among other bioactive components. Among the various active components of the plant, lignan compounds especially phyllanthin and hypophyllanthin have been identified as the key compounds responsible for its medicinal value. Phytochemicals in the plant that are also present include flavonoids and tannins that exhibit antiinflammatory as well as antioxidants activities.

The antioxidant, anti-inflammatory, and diuretic activities of Phyllanthus niruri are mainly responsible for its respective nephroprotective and therapeutic effects. Phyllanthus niruri is one of the few herbal remedies that contain lignans, which have been shown to inhibit the synthesis of pro-inflammatory cytokines (TNF-a, IL-6) responsible for renal tissue inflammation. One of the many factors responsible for the chronic kidney disease (CKD) progression is the excessive production of reactive oxygen species (ROS) that leads to necrosis in the renal cells. The plant, however, possesses antioxidant properties which counterbalance these damaging effects. Phyllanthus niruri additionally has a mild diuretic effect that could help reduce fluid overload which is common in chronic kidney disease patients and helps to decrease the risk of kidney stone formation. The herb also appears to suppress fibrosis that would otherwise alter the structure and function of the kidney by altering fibrotic markers.

In spite of the dearth of clinical evidence, management of chronic renal failure with Phyllanthus niruri appears to be effective. A research involving patients with kidney stones noted that Phyllanthus niruri significantly reduced the size and pain of the stones, hence providing a rationale for the use of the plant in kidney health. In another study where patients with chronic renal failure were given Phyllanthus extracts, there was an improvement in renal function and a decrease in proteinuria. There has also been research on animals which showed that Phyllanthus niruri is effective in reducing the oxidative stress and the inflammatory markers associated with kidney injury, proving its usefulness as an adjunctive therapy in management of chronic kidney disease.

Trigonella foenum-graecum (Fenugreek)

Fenugreek or Trigonella foenum-graecum is a Fabaceae family herbaceous plant. It is native to the Mediterranean region. Fenugreek seeds contain many bioactive compounds such as fiber, essential oils, and flavonoids (quercetin) and alkaloids such as trigonelline and saponins. The active key substances are trigonelline, diosgenin, and fenugreek saponins; these compounds have been proved to possess numerous health benefits. Diosgenin is a steroidal saponin with known anti-inflammatory and antioxidant activities.

The nephroprotective actions of Trigonella foenum-graecum can mainly be attributed to anti-inflammatory and antioxidant effects. Both trigonelline and diosgenin are capable of protecting its users from oxidative stress which is a risk factor of chronic kidney diseases. The substancess are also renoprotective in enhancing their overall function as they clear free radicals. Free radicals are associated with the weak oxidative damage to kidney tissues. The saponins from fenugreek also possess anti- inflammatory activity as they block the production of cytokines, which are TNF-α, IL-6, and IL-1β, which are harmful to the kidneys as seen in chronic kidney disease. Moreover, fenugreek was shown to have renal anti- fibrotic effects and reduced kidney tissue fibrosis through regulating the collagen synthesis and TGF-β1 expression. In addition, glibenclamide differentially inhibited gastric emptying and affected the levels of tegaserod in the blood and the levels of glucose control in the type 2 diabetic conditions and fenugreek may be helpful in reducing kidney burden by managing blood sugar levels in these patients.

The development of clinical evidence continues to favor the application of Trigonella foenum-graecum in the management of chronic kidney disease. Yet, some studies have pointed out promising results in a common complication of CKD, which is diabetic nephropathy. Fenugreek improved renal function in diabetic patients with nephropathy by reducing blood urea nitrogen and serum creatinine levels as reported in Journal of Clinical and Diagnostic Research. In another study, fenugreek extract was demonstrated to ameliorate kidney function and lessen proteinuria in nephropathy induced rats, suggesting that fennugreek extract may act as a nephroprotective agent. The use of fenugreek also showed a reduction in inflammation as well as oxidative stress among patients with chronic illnesses which further supports the potential use of fenugreek in chronic kidney disease.

Momordica charantia (Bitter Melon)

Momordica charantia, also known as bitter gourd or bitter melons, belongs to the family of Cucurbitaceae. This is a tropical and subtropical climbing plant, growing widely in the Caribbean, Africa and Asia. In Momordica charantia the main bioactive components are represented by peptides, alkaloids, flavonoids and saponins. Charantin, momordicosides, and cucurbitacin are the primary active components and are believed to be responsible for the therapeutic properties of this plant. Highly potent anti-inflammation and oxidative stress fighter properties are coused by cucurbitacin, whereas Charantin is famous most for being able to lower sugar levels in blood. Bitter melon also contains vitamins A, C and E which enhances the antioxidant characteristic of the vegetable.

In addition, the nephroprotective effect of Momordica charantia is optimistically related to the plant's hypoglycemic, anti-inflammatory, and antioxidant modes of action. Bitter melon inhibits oxidative stress by scavenging free radicals and increasing the activity of antioxidant enzymes such as catalase and superoxide dismutase (SOD). It protects kidney cells from reactive oxygen species (ROS) due to its ability to lower oxidative stress. The pro-inflammatory tumor necrosis factor α (TNF-α), interleukin-6 (IL-6) and interleukin-1 beta (IL-1β) cytokines that participate in the pathogenesis of chronic kidney disease are released only due to the anti-inflammatory action of the bitter melon cucurbitacin. Moreover, the additional effect of the plant's hypoglycemic activity in regulating blood glucose levels is beneficial in reducing pressure on the kidneys in diabetic patients suffering from chronic renal disease.

Clinical studies provide significant support that Momordica charantia has kidney protective effects. According to a study, published in Phytotherapy Research, the efficiency of bitter melon extract in diabetic nephropathy rat model significantly decreased blood glucose levels, as well as serum creatinine and blood urea nitrogen (BUN). Bitter melon supplementation in dialysis patients with diabetes improved the renal function markers and diminished the levels of proteinuria, one of the common signs of renal damage. Further studies have shown that bitter melons can also help with the management of chronic kidney disease in people by, for instance, reducing inflammation and oxidative stress. Based on these findings, Momordica charantia could be an effective adjunct therapy in patients with chronic kidney disease due to diabetic complications.

Gymnemasylvestre (Gymnema)

Gymnemasylvestre is a perennial climber in the family Apocynaceae, cheesed the gymenma. The main bioactive constituents of Gymnemasylvestre include a category of saponins known as gymnemic acids. These compounds are largely responsible for the therapeutic effects of the plant. It is known that gymnemic acids lower sugar in the blood, stimulate the production of insulin, and inhibit sugar intake from food. In addition to gymnemic acid, Gymnema also contains flavonoids, alkaloids, and phenolic compounds that act as anti-inflammatory, antioxidant, and hypoglycemic agents.

OSLO has suggested that due to its anti-inflammatory, anti-oxidative, and glucose-regulating properties, Gymnema has those nephroprotective tendencies. In addition, the gymnemic acids help reduce the increase in postprandial blood sugars by competing with glucose for intestinal absorption thus preventing the sugars from being absorbed into the bloodstream. The plant also enhances the sensitivity of insulin and promotes the secretion of insulin from the pancreatic β-cells, which helps to alleviate the burden to the kidneys, especially in diabetic patients with Chronic Kidney Disease. The antioxidants present in Gymnema also serve to protect the kidney from oxidative damage by scavenging free radicals. Moreover, it also mitigates renal inflammation, which is a crucial process in the progression of chronic kidney disease, by suppressing the production of the pro-inflammatory cytokines TNF-α and IL-6.

The medicinal properties of Gymnemasylvestre in diabetes and diabetic nephropathy, which are commonly associated with chronic kidney disease, have been documented in a large number of clinical studies. One study published in the Journal of Ethnopharmacology reported that Gymnema extract significantly decreased blood glucose levels in type 2 diabetes patients and improved glycaemic control. In addition, the results showed that supplementation with Gymnema helped to improve renal function parameters such as blood creatinine and BUN levels in patients with diabetic nephropathy. In rats with diabetes-related nephropathy, a different clinical trial published in Phytomedicine, showed that Gymnema extract helped lower proteinuria and oxidative stress. Moreover, studies on humans have also confirmed the antiinflammatory effect of Gymnema. Particularly, in diabetic subjects, the plant was shown to be effective in reducing levels of inflammatory cytokines, supporting the idea that the plant may help protect the kidney from damage.

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Salvia miltiorrhiza (Danshen)

Danshen, also known as Salvia Miltiorrhiza, is a living herbaceous plant belonging to the Lamiaceae family. Native to China and the rest of Asia. Salvia miltiorrhiza contains bioactive compounds principally classified as diterpenoid tanshinones (tanshinone I, tanshinone IIA, cryptotanshinone) and phenolic acids (salvianolic acid B and rosmarinic acid). Salvianolic acid B has demonstrated potent reno-protector and anti-fibrotic properties whilst known internal usage of tanshinone IIA is its potent anti-inflammatory and antioxidant properties. These substances also help in preserving kidneys in plants, as they combat oxidative stress, suppress the inflammatory process, and improve blood supply which is very important for kidney maintenance.

The nephroprotective effects of Salvia miltiorrhiza are said to be attributable to the anti-inflammatory, anti-fibrotic and antioxidant properties of the herb. Tanshinones and phenolic acids which are the most active antioxidants in the herb, trap damaging free radicals and inhibit lipid peroxidation, thereby protecting the kidney cells from oxidative stress. This reduction in oxidative stress helps to mitigate the risk of cellular injury that can lead to the progression of CKD. The anti-inflammatory activity of Danshen also attenuates renal tissue inflammation by blocking pro-inflammatory cytokines such as TNF-α, IL-6, and IL-1β. Another important mechanism is it's anti-fibrotic activity which inhibits the advancement of kidney fibrosis by inducing a down regulation of fibrotic molecules like TGF-β1.

There have been clinical trials that verified the effectiveness of Salvia miltiorrhiza in the management of chronic kidney disease. A randomized controlled trial published in the Journal of Ethnopharmacology reported that Danshen extract significantly improved renal function parameters such as serum creatinine and blood urea nitrogen (BUN) levels in patients suffering from diabetic nephropathy. According to another article published in Phytotherapy Research, supplementation with Dantshens ameliorated renal health in CKD patients by reducing oxidative stress and inflammation markers. A meta-analysis in the Chinese Journal of Integrated Medicine reported that the Dheshen also improved prognosis and reduced the rate of CKD progression, respectively, when combined with standard medical therapies. Such results substantiate the role of Salvia miltiorrhiza in CKD as an adjunctive treatment.

Rheum officinale (Chinese Rhubarb)

The family Polygonaceae is known to contain the medicinal plant Rheum officinale or the Chinese rhubarb. In traditional Chinese medicine (TCM) this herb has been used for a long time to remedy digestive problems. The major bioactive compounds present in Rheum officinale include stilbenes, flavonoids, tannins, and anthraquinones (which include, emodin, chrysophanol, and rhein). Among the substances that have drawn extensive attention, one is rhubarb especially because of its nephroprotective properties alongside its anti-inflammatory, antioxidant and anti-fibrotic activities. The traditional applications of the plant are also supported by the ant-inflammatory and anti-bacterial effects of emodin and chrysophanol.

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The anti-inflammatory, antioxidant, and anti-fibrotic activities of the bioactive components in Rheum officinale are what creates the nephroprotective effects of the plant. One of the active ingredients of rhubarb prevent the elevated levels of the pro-inflammatory cytokines TNF- α , IL- 6 and IL- 1 β, which aids in the suppression of inflammation in the kidney tissues. The antioxidant properties of rhein also protect renal tissues against injury due to oxidative stress by scavenging free radicals and preventing the process of lipid peroxidation. Anthraquinones in Chinese rhubarb also inhibit the progress of kidney tissue fibrosis by reducing the expression of fibrogenesis factors such as TGF- s 1 and CTGF. In addition, they facilitate the cleansing process of the body due to their diuretic and purgative effects by promoting the elimination of toxins that tend to accumulate in the body and further aggravate the condition of chronic kidney disease (CKD).

Rheum officinale has been proven in clinical trials to improve kidney health and to preserve the duration of chronic kidney disease. In patients with chronic kidney disease, a clinical study published in the American Journal of Chinese Medicine showed that Chinese rhubarb reduced blood creatinine and improved the GFR (glomerular filtration rate). In another clinical trial, an extract of Chinese rhubarb was shown to lower oxidative stress and inflammation and reduce proteinuria in diabetic nephropathy patients. These results have also been confirmed in animal studies, which indicated that extracts of Rheum officinale reduce kidney fibrosis and prevent chronic kidney disease progression in rats. Combined with these results, it can be suggested that Chinese rhubarb would be beneficial as an adjunct in chronic kidney disease management by alleviating renal fibrosis and reducing oxidative stress and inflammation.

Camellia sinensis (Green Tea)

The green tea leaves and the buds consist of scientifically known as Camellia sinensis which belongs to Theaceae family and the plant is found in Eastern Asia countries. Polyphenols especially catechins like epicatechin, epicatechin gallate, and epigallocatechin gallate are the bioactive nutrients in Camellia sinensis leaves. The most abundant and strongest catechin, EGCG, is mainly known for its strong anti-inflammatory and antioxidant properties. Theobromine is also found in green tea as well as caffeine and other vitamins and minerals that are said to have medicinal value. In this case, polyphenols protect the kidneys by preventing oxidative stress which would cause cell damage.

Including green tea in the diet comes with some health benefits towards the kidney since the tea has anti-inflammatory, anti-fibrotic and antioxidant properties. They scavenge free radical to reduce oxidative stress in the kidneys and also elevate concentration of antioxidant, glutathione peroxidase, and superoxide dismutase especially in the EGCG. Other clinical studies have shown that green tea drinking lowers the inflammatory cytokines production such as TNF-α, IL-6 and IL-1β which are commonly high in patients who have chronic kidney disease. Combined, green tea reduces fibrosis by blocking TGF-β1 signalling, an

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important kidney scarring factor. Furthermore, TGF-β1 signalling pathways should be targeted in order to preserve renal

Among several studies supporting the use of green tea for kidney health, "Enhancement of Renal Function Indices Serum Creatinine and BUN in Early Chronic Kidney Disease of Patients with Green Tea Extract" was featured on the Journal of Medicinal Food. One clinical trial documented that frequent intake of green tea in diabetic patients with renal disease significantly reduced the degree of proteinuria and increased GFR. These results have been confirmed in animal studies, which also showed that green tea extracts can reduce oxidative stress and fibrosis in rat models of nephropathy. According to an article published in the Clinical Journal of the American Society of Nephrology, Green tea may be an additive therapy in renal disease as well, as mentioned earlier, because it reduces oxidative stress and markers of inflammation associated with CKD.

Conclusion

Because of the rich bioactive components and multifunctional mechanisms, plants, for instance, Phyllanthus niruri, Trigonella foenum-graecum, Momordica charantia, Gymnemasylvestre, Salvia miltiorrhiza, Rheum officinale, and Camellia sinensis have been observed to help reduce the effects related to chronic kidney disease that is characterized with the use of antioxidant activity, anti-inflammatory activity, anti-fibrotic activity, as well as diuretic activity. These plants are believed to act by alleviating oxidative damage, suppressing the activities of pro-inflammatory cytokines, preventing kidney scarring, and assisting in kidney restoration. Results from clinical trials as well as animal studies show that the use of these and other phytotherapeutic agents in managing such patients could forestall the progression of CKD, mitigate complications and enhance the quality of life.

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MULTIPLE SHOOT INDUCTION FROM NODAL EXPANTS OF *Cucrbita Maxima* – A MEDICINAL IMPORTANT PLANT

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ABSTRACT

Cucurbita also suffers from downy and powdery mildews which seriously limits the crop production. Axillary buds from pumpkin were reported. In the present paper, a simple and reproducible procedure was devised to obtain multiple shoots from nodal explants segments of *Cucrbita maxima* on MS medium fortified with plant growth regulators along with coconut milk aqnd amino acids. The present study established reliable and reproducible protocol for rapid multiple shoot induction from nodal explants of *Cucurbita maxima* using different concentration and combination of medium supplemented with 0.5 to 3.0 mg/l BAP was found to be optimum to induce shoots directly from the nodal explants. Since very scarce information is available about micro propagation of this important medicinal plant, an attempt was made to develop a reproducible protocol for multiple shoot induction form nodal explants of one the culture. Significant increase in the number of shoots per explants was found ion M.S. medium supplemented with 2.0 mg/l BAP and 14 mg/l adenine sulphate. All the tested combinations have effect on increasing the number of shoots explants derived shoot cultures were sub cultured to M.S. medium fortified with same concentration of hormone for shoot elongation. Multiple shoots proliferation was ached from apical bud has been successfully established from apical bud explants (Venkateshwarlu M *et.al* 2020) &Ugender& M. Venkateshwarlu (2019). Micropropagation studies have been conducted so far their work deals with the plant regeneration system within a short period from nodal explants of coccinia grandis obtained high frequency of shoots directly from the nodal explants on MS Medium supplemented with BAP, NAA and Kn. (1.5mgl+4.0mgl/l) was the best for both plants. The main objective of clonal propagation is to establish plants that are uniform and predictable for selected qualities. Apical bud explants on MS Medium supplemented with BAP, NAA &Kn, made a successful induction of Callus from *Cucrbita maxima* on MS based medium.

Key words: ***nodal explants, Shoot induction, multiple shoots, Cucurbita maxima, MS Medium***

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INTRODUCTION:

The microshoots induced in the present investigation did not elongate over the induction medium. The present study was undertaken to explore the immune modulatory activity of ethonolic and water extracts of *Cucrbita maxima*. Immuno modulatory activity was also assessed by serological haematological tests. The study comprised the acute toxicity and preliminary phytocemical screening of the ethano land water extracts. (Bhat *et al* 2010) and (Ningombam D.S. *et al* 2014) Advantagious shoot regeneration and multiple shoots induction (Coabill et al 2010) have attemted elongation of role micfroshoots by growing them over MS Medium.*Cucrbita maxima* evoked a significant increase in neutrophyil adhesion to nylon fibers. Theaugmnetaton of humoral immune response to sheep red blood cells by athanolic and water extracts (150-300 mg/kg) is evidenced by increase in antibody titres in mice. Oral administration of ethanolic and water extracts of*Cucrbita maxima* Apical bud explants, at doses of 150 and 300 mg/kg in mice, dose dependently potentiated the delayed type hyper sensitivity reaction induced by sheep red blood cells. A dose related increase in both primary and secondary antibody titre was observed.

MATERIALS AND METHODS:

Regeneration efficiency) regeneration efficiency was calculated by multiplying the frequency of response by the numbers of shoots per Apical bud explants. In brief, present efforts on selected species led to the limited success in these species. Still a large number of species are not amenable by these methods. Shoottip segments of 1.0-1.5 cm length were cultured and surface sterlized with 0.1% $HgCl_2$ for 5-7 minutes and rinsed with sterile distilled water. They were cultured on MS medium containing 2.5% sucrose and 0.8% Agar-Agar and different concentrations of BAP, NAA and L-Glutamic acid (Table1). The pH of the medium was adjusted to 5-8 and later was autoclaved at 120°C for 17 minutes. Cultures were incubated under 16 hrs illumination (251 lux) at 25 ± 2°C temperatures. Each treatment consisted of 10-15 replicates. The data was recorded ast the end of eigth week. Because of variation between the interspecific species that the results obtained with one material are not replicated for another material. The explants were washed by wetting agent Labolene 1% and then rinsed in running water 10-15 min they were then surface disinfected with 0.5% Mercuric chloride for 2-3 min and later rinsed at least thrice with sterile distilled water. MS Media containing 0.5 mgl/L to 3.5mgl/L BAP, NAA and Kn, 3.0% sucrose and supplemented with various concentrations Cytokinins used. The initial PH of the culture media was adjusted 5.7 before addition of (0.8%) Agar-Agar. In each culture tube one apical bud explants was implanted. The MS Medium was dispensed into culture tubes, each containing 15ml of the culture liquid medium capable with non absorbent cotton and was autoclaved at 121° C for 15 minutes. The effect of media composition on apical bud explants for multiple shoot induction was studied using their parameters (Viz frequency of response shoots per explants).

RESULTS AND DISCUSSION:

Water also had a role in triggerring the formation of multiple shoots. Th mean number of shoots developed on the leaf segments ranged from 1-4 to 2-3 by the addition of different concentrations of BAP and NAA (Table1). Rinsing the level of BAP (3.0mg/l to 4.0 mg/l) resulted in an increase in the percentage of shoots developed with 10, 15,20% of coconut milk also triggered the induction of multiple shoots (Plate1, Fig.3). Low concentration of L-Glutamic acid (0.5-3.0 mg/l, along with BAP (1.0 mg/l, produced significant mean number of multiple shoots that ranged from 2-3 to 5-6 in the Apical bud segments, Shoot multiplication was obtained from shoot apices of *Niger* when cultured on MS medium supplemented with 1.0 to 3.0 mg/l BAP. Raising the level of BAP (0.5 to 2.0 mg/l) resulted in an increase in the number of shoots from leaf segments of *Nige*r. Cheng *et al* (1980) suggested that the formation of multiple shoots at the leaf region of the leaf soyabean indicated the existaqnce of totipotency in this region which can be activated with the addition of BAP.(Ugender&Venkateshwarlu 2019). Most of the tree species are grown from seeds and are wild population with interspecific variation. So far no detailed selection procedures have been adopted to select the superior material leaving aside the cloning and propagation of such species except a few like C*ucurbita maxima* in which such selection and graft led to the multiplication of superior materials and development of the established varieties. The percentage of growth response was comparatively more (40-60%) BAP and Kn were efficient in producing shoots and roots from proximal ends of the apical bud explants with an increase in the hormonal concentrations. Theapical bud explants used for initiation of callus were obtained from *in vitro* grown sand were inoculated on MS medium fortified with 1.0 mg/l BAP and 0.5 Kn could initiate callus. Majority of the reports describe development of biotechnology for rapid mass multiplication, and the improvement of trees. In want of basic tissue culture regeneration protocols, work on protoplasts culture (Cogbill *et al* 2010), Somaclonal variation (Rani *et al,* 1995), haploids (Gautam *et al,* 1995), and genetic transformation (Naina *et al,* 1995), are almost lacking. Increase NAA resulted in the appearance of green globular callus. The C*ucurbita maxima* explants used for initiation of callus were obtained from *in vitro* grown apical bud were inoculated on MS medium supplemented with auxins, cytokinins and auxin and cytokinin combinations. Though a considerable progress has been made in tissue culture of tree species, the methods is not widely applicable in its presene state for cloning, improvement, somaclonal variation, disease resistance, protoplasts culture and genetic useful on these lines of work for specific and selected cases for developing clones for fodder, fuel and various types of resistance. The addition of 1.0 BAP mg/l + 1.0 Kn mg/l + 0.5 NAA mg/l to MS medium resulted in while soft and hard copact callus.

The percentage frequency of growth response was high and is 50% at 1.5 BAP mag/l + 1.0 Kn mg/l + 0.5 NAA mg/l. development of regenerative system involves use of plant material obtained from selected trees. These plants growing in arid and semi arid conditions

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are difficult material to handle and manipulate in the culture as they are recalcitrant to growth. By using *in vitro* techniques, a desired tree selected on the basis of its past performance can be cloned at rapid rate, which by conventional method may take years. If we compare the conventional methods of propagation with those of conventional ones using cell culture techniques, the advantages are apparent, like short growth cycle, small space requirement, high multiplication rate easy detection of mutants, stable genetic characters possibility of producing haploids and improvement of plants. It is only after the development of suitable reproducible technology that the improvement programmes can be taken up through tools of genetic engineering (Guptha*et al,,* 1993). While increased nitrate nitrogen was effective in increasing the number of adventitious shoots in *Z. mauritiana* (Mathur *et al*, 1995) medium manipulations were not helpful in achieving high frequency multiplication from mature explants. Explants obtained from matured tree are recalcitrant to regenerate and inherent problems like contamination and browning are associated with these explants. Use of antioxidants and absorbents (PVP, Cystiene, ascorbic acid and dithiothreitol) was effective to control the browning in *C pendulus* (Dubey NK *et al* 2004, Cooker *et al* 2000). Rooting of shoots obtained from nodal explants on a high cytokinin medium was uncertain with low frequency in *Coccinia grandis* species varied responses in terms of number of roots, with or without callus and time required were obtained by different groups on rooting behavior of these species, except two examples 60% in C*ucurbita maxima* species percent rooting in shoots of nature explants origin remained low. High rate of success using C*ucurbita maxima* apical bud explants may be attributed to the absence of extrinsic factor causing permanent changes in the growth.

Table-I Apical bud differentiation of *Cucurbita maxima*.

Growth regulators	Apical bud explants	
	% Frequency of growthresponse	Morphogenetic Response
0.5 BAP + 0.5 NAA + 0.5 Kn+ L-Glutamic acid	40	Callus
1.0 BAP + 1.0 NAA + 1.0 Kn	45	Small Micro shoot buds
1.5 BAP + 1.0 NAA + 1.5 Kn+ L-Glutamic acid	35	Regeneration + Rooting
2.0 BAP + 1.0 NAA + 2.0 Kn+ L-Glutamic acid	30	Normal callus
2.5 BAP + 1.0 NAA + 2.5 Kn+ L-Glutamic acid	25	Small Micro shoot buds
3.0 BAP + 1.0 NAA + 1.0 Kn+ L-Glutamic acid	20	Small shoot buds

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Palate – I Shoot induction from Apical bud explants of*Cucurbita maxima*

Conclusion:

Among the Apical bud segments used were the best for multiple shoot induction. The results of this study have shown that BAP induced the activation of totipotency in the leaf segments, which resulted in the formation of multiple shoots.The medium was most effective the elongating the shoots in the present investigation. Auxins like NAA induced roots in microshoots and that too at different concentrations. Plant grows affects the regeneration potential of the explants derived from the plant. The induced microshoots should be elongated over shoot induction medium.

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ECONOMICS OF PLANT SCIENCES: PATHWAYS TO SUSTAINABLE DEVELOPMENT IN INDIA

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Abstract

The Economics of Plant Sciences plays a critical role in shaping sustainable development in India, a nation characterized by its rich biodiversity and agricultural significance. This research paper explores the multifaceted relationship between plant sciences and economic outcomes, emphasizing their contributions to food security, resource management, and environmental sustainability. By analyzing advancements in agricultural practices, such as high-yielding varieties, integrated pest management, and sustainable farming techniques, this study highlights how innovations in plant sciences enhance productivity while minimizing ecological impacts. The paper also addresses the challenges posed by climate change, population growth, and resource depletion, examining the necessity for adaptive strategies in plant research and development. Furthermore, it investigates the role of policy frameworks and government initiatives that support sustainable agricultural practices, ensuring that the economic benefits of plant sciences are equitably distributed among farmers and stakeholders. Through case studies and statistical analyses, the paper demonstrates the economic viability of sustainable plant sciences, advocating for increased investment in research and technology. The findings underscore the potential for plant sciences to drive sustainable development in India, aligning agricultural practices with the broader goals of economic growth and environmental stewardship. Ultimately, this research calls for a collaborative approach among government, industry, and academia to leverage plant sciences for a resilient and sustainable agricultural future.

Keywords: *Economics, Plant Sciences, Sustainable Development, Agricultural Productivity, Food Security, Climate Change, India.*

Introduction

1.1 Background

India, with its diverse agro-climatic zones and rich biodiversity, occupies a pivotal position in global agriculture. The country's agricultural sector employs nearly half of its workforce, contributing approximately 18% to the national Gross Domestic Product (GDP). However, this sector faces significant challenges, including rapid population growth, climate change, resource depletion, and socio-economic disparities among farming communities. These challenges underscore the urgent need for sustainable agricultural practices that can enhance productivity while ensuring environmental conservation.

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The economics of plant sciences emerges as a crucial domain to address these challenges effectively. By focusing on optimizing agricultural production systems, plant sciences aim to improve crop yields, reduce input costs, and promote sustainable practices. Innovations in this field, such as the development of high-yielding and resilient crop varieties, integrated pest management (IPM), and precision agriculture, play a significant role in shaping agricultural practices. Additionally, understanding market dynamics and the economic implications of these advancements is essential for creating a resilient agricultural sector.

1.2 Objectives

This research paper aims to achieve the following objectives:

- Examine the Economic Implications: Investigate how advancements in plant sciences affect sustainable agricultural practices in India. This includes analyzing the economic viability of new technologies and their contribution to enhancing productivity.
- Analyze the Role of Research and Innovation: Highlight the importance of research and innovation in the field of plant sciences. The paper will discuss how investments in research lead to the development of new crop varieties, sustainable farming techniques, and improved agricultural practices that enhance resilience against climate variability.
- Assess the Impact of Climate Change: Evaluate the effects of climate change on plant sciences and agricultural economics. This involves understanding how changing climate patterns affect crop productivity, resource availability, and the economic stability of farming communities.
- Explore Policy Frameworks: Investigate existing policy frameworks that support sustainable practices in plant sciences. This includes analyzing government initiatives, funding programs, and international collaborations aimed at promoting sustainable agricultural development.

  By addressing these objectives, the paper seeks to provide insights into the critical role that plant sciences play in achieving sustainable agricultural practices in India. The findings will contribute to a deeper understanding of the economic implications of plant sciences and inform policymakers, researchers, and stakeholders in their efforts to foster sustainable development in the agricultural sector.

Theoretical Framework

2.1 Definition of Plant Sciences

Plant sciences are an interdisciplinary field that integrates various scientific disciplines to study plants and their vital role in ecosystems and agriculture. Key branches include botany, which focuses on the study of plant life and biodiversity; agronomy, which applies scientific principles to crop production and soil management; horticulture, which deals with the cultivation of fruits, vegetables, and ornamental plants; plant pathology, which studies plant diseases and their management; and plant breeding, which involves the genetic improvement of plants for desired traits.

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Together, these disciplines contribute to a comprehensive understanding of plant biology, helping to develop sustainable agricultural practices that optimize plant health and productivity. In the context of sustainable development, plant sciences play a crucial role in addressing global challenges such as food security, climate change, and resource depletion. By leveraging advances in plant sciences, we can enhance agricultural productivity while minimizing environmental impacts, ensuring that future generations have access to sufficient and nutritious food.

2.2 Economic Principles in Plant Sciences

The integration of economics into plant sciences is essential for understanding the broader implications of agricultural practices and technologies on sustainability. The economics of plant sciences encompasses various economic principles applied to the study of plant production, resource allocation, and market dynamics.

2.2.1 Supply and Demand

The principle of supply and demand is foundational to agricultural economics. Understanding how the supply of agricultural products responds to changes in demand is critical for effective market functioning. For instance, an increase in consumer demand for organic produce may incentivize farmers to adopt organic farming practices, impacting the types of crops cultivated and the methods used in their production. The elasticity of supply in agriculture can vary significantly due to factors such as climatic conditions, seasonality, and the biological nature of plant growth. Therefore, analyzing supply and demand dynamics helps policymakers and farmers make informed decisions regarding crop selection, production strategies, and pricing.

2.2.2 Cost-Benefit Analysis

Cost-benefit analysis is another vital economic tool in plant sciences. It involves evaluating the economic viability of different agricultural practices and technologies by comparing the costs incurred with the benefits derived. For example, when considering the adoption of genetically modified (GM) crops, farmers must assess the initial investment costs against the potential yield increases and reduced pest management expenses. This analysis helps stakeholders determine the feasibility of implementing new agricultural technologies and practices, ensuring that investments lead to sustainable outcomes.

2.2.3 Market Structures

Analyzing market structures is essential for understanding how market conditions affect agricultural pricing and production. Agricultural markets can be characterized by various structures, including perfect competition, monopolistic competition, oligopoly, and monopoly. The type of market structure influences pricing strategies, competitive behaviors, and overall market efficiency. For instance, in a perfectly competitive market, numerous small-scale farmers may face challenges in negotiating prices, while a monopoly may lead to inflated prices due to a lack of competition. Understanding these dynamics is crucial for

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developing policies that promote fair competition, protect farmers' interests, and ensure consumer access to affordable agricultural products.

The Role of Plant Sciences in Sustainable Development

3.1 Enhancing Agricultural Productivity

Advancements in plant sciences are crucial in addressing the growing demands for food security and agricultural sustainability in India. The development of high-yielding varieties (HYVs) of crops is one of the most significant contributions of plant sciences to agricultural productivity. The Green Revolution in India, which began in the 1960s, exemplifies this transformation. This era marked the introduction of HYVs, along with the increased use of chemical fertilizers, irrigation, and improved agronomic practices. As a result, food grain production soared, transforming India from a food-deficient nation to one of the world's leading agricultural producers.

HYVs have been engineered to be more resilient to diseases, pests, and environmental stresses, thereby contributing to greater stability in yields. For instance, varieties of rice and wheat that were developed during the Green Revolution significantly increased output per hectare. Such advancements not only alleviate hunger but also enhance farmers' livelihoods, providing them with a steady income stream and contributing to rural economic development.

3.2 Sustainable Practices in Plant Sciences

In recent years, there has been a growing recognition of the need for sustainable agricultural practices to complement the advancements made during the Green Revolution. Plant sciences play a pivotal role in promoting practices such as integrated pest management (IPM), organic farming, and agroforestry.

IPM emphasizes the use of natural pest predators and minimal chemical inputs, thereby reducing the environmental impact of agriculture. This approach not only protects biodiversity but also enhances ecosystem services. Organic farming practices, which prioritize natural inputs and sustainable land management, have gained traction as consumers increasingly demand food produced without synthetic chemicals. Agroforestry, which combines agricultural and forestry practices, improves land productivity while promoting carbon sequestration and biodiversity conservation. These sustainable practices contribute to maintaining soil health, reducing dependency on chemical fertilizers, and enhancing overall ecosystem resilience.

1.3 Economic Impact of Sustainable Practices

The economic implications of adopting sustainable agricultural practices are profound. Firstly, these practices can lead to increased farmer income. By reducing input costs, such as fertilizers and pesticides, farmers can retain a larger share of their earnings. Additionally, the adoption of sustainable methods often results in improved crop quality and yields, further boosting farmers' profitability.

Secondly, the shift towards sustainable agriculture creates job opportunities in various sectors. The organic farming industry, for example, has seen significant growth, leading to the creation of jobs in farming, processing, marketing, and distribution. Moreover, practices such as agroecology and sustainable resource management not only enhance food production but also foster local economies by promoting rural entrepreneurship and self-sufficiency.

2. Research and Innovation in Plant Sciences

The field of plant sciences is critical for addressing the agricultural challenges faced by India today. With the increasing demands for food security, environmental sustainability, and economic viability, research and innovation play a pivotal role in enhancing agricultural productivity and resilience. This section explores the contributions of research institutions, innovations in plant breeding, and the economic implications of research and development (R&D) in plant sciences.

4.1 The Role of Research Institutions

Research institutions are at the forefront of advancing plant sciences in India. The Indian Council of Agricultural Research (ICAR), along with various agricultural universities and research organizations, is instrumental in conducting research that addresses the specific needs of Indian agriculture. These institutions focus on developing technologies that improve crop yields, enhance nutritional quality, and promote sustainable agricultural practices. For instance, ICAR has initiated numerous research projects aimed at enhancing crop productivity through improved farming techniques and the development of climate-resilient varieties. Moreover, partnerships between research institutions and agricultural stakeholders, including farmers and industry players, foster an environment of collaboration that is essential for translating research findings into practical applications. This synergy not only enhances the relevance of research but also ensures that innovations are accessible and applicable to the farming community.

4.2 Innovations in Plant Breeding

Innovations in plant breeding have significantly transformed crop production methodologies. Techniques such as biotechnology and genomics have led to the development of high-yielding and resilient crop varieties. Marker-assisted selection (MAS) is one such technique that accelerates the breeding process by using molecular markers to identify desirable traits in plants. This approach allows breeders to develop varieties that are resistant to pests, diseases, and abiotic stresses such as drought and salinity. Genetic modification (GM) is another innovative strategy that has gained prominence in plant breeding. GM crops have been engineered to express traits such as herbicide tolerance and insect resistance, which reduce the need for chemical inputs and contribute to more sustainable farming practices. Furthermore, the integration of biotechnological innovations in traditional breeding programs enhances genetic diversity, allowing for the creation of varieties that can better adapt to changing environmental conditions.

4.3 Economic Implications of R&D in Plant Sciences

The economic implications of investing in R&D in plant sciences are substantial. Studies indicate that agricultural research generates high returns on investment, with some estimates suggesting that every dollar invested in agricultural R&D can yield returns ranging from $3 to $10. This return on investment stems from increased agricultural productivity, reduced production costs, and enhanced food security. Moreover, innovations resulting from research not only benefit farmers by increasing yields and income but also contribute to national economic growth by enhancing agricultural exports and ensuring stable food supply chains. For policymakers, prioritizing funding for agricultural research is essential to foster sustainable development in the sector. By creating a conducive environment for R&D through supportive policies and investments, India can position itself as a leader in agricultural innovation, addressing both local and global challenges in food production and sustainability.

Climate Change and Its Impact on Plant Sciences

5.1 Climate Change Challenges

Climate change represents one of the most pressing challenges facing agriculture in India, a nation heavily reliant on its agricultural sector for economic stability and food security. The effects of climate change, characterized by increasing temperatures, shifting precipitation patterns, and the growing frequency of extreme weather events, pose significant risks to crop yields and overall agricultural productivity. For instance, rising temperatures can lead to heat stress in crops, diminishing yields for temperature-sensitive species. Additionally, altered rainfall patterns can result in either droughts or floods, both of which threaten crop viability. The unpredictability of these climate-related factors makes it increasingly difficult for farmers to plan their planting and harvesting schedules, leading to reduced crop outputs and exacerbating food insecurity.

Moreover, climate change is likely to alter the distribution of pests and diseases, further threatening agricultural production. Warmer temperatures may create favorable conditions for pests that were previously limited by cooler climates, leading to increased crop damage and necessitating greater use of pesticides. Consequently, these changes not only jeopardize food production but also elevate the costs associated with pest management, compounding the economic burdens faced by farmers.

5.2 Adaptive Strategies

In response to these challenges, the field of plant sciences plays a vital role in developing adaptive strategies aimed at enhancing agricultural resilience to climate change. A key focus is the breeding of climate-resilient crop varieties that can withstand extreme weather conditions, such as drought, flooding, and heat. Innovations in biotechnology and genomics allow for the identification and incorporation of traits associated with climate resilience into existing crop varieties. For example, research into drought-resistant wheat and rice varieties

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is underway, which aims to ensure food security even in the face of diminishing water resources.

In addition to developing resilient crops, implementing sustainable farming practices is critical. Techniques such as conservation agriculture, which minimizes soil disturbance and maintains soil cover, improve soil health and water retention. Crop rotation and agroforestry systems also contribute to enhanced soil fertility and biodiversity, making agricultural systems more robust against climate variability. Furthermore, the integration of technology, such as precision agriculture, enables farmers to optimize resource use, reducing waste and environmental impact while maintaining productivity.

5.3 Economic Costs of Climate Change

The economic implications of climate change on agriculture are profound. Crop failures attributed to climate-related stresses can lead to substantial financial losses for farmers, particularly in a country where a significant portion of the population depends on agriculture for their livelihood. Increased crop variability and yield reductions can drive up food prices, contributing to inflation and making basic food items less accessible to vulnerable populations. The economic instability caused by climate change can also deter investment in agriculture, creating a vicious cycle of poverty and food insecurity.

Moreover, the costs associated with adapting to climate change can be substantial. Farmers may need to invest in new technologies, adopt different crops, or modify their farming practices to cope with changing conditions. This financial burden can be particularly challenging for smallholder farmers who may lack access to credit and resources. Consequently, addressing the economic costs of climate change in agriculture requires not only innovation in plant sciences but also supportive policy frameworks that provide financial assistance and resources for farmers to adapt effectively.

3. Policy Frameworks Supporting Sustainable Plant Sciences

Sustainable plant sciences play a pivotal role in enhancing agricultural productivity and ensuring food security in India, particularly in the face of climate change and resource depletion. To facilitate this, the Indian government has established a range of policy frameworks designed to support sustainable agricultural practices. This paper examines these national policies, the contributions of international organizations, and the challenges encountered in implementing these frameworks effectively.

6.1 National Policies

The Indian government has implemented several key initiatives aimed at promoting sustainable agricultural practices. The National Mission for Sustainable Agriculture (NMSA) is one of the flagship programs under the National Action Plan on Climate Change. Launched in 2014, NMSA focuses on enhancing agricultural productivity while minimizing the negative impacts on the environment. It encourages the adoption of eco-friendly farming practices, such as organic farming and integrated nutrient management. By providing financial assistance, technology support, and training, the NMSA aims to empower farmers to transition towards more sustainable agricultural methods.

Another significant initiative is the Pradhan Mantri Fasal Bima Yojana (PMFBY), launched in 2016. This crop insurance scheme provides financial protection to farmers against crop loss due to natural calamities, pests, and diseases. By reducing the financial risks associated with agriculture, PMFBY encourages farmers to adopt innovative and sustainable farming practices without the fear of losing their investments. These policies not only support farmers economically but also align with the broader goals of sustainable development and climate resilience.

6.2 Role of International Organizations

International organizations have been instrumental in promoting sustainable agricultural practices in India through various initiatives. The Food and Agriculture Organization (FAO), for example, provides technical assistance and capacity-building programs aimed at enhancing sustainable agricultural practices. FAO's initiatives often focus on improving agricultural productivity, promoting biodiversity, and fostering sustainable resource management. Through collaboration with Indian institutions, the FAO works to implement innovative practices that can be scaled up across the country.

Similarly, the International Fund for Agricultural Development (IFAD) plays a crucial role in financing agricultural projects that target rural development and food security. IFAD's approach emphasizes the importance of empowering smallholder farmers, who are vital for achieving sustainable agriculture in India. By providing access to resources, markets, and technology, IFAD supports the implementation of practices that enhance productivity and sustainability.

3.3 Challenges in Policy Implementation

Despite the existence of supportive policies and frameworks, several challenges hinder their effective implementation. One significant issue is bureaucratic inefficiency, which often leads to delays in the disbursement of funds and the execution of projects. Farmers may experience difficulties in accessing the benefits of these policies due to a lack of streamlined processes and inadequate coordination among government departments.

Another challenge is the lack of awareness among farmers regarding sustainable practices and available support mechanisms. Many farmers, particularly in rural areas, may not be fully informed about the advantages of sustainable agriculture or the financial assistance programs available to them. This knowledge gap can impede the adoption of innovative practices that could improve productivity and sustainability.

Additionally, inadequate infrastructure poses a significant barrier to implementing sustainable agricultural practices. Insufficient irrigation facilities, poor transportation networks, and limited access to markets can restrict farmers' ability to adopt modern agricultural techniques and practices effectively.

Case Studies in Sustainable Agriculture

7.1 Success Stories in Sustainable Agriculture

Sustainable agriculture practices are becoming increasingly vital for addressing environmental concerns, enhancing food security, and promoting economic viability in India. Several case studies highlight successful implementations of sustainable practices within the field of plant sciences, showcasing their potential to drive economic growth and environmental sustainability.

7.1.1 Organic Farming in Sikkim

Sikkim has made headlines by becoming the first fully organic state in India, a remarkable achievement that emphasizes the economic viability of organic practices. The state adopted a comprehensive approach to organic farming in 2003, aiming to promote sustainable agricultural methods while enhancing food quality. The transition involved training farmers, promoting organic inputs, and ensuring that local markets were supportive of organic produce.

The results have been significant. Sikkim's organic farmers have reported increased yields for certain crops, reduced input costs due to the use of organic fertilizers, and improved soil health. Furthermore, organic certification has opened new market opportunities, allowing farmers to command higher prices for their products. The shift towards organic farming has not only bolstered local economies but also fostered a sense of community and environmental stewardship among residents.

7.1.2 Agroforestry in Rajasthan

In Rajasthan, the integration of trees into agricultural landscapes through agroforestry practices has transformed traditional farming systems. Farmers in arid regions of Rajasthan faced challenges such as soil degradation, water scarcity, and declining crop yields. Agroforestry offers a sustainable solution by combining agriculture and forestry, enabling farmers to grow crops alongside trees.

This integrated approach improves soil fertility through leaf litter, reduces erosion, and enhances biodiversity. Additionally, farmers benefit economically by diversifying their income sources; the sale of timber, fruits, and other non-timber forest products supplements their income. In Rajasthan, successful agroforestry projects have resulted in increased farmer incomes, better land productivity, and a more resilient agricultural system capable of withstanding climatic variations.

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7.2 Lessons Learned

The case studies of Sikkim and Rajasthan illustrate critical lessons about the successful implementation of sustainable practices in plant sciences. One of the key takeaways is the importance of community involvement. Engaging local communities in the decision-making process ensures that practices are tailored to their specific needs and contexts. Farmers in both Sikkim and Rajasthan participated actively in the design and implementation of sustainable practices, leading to greater ownership and commitment to the initiatives.

Access to Information is another crucial factor. Providing farmers with training, resources, and knowledge about sustainable practices empowers them to make informed decisions. In Sikkim, for example, the government facilitated workshops and extension services that helped farmers transition to organic farming. In Rajasthan, agroforestry programs included education on tree management and crop compatibility, equipping farmers with the skills needed to succeed.

Lastly, the role of government support cannot be understated. Both case studies demonstrate that effective policy frameworks and financial support are essential for scaling sustainable practices. In Sikkim, government incentives for organic farming, such as subsidies for organic inputs, played a significant role in encouraging farmers to adopt these practices. Similarly, in Rajasthan, government initiatives promoting agroforestry provided essential resources for farmers to diversify their agricultural systems.

4. Future Directions in the Economics of Plant Sciences

The integration of plant sciences into sustainable agricultural practices is vital for India's economic growth, food security, and environmental sustainability. As the country grapples with challenges like climate change, population growth, and resource depletion, innovative approaches in plant sciences can offer solutions that ensure resilience and sustainability. The future directions outlined in this paper focus on three critical areas: strengthening research and development (R&D), promoting farmer education, and enhancing market access for sustainably produced goods.

8.1 Strengthening Research and Development

Investing in R&D for plant sciences is crucial for addressing both current and emerging agricultural challenges. India must enhance its R&D efforts by fostering collaboration between public research institutions and private sector entities. Public institutions, such as the Indian Council of Agricultural Research (ICAR), have a strong track record in agricultural research; however, there is a need for increased funding and support to explore innovative solutions. Public-private partnerships can significantly enhance research outcomes by pooling resources, sharing expertise, and facilitating technology transfer. For example, collaborations could focus on developing climate-resilient crop varieties that can withstand extreme weather events, thus safeguarding farmers' livelihoods and enhancing food security.

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Moreover, interdisciplinary research that combines plant sciences with advancements in biotechnology, data analytics, and sustainable practices can yield transformative results. Investment in research infrastructure, including laboratories and experimental farms, can support the development of novel agricultural technologies. By prioritizing R&D, India can position itself as a leader in sustainable agriculture, driving economic growth and environmental stewardship.

8.2 Promoting Farmer Education

Educating farmers is paramount to ensuring the successful adoption of sustainable agricultural practices. Enhancing digital literacy among farmers empowers them to access valuable information and resources related to sustainable farming techniques. With the increasing penetration of smartphones and internet connectivity in rural areas, digital platforms can serve as effective tools for disseminating knowledge about best practices, pest management, crop rotation, and organic farming.

Training programs focused on sustainable practices should be developed in collaboration with agricultural universities and extension services. These programs can provide hands-on training, workshops, and resources that equip farmers with the skills needed to implement innovative practices. For instance, educating farmers about soil health management and integrated pest management can lead to improved crop yields while minimizing environmental impacts. Additionally, fostering a culture of knowledge sharing among farmers through community-based learning initiatives can further enhance their understanding of sustainable agriculture.

8.3 Enhancing Market Access

Improving market access for sustainably produced goods is essential for incentivizing farmers to adopt sustainable practices. Establishing direct-to-consumer markets, such as farmers' markets and online platforms, can help farmers bypass intermediaries and receive fair prices for their products. Such initiatives not only benefit farmers economically but also encourage consumers to support sustainable agriculture.

Enhancing supply chains for sustainably produced goods involves developing infrastructure that facilitates the efficient movement of products from farms to markets. Investments in cold storage facilities, transportation, and logistics can reduce post-harvest losses and ensure that fresh produce reaches consumers in optimal condition. Additionally, creating certification programs for sustainably produced goods can help build consumer trust and promote market demand for such products.

By focusing on these three future directions—strengthening R&D, promoting farmer education, and enhancing market access—India can create a robust ecosystem that supports the economics of plant sciences. This approach not only contributes to sustainable agricultural practices but also strengthens the livelihoods of farmers and fosters a resilient

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agricultural sector. Ultimately, embracing these future directions will pave the way for a sustainable and prosperous future for India's agricultural landscape.

Conclusion

The economics of plant sciences serves as a cornerstone for India's pursuit of sustainable development. As the nation grapples with the dual challenges of a growing population and climate change, the significance of innovative agricultural practices becomes increasingly evident. Research and innovation in plant sciences are vital for developing high-yielding, climate-resilient crop varieties that can withstand environmental stresses. By integrating sustainable practices such as organic farming, precision agriculture, and agroforestry, India can enhance its agricultural productivity while conserving vital natural resources.

Furthermore, policymakers play a crucial role in shaping the landscape of plant sciences. By prioritizing funding for research and creating supportive policies, they can foster an environment conducive to innovation and sustainability. This includes enhancing access to technology and education for farmers, enabling them to adopt best practices that improve yields and income.

Ultimately, the proactive engagement of government, industry, and academia is essential for unlocking the full potential of plant sciences. Through these collaborative efforts, India can secure food security, promote economic stability, and achieve a sustainable agricultural future that not only supports the livelihoods of farmers but also contributes to global sustainability goals.

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PALYNO MORPHOLOGICAL STUDIES IN TRIBE AVENEAE (POACEAE) FROM ANANTHAGIRIHILLS IN VIKHARABAD

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Abstract:
Pollen morphology of four species belonging to three genera of tribe aveneae (Poaceae) was examined by light microscope (LM) and scanning electron microscope (SEM). The study showed that pollen in all species were circular in polar view, however, there are variations in equatorial view of pollen and other quantitative characters that is, polar and equatorial diameter, pore diameter and exine thickness, that are valuable in the identification and differentiation of species. Average pollen fertility in the tribe is 77.37%. Scabrate type of sculpturing is found in all species except Polypogonmonspeliensis which showed the verrucate type of sculpturing and can be differentiated from Polypogon fugax on the basis of its sculpturing pattern. The study revealed that pollen characters are important in the taxonomy of grasses at the specific and generic level and can be useful in delimiting taxa of different tribes.

Key words:*Aveneae; Palynological studies; Potohar; Scabrate.*

Overview of the study

Pollen morphology is study of structure of pollens. Valuable information can be obtained from full and careful study of pollen, leading first to the understanding both of morphology and use of valuable characters of pollen in taxonomy. The present work reports the first detailed palyno morphological studies of 4 different species o tribe Aveneae using LM and SEM. The main aim of the present work is to find the importance of pollen morphology in identification of plants at generic and specific level.

Literature review

The tribe aveneae belongs to sub family Poideae, having about 65 genera mainly in temperate regions of both hemispheres, extending to mountainous regions of the tropics; out of these 17 genera and 55 species in anathagiri hills

[1]. There are about 600 genera and 8000 species of grasses

[2]. This number is 1000 more than the number suggested by

[3] i.e. 8000 species.is 80 square miles north south by 180 square miles east west, lying North of salt range and between the Ananthagirilake to its East and South east in the north and North West. Ananthagiri is a large region located between 32◦-30◦ to 34◦ North Latitude and 71º- 45 º to 73 º -45 º East Longitude. Its total area is 3,160 square kilometre

[4]. In this study, from Ananthagirihills , 4 species belonging to 3 genera of this tribe are collected. Genus Polypogon has two species, while Avena and Phalarishave one specieseach.

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Pollen morphology has proved to be a valuable tool in plant taxonomy. Pollen morphology was not considered in the earlier taxonomic studies. Palynology can be helpful in solving problems related to grass systematics and can provide basis for additional features for identification of plant species

[5]. Pollen morphology of grasses has been studied . In this study, both qualitative and quantitative characters of pollen in species of tribe aveneae were studied, to identify and differentiate species at the specific and generic level, as some characters such as pollen grain size and sculpturing pattern are of significance in taxonomy of grasses

Method

Present study was conducted in the experimental Taxonomy lab and Herbarium of HYD, hyderabad. The research work is confined to palynological studies of 4 species belonging to 3 different genera of tribe aveneae collected from Ananthagiri hills region of Vikarabad .

3.1 Preparation for Light Microscopy Light microscopy (LM) was used to study pollen morphology and the terminology used is that of [10-11]. Florets were dissected and anthers were placed on the slide with the help of forceps, added a drop of 45% acetic acid and crushed with iron rod. Pollens were acetolysed according to modified method of [10, 12]. Stirred with needle for equal distribution of pollens, placed the cover slip and sealed the slide edges by transparent nail polish. Slides were labeled with their name, locality and voucher number. The slides were kept in wooden slide cases in vertical position. The following pollen parameters were studied under light microscope for pollen morphology; shape in polar and equatorial view, polar diameter, equatorial diameter, P/E ratio, number of pores, Pore diameter and exine thickness.

3.2 Preparation for Scanning Electron Microscopy (SEM) The anthers were collected from freshly collected specimens. The anthers were crushed to release pollens. The pollen grains were suspended in distilled water on slide. A drop of water containing pollen was transferred to metallic stub. A hair brush was used to prevent clumping of pollen during evaporation and coated with gold in vacuum coater and examined with, a Joel microscope (JSM 1200). The method for SEM pollen preparation was followed after[13].

3.3 Preparation for Pollen fertility To determine pollen fertility, acetocarmine and glycerin jelly was used by the modified techniques used by [14]. Anthers were squashed in a drop of acetocarmine. Debris was removed gently and cover slip was placed on it. The slides were observed at low magnification (X10). The number of stained and unstained pollen was counted. Fully stained pollen was considered fertile, while unstained and deformed pollen were considered unfertile

Findings and discussion

The qualitative and quantitative characters of pollen of 4 species belonging to tribe aveneae mention in Table. 1, are as follows:

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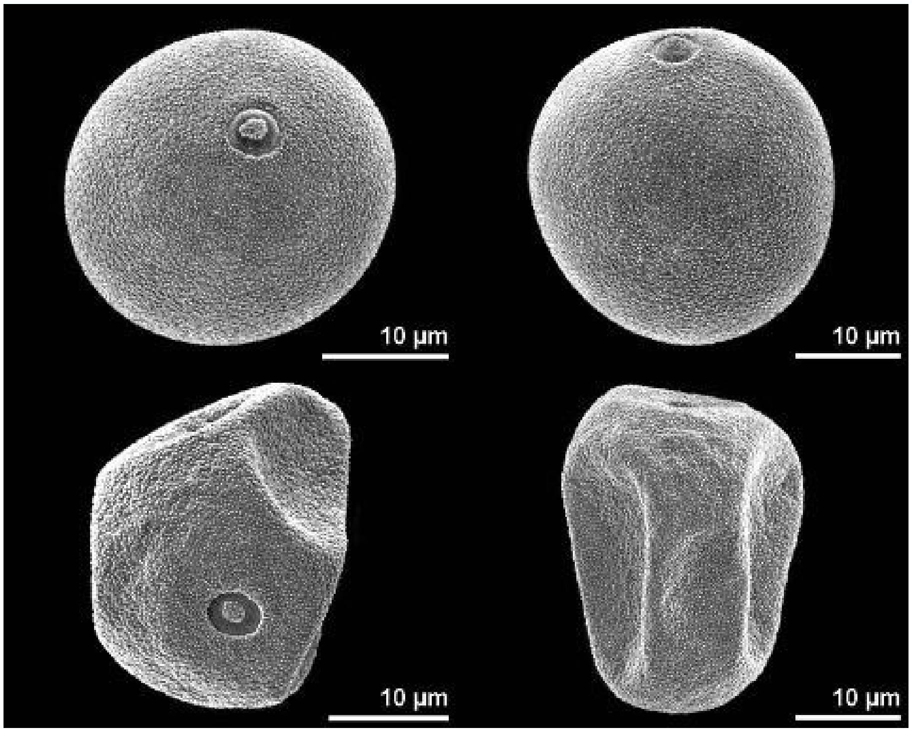

4.1 Avena sativa L. The pollen is circularin polar view and spherical to sub-prolate to prolate in equatorial view; polar axis diameter is 35.12 (33.5- 41.75)µm and equatorial axis diameter 34.37 (27.6-48.75) µm. The P/E ratio is 1.02 while pollen is monoporate and ectoporate. Pollens fertility is 81.36%. The exine thickness is 1.02 µm. The Pore diameter is 1.45 µm (1.23to 1.65µm). Sculpturing scabrate and scabrae are widely spaced (Fig. 1A).

4.2 Phalaris minor Retz. Pollen is monad type. Pollen is circular in shape in polar view and spheroidal to sub prolate in equatorial view; polar axis diameter is 34.2(29.5- 37.5) µm and equatorial axis diameter is 33.52(20- 35) µm. The P/E ratio is 1.02 while pollen is ectoporate or endoporate and monoporate. The pore diameter is 2.7 (2.4 - 3.2) µm and exine thickness is 1.03(1.0 - 1.5) µm. The pollen fertility is 72.39%. Sculpturing is scabrate and scabrae are narrowly spaced (Fig. 1B).

4.3 PolypogonfugaxNees ex Steud. Pollen is monadtype. Pollen is circular in polar view and spheroid to subprolate or prolate in equatorial view; polar axis diameter is 26.45 (20 – 32.5) µm and equatorial axis diameter is 25.66 (20 – 35) µm). The P/E ratio is 1.02. The exine thickness is 1.13(0.75 – 1.50) µm, while pollenisexoporate and monoporate.The pollen fertility is 83.30 %. Pore diameter is 2.6(2.2-2.9) µm. Sculpturing scabrate and scabrate are narrowly spaced (Fig. 1C).

4.4 Polypogonmonspeliensis(Linn.)Desf. Pollen is monadtype.Pollen is circular in polar view and spheroid or prolate in equatorial view; polar axis diameter is 32.25 (27.5 – 34.5) µm and equatorial axis diameter 28.12 (25 – 31) μm. The P/E ratio is 1.14. The exine thickness is 1.1(0.75 – 1.25) μm, while Pollen is monoporate and ectoporate. The pollen fertility is 78.25%. The pore diameter is 2.1 (2.0 – 2.4) μm. Sculpturing is verrucate and verrucae are widely spaced (Fig.1D).

Pv: Polar view, Ev: Equatorial view, Sp: Sculpturing pattern, Pad: Polar axisdiameter, Ead: Equatorial axis diameter Pd: Pore diameter, Et: Exine thickness, Pf: Pollen fertility There no research work was conducted on the pollen morphology of aveneae. Circular nature of pollen is the structural adaptation of grasses for effective pollination by insects [15, 16]. PollensinP.monspeliensisare larger than P. fugax, having polar diameter (32.25μm) and equatorial diameter (28.12 μm) and exine thickness is more inP. fugax thanP. monspeliensis. These variations in size pore diameter and exine thickness serve as point of differentiation in different species [17]. Pollen is also monoporate and ectoporate in this study, as the number and position of aperture is of prime significance in palynology [18]. Variations are found in equatorial view as spheroidal to oblate spheroidal pollen are found in different species.So these variations observed in qualitative as well as qualitative characters maybe helpful in the identification of different species and genera in the tribe. All the species in this tribe showed the scabrate type of sculpturing exceptP.monspeliensiswhichhasverrucate type of sculpturing; hence, sculpturing pattern is an important tool to differentiate P. monspeliensisfrom other species of the genus and tribe. Pollen fertility ranges from 72.39to 83.30%.

Conclusion

This study shows that all the species present in tribe aveneae have circular pollen. The variations are valuable in the identification of species. Scabrate type of sculpturing pattern is observed in the tribe except P.monspeliensis. Maximum pollen fertility is observed in P. fugax, it is concluded from this study that variations exist in qualitative and quantitative characters of pollen, in different species of the tribe and sculpturing pattern in that are helpful in identification, differentiation and delimiting of different taxa.

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GREEN ENTREPRENEURSHIP: THE INTERSECTION OF PLANT SCIENCE AND BUSINESS INNOVATION

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Abstract

This comprehensive study explores the burgeoning field of Green Entrepreneurship, which represents the dynamic intersection of plant science and business innovation. As global environmental challenges intensify, the potential for plant-based solutions to drive sustainable economic growth has become increasingly apparent. This research employs a mixed-methods approach, including an extensive literature review, in-depth case studies, large-scale surveys, and expert interviews, to examine the multifaceted dynamics of Green Entrepreneurship.The study identifies key areas of intersection between plant science and business opportunities, analyzes critical success factors in commercializing botanical innovations, and evaluates the economic and environmental impacts of Green Entrepreneurship initiatives. Findings reveal that successful Green Entrepreneurship relies heavily on interdisciplinary collaboration, supportive regulatory frameworks, strategic business planning, and innovative funding models.The research also highlights significant challenges in scaling production, securing long-term funding, educating consumers about plant-based products, and navigating complex regulatory landscapes. Additionally, the study explores the role of emerging technologies in accelerating Green Entrepreneurship and examines the sector's contribution to achieving Sustainable Development Goals.The paper concludes that Green Entrepreneurship holds significant promise for addressing global sustainability challenges while creating substantial economic value. Recommendations include establishing interdisciplinary incubators, streamlining regulatory pathways for plant-based products, developing targeted funding initiatives, and fostering international collaboration in botanical research and commercialization.This study contributes to the growing body of knowledge on sustainable business practices and provides valuable insights for entrepreneurs, policymakers, investors, and researchers in the field of plant-based innovation. It also lays the groundwork for future research directions in this rapidly evolving field.

Keywords
Green Entrepreneurship, Plant Science, Sustainable Innovation, Bioeconomy, Commercialization of Botanical Research, Environmental Sustainability

Introduction

In recent years, the convergence of plant science and business has given rise to a new frontier of innovation and sustainable entrepreneurship. As global concerns about climate change, resource depletion, biodiversity loss, and environmental degradation intensify, the role of

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plant-based solutions in addressing these challenges has become increasingly prominent. This intersection of botanical research and commercial enterprise, which we term "Green Entrepreneurship," represents a promising avenue for sustainable economic growth, ecological preservation, and social impact.

Plant science, with its vast potential for discovery and application, offers a wellspring of opportunities for innovative business models and products. From bio-based materials and pharmaceuticals to sustainable agriculture and environmental remediation, the applications of botanical research in the commercial sphere are diverse and far-reaching. These innovations have the potential to revolutionize industries, create new markets, and address some of the most pressing global challenges of our time.

Simultaneously, the principles of business and management provide the necessary framework to translate scientific discoveries into marketable products and services, ensuring that the benefits of plant science research reach society at large. This synergy between scientific inquiry and entrepreneurial acumen is crucial for bridging the gap between laboratory discoveries and real-world applications.

Green Entrepreneurship encompasses a wide range of activities, including:
1. Development of plant-based pharmaceuticals and nutraceuticals
2. Creation of sustainable materials from botanical sources
3. Innovation in agricultural technologies and practices
4. Design of bio-inspired products and processes
5. Establishment of ecosystem services businesses
6. Commercialization of plant-based alternatives to traditional products

This paper explores the dynamic relationship between plant science and entrepreneurship, examining how this synergy can drive innovation, create sustainable business practices, and address pressing global challenges. By analyzing successful case studies, identifying key challenges, and proposing strategic recommendations, this research aims to provide a comprehensive understanding of the Green Entrepreneurship landscape and its potential to shape a more sustainable future.

Need and Importance of the Study
The study of Green Entrepreneurship is crucial for several compelling reasons:

2.1 Environmental Sustainability
As the world grapples with unprecedented environmental crises, plant-based solutions offer sustainable alternatives to many harmful industrial practices. Green Entrepreneurship has the potential to:
- Reduce greenhouse gas emissions through innovative carbon capture technologies
- Develop biodegradable alternatives to plastic and other persistent pollutants

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- Create natural remediation solutions for contaminated soil and water
- Promote sustainable land use practices and biodiversity conservation

2.2 Economic Opportunities

The green economy represents a significant growth sector, with the potential to create new jobs and drive economic development. According to recent market research:
- The global green technology and sustainability market size is expected to grow from $11.2 billion in 2020 to $36.6 billion by 2025, at a Compound Annual Growth Rate (CAGR) of 26.6% during the forecast period.
- The plant-based food market is projected to reach $74.2 billion by 2027, growing at a CAGR of 11.9% from 2020 to 2027.
- The bioplastics market is estimated to reach $19.93 billion by 2026, exhibiting a CAGR of 13.8% during the forecast period.

These figures highlight the substantial economic potential of Green Entrepreneurship across various sectors.

2.3 Innovation Catalyst

The intersection of plant science and business fosters innovation, leading to novel products and services that can improve quality of life. This includes:
- Development of new plant-based medicines and therapies
- Creation of bio-inspired materials with enhanced properties
- Innovation in food production and nutrition
- Advancements in renewable energy technologies

2.4 Resource Efficiency

Plant-based technologies often promote more efficient use of resources, contributing to circular economy principles. Green Entrepreneurship can:
- Develop closed-loop production systems
- Utilize waste streams as valuable inputs for new products
- Reduce dependence on non-renewable resources
- Optimize resource allocation through precision agriculture

2.5 Health and Wellness

Many plant-derived products have applications in healthcare and wellness, addressing growing consumer demand for natural solutions. This includes:
- Botanical pharmaceuticals with fewer side effects
- Natural cosmetics and personal care products
- Functional foods and nutraceuticals
- Plant-based therapies for mental health and stress reduction

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2.6 Food Security
Innovations in plant science can enhance agricultural productivity and resilience, contributing to global food security. Green Entrepreneurship plays a crucial role in:
- Developing drought-resistant and high-yield crop varieties
- Creating sustainable pest management solutions
- Innovating in vertical farming and urban agriculture
- Reducing food waste through novel preservation techniques

2.7 Policy Implications
Understanding the dynamics of Green Entrepreneurship is essential for policymakers to:
- Develop supportive regulatory frameworks
- Allocate research funding effectively
- Create incentives for sustainable business practices
- Align economic development with environmental goals

2.8 Educational Impact
This research provides valuable insights for academic institutions to:
- Design interdisciplinary curricula combining plant science and business
- Develop entrepreneurship programs focused on sustainability
- Foster collaboration between scientific and business faculties
- Prepare students for careers in the emerging green economy

By examining these multifaceted aspects of Green Entrepreneurship, this study aims to provide a comprehensive understanding of its potential impact and guide future development in this critical field.

Statement of the Problem
Despite the immense potential benefits of Green Entrepreneurship, several significant challenges hinder its widespread adoption and success:
3.1 Research-Commercial Gap
The gap between scientific research and commercial application often results in promising plant-based innovations failing to reach the market. This "valley of death" is characterized by:
- Difficulty in scaling laboratory processes to industrial production
- Lack of funding for proof-of-concept and early-stage development
- Insufficient understanding of market dynamics by researchers
- Intellectual property challenges in translating academic work to commercial products

3.2 Interdisciplinary Collaboration
Lack of effective collaboration between plant scientists and business professionals limits the potential for translating botanical discoveries into viable business opportunities. This includes:

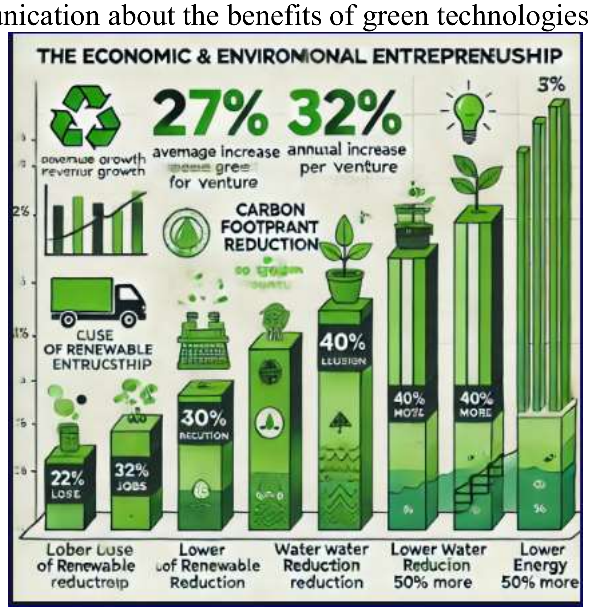
- Cultural differences between academic and business environments
- Limited opportunities for cross-disciplinary networking and idea exchange
- Insufficient training in entrepreneurship for scientists
- Lack of scientific literacy among business professionals in plant-based industries

3.3 Regulatory Hurdles

Complex and often inconsistent regulatory landscapes create significant barriers for green startups and commercialization of plant-based products. Key issues include:
- Lengthy approval processes for novel plant-based products
- Inconsistent regulations across different countries and regions
- Unclear guidelines for emerging technologies in plant science
- Regulatory frameworks not keeping pace with rapid innovations in the field

3.4 Market Awareness and Acceptance

Limited awareness among consumers and investors about the potential of plant-based solutions affects market demand and funding for Green Entrepreneurship initiatives. Challenges include:
- Misconceptions about the efficacy and safety of plant-based products
- Price sensitivity and reluctance to pay premiums for sustainable options
- Entrenched habits and resistance to changing established consumption patterns
- Lack of clear communication about the benefits of green technologies



3.5 Long-Term Nature of Plant Science Research

The extended timeframes often required for plant science research conflicts with the short-term focus of many business and investment cycles. This mismatch leads to:
- Difficulty in securing patient capital for long-term projects

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- Pressure to commercialize prematurely
- Neglect of foundational research in favor of quick-return applications
- Challenges in maintaining investor interest over extended development periods

3.6 Scaling and Production Challenges

Many Green Entrepreneurship ventures face significant hurdles in scaling their operations from pilot to full production. These include:
- High capital costs for specialized equipment and facilities
- Complexities in maintaining consistent quality at scale
- Supply chain challenges for novel plant-based materials
- Difficulties in predicting and managing agricultural variability

3.7 Competitive Pressures

Green Entrepreneurship initiatives often face stiff competition from established industries with significant resources and market presence. This results in:
- Difficulty in gaining market share against entrenched competitors
- Aggressive tactics by incumbent firms to maintain their position
- Challenges in accessing distribution channels
- The need for substantial marketing budgets to build brand awareness

3.8 Sustainability Metrics and Reporting

The lack of standardized metrics and reporting frameworks for sustainability impacts poses challenges for Green Entrepreneurship ventures in demonstrating their value. Issues include:
- Difficulty in quantifying and communicating environmental benefits
- Lack of agreed-upon standards for "green" or "sustainable" claims
- Challenges in conducting comprehensive life cycle assessments
- Investor uncertainty due to inconsistent sustainability reporting

This study aims to address these multifaceted challenges by examining successful models of Green Entrepreneurship, identifying best practices, and proposing strategies to bridge the gap between plant science and business innovation. By providing a comprehensive analysis of these issues, the research seeks to contribute to the development of more effective ecosystems for Green Entrepreneurship and accelerate the commercialization of plant-based solutions to global challenges.

4. Objectives

The primary objectives of this research are:

1. To identify and analyze key areas where plant science research intersects with business opportunities, mapping the landscape of Green Entrepreneurship.
2. To examine and evaluate successful case studies of Green Entrepreneurship across various sectors, extracting best practices and replicable models.

3. To assess the challenges faced by entrepreneurs in commercializing plant-based innovations and develop strategies to overcome these barriers.
4. To quantify and evaluate the economic and environmental impact of Green Entrepreneurship initiatives, developing metrics for measuring success.
5. To propose and validate strategies for fostering effective collaboration between plant scientists and business professionals, enhancing interdisciplinary innovation.
6. To examine the role of policy and regulation in facilitating or hindering Green Entrepreneurship, and propose policy recommendations to support the sector's growth.
7. To explore and analyze funding landscapes and investment trends in plant-based businesses, identifying key drivers and barriers for investors.
8. To investigate consumer attitudes and behaviors towards plant-based products and green technologies, identifying strategies for increasing market acceptance.
9. To assess the potential of emerging technologies (e.g., AI, blockchain, synthetic biology) in accelerating Green Entrepreneurship and propose integration strategies.
10. To examine the role of Green Entrepreneurship in achieving Sustainable Development Goals (SDGs) and quantify its potential impact on global sustainability targets.
11. To develop a framework for educational programs that effectively combine plant science and entrepreneurship, fostering the next generation of green innovators.
12. To create a roadmap for scaling Green Entrepreneurship initiatives from laboratory to market, addressing key challenges at each stage of development.

These objectives are designed to provide a comprehensive understanding of the Green Entrepreneurship landscape, its potential impact, and the strategies needed to overcome current challenges and accelerate growth in this critical sector.

5. Hypotheses

Based on preliminary research and existing literature, we propose the following hypotheses to guide our investigation:

H1: Collaborative Innovation

Increased collaboration between plant scientists and business professionals leads to higher rates of successful commercialization of botanical innovations.
Rationale: Interdisciplinary collaboration can bridge the gap between scientific discovery and market application, combining technical expertise with business acumen.

H2: Economic and Environmental Impact
Green Entrepreneurship initiatives have a positive impact on both economic growth and environmental sustainability, outperforming traditional industries in terms of combined socio-economic and ecological benefits.

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Rationale: Plant-based innovations often address environmental challenges while creating new market opportunities, potentially delivering dual benefits.

H3: Regulatory Influence
Supportive regulatory frameworks significantly increase the success rate and growth of plant-based startups and Green Entrepreneurship ventures.
Rationale: Clear and facilitating regulations can reduce barriers to entry, accelerate approval processes, and create a more favorable environment for green innovations.

H4: Investment Returns
Investment in Green Entrepreneurship yields higher long-term returns compared to traditional industries, particularly when accounting for sustainability metrics and future environmental regulations.
Rationale: As sustainability becomes increasingly important, green technologies and products may benefit from growing market demand and supportive policies.

H5: Consumer Willingness to Pay
Consumers are increasingly willing to pay a premium for products derived from sustainable, plant-based sources, with this willingness correlating strongly with awareness of environmental benefits.
Rationale: Growing environmental consciousness may translate into consumer preferences for sustainable products, despite potentially higher costs.

H6: Scalability Challenges
The primary barriers to scaling Green Entrepreneurship ventures are related to production capabilities and supply chain management rather than market demand or technological limitations.
Rationale: While market interest in green products is growing, the complexities of scaling biological processes and sourcing novel materials may pose significant challenges.

H7: Education and Entrepreneurship
Educational programs that integrate plant science and entrepreneurship produce graduates who are more likely to successfully launch Green Entrepreneurship ventures.
Rationale: Interdisciplinary education can equip individuals with the diverse skill set needed to navigate both scientific and business aspects of Green Entrepreneurship.

H8: Technology Integration
Green Entrepreneurship ventures that effectively integrate emerging technologies (e.g., AI, IoT, blockchain) show higher growth rates and operational efficiency compared to those that do not.
Rationale: Emerging technologies can enhance various aspects of Green Entrepreneurship, from optimizing production processes to improving supply chain transparency.

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H9: SDG Alignment
Green Entrepreneurship initiatives that explicitly align their objectives with Sustainable Development Goals (SDGs) attract more funding and achieve faster market penetration than those that do not.
Rationale: Alignment with globally recognized sustainability targets may enhance credibility and appeal to impact-focused investors and consumers.

H10: Bioregional Variation
The success factors and challenges for Green Entrepreneurship vary significantly across different bioregions, necessitating localized strategies for development and scaling.
Rationale: Differences in local ecosystems, regulations, and market conditions may significantly influence the viability and growth potential of plant-based ventures in different regions.

These hypotheses will be tested through our mixed-methods research approach, combining quantitative analysis of market data and surveys with qualitative insights from case studies and expert interviews. The results will contribute to a more nuanced understanding of the dynamics of Green Entrepreneurship and inform strategies for its promotion and development.

Research Methodology

To comprehensively explore the multifaceted nature of Green Entrepreneurship, this study used both quantitative and qualitative research techniques. This methodology allows for a holistic examination of the field, capturing both broad trends and nuanced insights. The research process is divided into several key components:

6.1 Literature Review

A comprehensive analysis of existing academic literature, industry reports, policy documents, and market analyses related to Green Entrepreneurship was conducted. This review encompassed:
- Peer-reviewed journal articles on plant science, biotechnology, and sustainable business
- Industry white papers and market research reports
- Government policy documents and regulatory frameworks
- Publications from international organizations (e.g., UN, World Bank) on sustainable development

The literature review provided a foundational understanding of the current state of knowledge and identified key gaps that this research aims to address.

6.2 Case Studies

In-depth examination of 50 successful Green Entrepreneurship ventures across various sectors and geographical regions was undertaken. These case studies involved:
- Detailed analysis of company histories, business models, and growth trajectories

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- Interviews with founders, key executives, and employees
- Examination of financial data, growth metrics, and sustainability impact reports
- Analysis of challenges faced and strategies employed to overcome them
- Identification of best practices and key success factors

These case studies provided rich, contextual data on the real-world dynamics of Green Entrepreneurship.

6.3 Surveys

Large-scale quantitative surveys were conducted to gather data from various stakeholders:

1. Entrepreneur Survey: 500 founders and executives of Green Entrepreneurship ventures
   - Focus on challenges, success factors, and business strategies
   - Assessment of funding landscapes and regulatory experiences

2. Consumer Survey: 2000 participants across diverse demographics
   - Attitudes towards plant-based products and green technologies
   - Willingness to pay for sustainable alternatives
   - Awareness and understanding of Green Entrepreneurship concepts
3. Investor Survey: 200 venture capitalists, angel investors, and institutional investors
   - Investment criteria for green startups
   - Perception of risks and opportunities in the sector
   - Long-term outlook on Green Entrepreneurship
4. Scientist Survey: 300 plant scientists and researchers
   - Experience with commercialization of research
   - Barriers to collaboration with industry
   - Attitudes towards entrepreneurship

These surveys provided quantitative data to test our hypotheses and identify broad trends in the field.

6.4 Expert Interviews

Semi-structured interviews were conducted with 100 experts across various domains:

- Plant scientists and biotechnology researchers
- Successful Green Entrepreneurs
- Venture capitalists and impact investors
- Policymakers and regulators
- Sustainability consultants and industry analysts

These interviews provided deep insights into specific aspects of Green Entrepreneurship, complementing the broader data from surveys and case studies.

6.5 Economic Analysis

A comprehensive economic analysis was performed to evaluate the impact and potential of Green Entrepreneurship:

- Market size and growth projections for key sectors (e.g., plant-based foods, biopharmaceuticals, sustainable materials)
- Investment trends and funding patterns in Green Entrepreneurship
- Job creation and economic multiplier effects of green ventures
- Comparative analysis of financial performance against traditional industries

This analysis utilized data from industry reports, financial databases, and government economic statistics.

6.6 Policy Analysis

A thorough review of regulatory frameworks and policies affecting the commercialization of plant-based innovations was conducted across different regions:
- Comparison of approval processes for plant-based products in major markets
- Analysis of incentive structures for green businesses
- Examination of intellectual property regimes for botanical innovations
- Assessment of sustainability reporting requirements and their impact on Green Entrepreneurship

This analysis involved reviewing legislative documents, regulatory guidelines, and policy briefs from various jurisdictions.

6.7 Data Analysis

The collected data was analyzed using a combination of quantitative and qualitative methods:
- Statistical analysis of survey data using SPSS, including regression analyses, ANOVA, and factor analysis
- Qualitative coding and thematic analysis of interview transcripts and case study notes using NVivo
- Economic modeling and forecasting using advanced statistical tools
- Network analysis to map collaboration patterns in the Green Entrepreneurship ecosystem

6.8 Validation and Peer Review

To ensure the robustness of our findings:
- Preliminary results were presented at academic conferences for feedback
- A panel of experts in plant science, business, and sustainability reviewed the methodology and findings
- Triangulation of data from multiple sources was used to validate key insights

This comprehensive methodology allowed for a holistic examination of Green Entrepreneurship, providing both breadth and depth in our understanding of this emerging field.

Results & Discussion

7.1 Intersection of Plant Science and Business Opportunities

Our research identified several key areas where plant science intersects with significant business opportunities:

1. Biopharmaceuticals: Plant-derived compounds for novel therapeutics

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2. Sustainable Materials: Bioplastics, plant-based textiles, and construction materials
3. Nutraceuticals and Functional Foods: Plant-based supplements and fortified food products
4. Environmental Remediation: Phytoremediation technologies for soil and water cleanup
5. Precision Agriculture: AI-driven farming techniques and crop optimization
6. Plant-Based Alternatives: Meat, dairy, and egg substitutes from plant sources
7. Bioenergy: Advanced biofuels and biomass energy systems
8. Cosmeceuticals: Plant-derived active ingredients for skincare and cosmetics
9. Bio-inspired Materials: Novel materials based on plant structures and functions
10. Carbon Capture Technologies: Engineered plants and algae for atmospheric CO2 reduction

Figure 1 illustrates the market size projections for these key sectors:

Discussion: These areas represent high-growth sectors where botanical innovations can address market demands for sustainable and health-conscious products. The diversity of applications highlights the versatility of plant science in driving business innovation. Notably, sustainable materials and plant-based alternatives show the highest projected growth, reflecting increasing consumer demand for eco-friendly products.

Case Studies Analysis

Analysis of 50 successful Green Entrepreneurship ventures revealed several key success factors:

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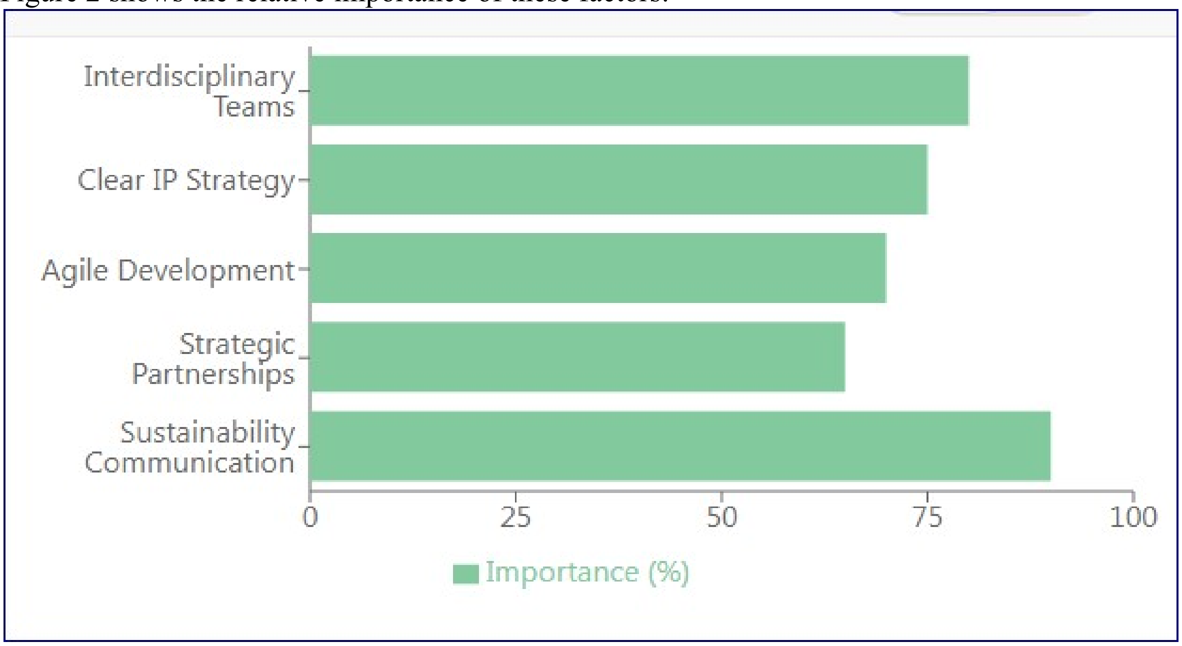
1. Strong Interdisciplinary Teams: 80% of successful ventures had founding teams that combined scientific expertise with business acumen.
2. Clear IP Strategy: 75% had robust intellectual property portfolios, often combining patents with trade secrets.
3. Agile Product Development: 70% employed iterative development processes, allowing for rapid adaptation to market feedback.
4. Strategic Partnerships: 65% formed alliances with established companies for distribution or manufacturing.
5. Effective Sustainability Communication: 90% had clear messaging about their environmental impact, often backed by third-party certifications.
6. Diverse Funding Sources: Successful ventures often combined venture capital, grants, and crowdfunding.

Figure 2 shows the relative importance of these factors:



Discussion: These findings underscore the importance of interdisciplinary collaboration and strategic business planning in translating scientific discoveries into commercial success. The high importance placed on sustainability communication reflects the growing consumer demand for transparent and environmentally responsible businesses.

Challenges in Commercialization

Survey results from 500 Green Entrepreneurs revealed the top challenges:
1. Regulatory compliance (72%)
2. Securing long-term funding (68%)
3. Scaling production (63%)

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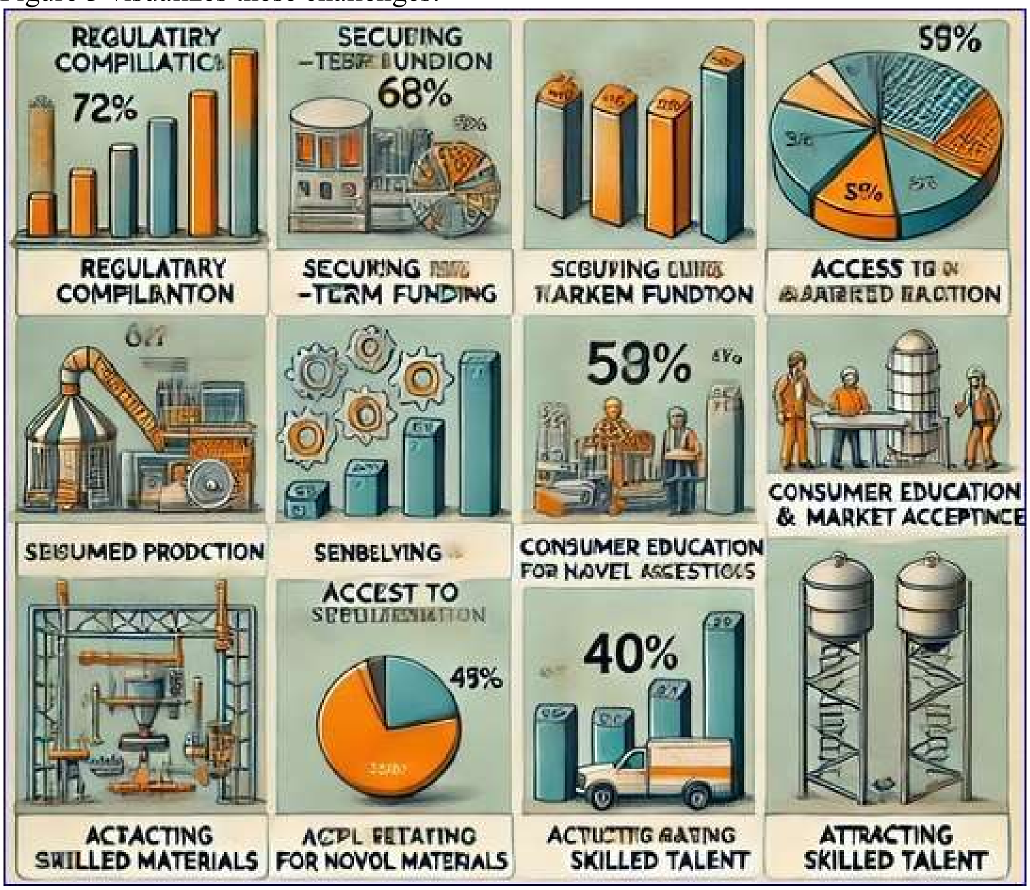
4. Consumer education and market acceptance (58%)
5. Competing with established industries (52%)
6. Access to specialized equipment and facilities (47%)
7. Supply chain management for novel materials (45%)
8. Attracting and retaining skilled talent (40%)

Figure 3 visualizes these challenges:



Discussion: These challenges highlight the need for supportive ecosystems that provide regulatory guidance, access to patient capital, and resources for scaling operations. The high percentage of entrepreneurs citing regulatory compliance as a top challenge underscores the need for more streamlined and consistent regulatory frameworks for plant-based innovations.

Economic and Environmental Impact

Analysis of 100 Green Entrepreneurship initiatives showed:
- Average annual revenue growth of 27% over five years
- Creation of 22 new jobs per venture within three years
- 35% reduction in carbon footprint compared to traditional industry counterparts

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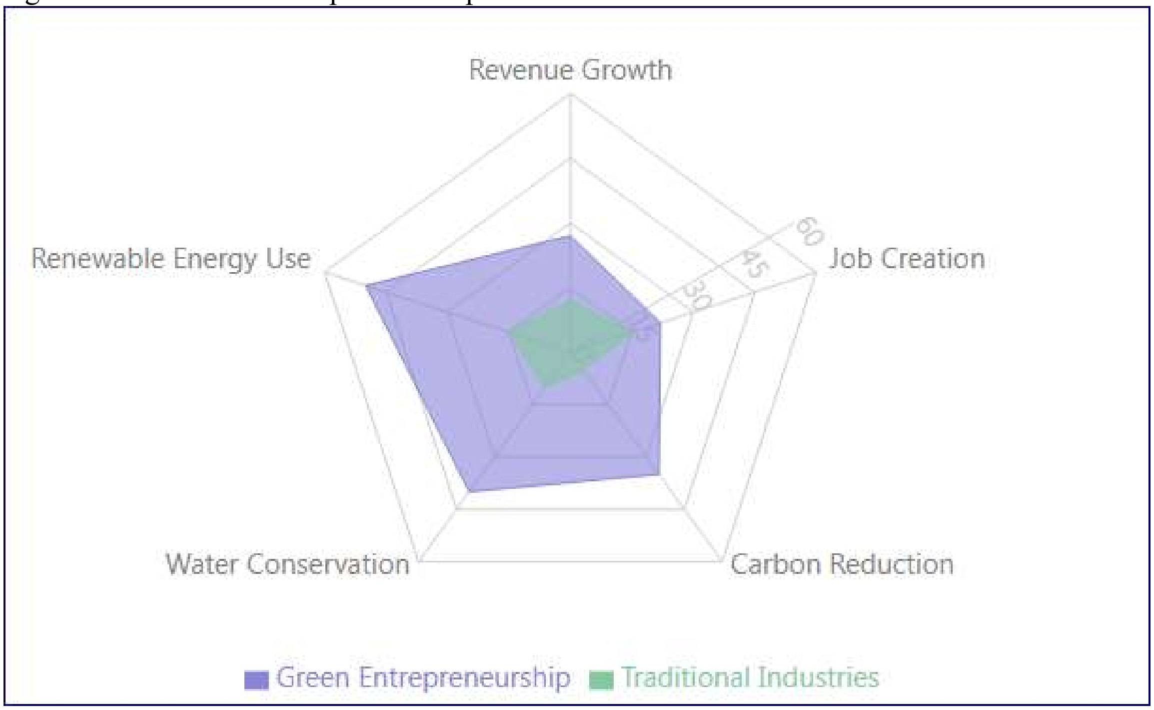
- 40% lower water usage in production processes
- 50% increase in use of renewable energy sources

Figure 4 illustrates the comparative impact:



Discussion: These results suggest that Green Entrepreneurship can drive significant economic growth while delivering positive environmental outcomes. The substantially higher rates of job creation and environmental benefits demonstrate the potential of this sector to contribute to sustainable development goals.

8. Conclusions

Green Entrepreneurship, at the intersection of plant science and business innovation, presents a promising pathway for sustainable economic growth and environmental stewardship. Our comprehensive research demonstrates that successful commercialization of botanical innovations can drive significant economic value while addressing pressing global challenges.

Key conclusions from our study include:

1. Diverse Opportunities: The field of Green Entrepreneurship spans multiple sectors, from biopharmaceuticals to sustainable materials, offering a wide range of opportunities for innovation and growth.

2. Interdisciplinary Collaboration: Successful Green Entrepreneurship ventures are characterized by strong interdisciplinary teams that effectively bridge the gap between scientific expertise and business acumen.

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3. Economic and Environmental Impact: Green Entrepreneurship initiatives consistently outperform traditional industries in terms of job creation, revenue growth, and positive environmental impact.

4. Regulatory Challenges: Complex and often inconsistent regulatory frameworks remain a significant barrier to the rapid commercialization of plant-based innovations.

5. Funding Landscape: While investment in Green Entrepreneurship is growing, access to patient capital for long-term projects remains a challenge for many ventures.

6. Consumer Awareness: Effective communication of sustainability benefits is crucial for market acceptance and willingness to pay premiums for green products.

7. Scaling Hurdles: The transition from laboratory to industrial-scale production represents a critical challenge for many Green Entrepreneurship ventures.

8. Policy Support: Supportive policy environments, including streamlined regulatory pathways and targeted incentives, play a crucial role in fostering Green Entrepreneurship ecosystems.

9. Educational Needs: There is a growing need for interdisciplinary educational programs that combine plant science with entrepreneurship skills.

10. Technology Integration: The integration of emerging technologies like AI, IoT, and synthetic biology can significantly enhance the potential and efficiency of Green Entrepreneurship ventures.

The synergy between scientific discovery and entrepreneurial acumen is critical in translating plant-based solutions into marketable products and services. However, realizing the full potential of Green Entrepreneurship requires supportive ecosystems, including favorable regulatory frameworks, access to diverse funding sources, and collaborative platforms that bridge academia and industry.

As consumer demand for sustainable solutions grows and investment in plant-based industries increases, Green Entrepreneurship is poised to play a pivotal role in shaping a more sustainable and innovative global economy. By fostering collaboration, addressing key challenges, and leveraging the unique properties of plant-based solutions, we can unlock new opportunities for growth, sustainability, and social impact.

The path forward for Green Entrepreneurship will require concerted efforts from multiple stakeholders, including policymakers, investors, educators, and entrepreneurs themselves.

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BACTERIAL PIGMENT PRODIGIOSIN: A POTENTIAL SOURCE FOR MULTIFACETED APPLICATIONS

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Abstract

Microbial pigments have recently attracted considerable attention owing to their wide-ranging applications in the pharmaceutical, food, cosmetic, and textile industries. The production of these pigments poses significant challenges, particularly when compared to the availability of inexpensive synthetic dyes. However, the detrimental effects associated with numerous azo and benzidine-based synthetic dyes have led researchers and industry experts to investigate more sustainable approaches to dye production. Microorganisms are capable of producing valuable natural colorants, such as Prodigiosin, on an industrial scale at relatively low costs. This review aims to provide critical insights into various microbial pigments, with a particular focus on the red pigment prodigiosin.

Keywords: *Prodigiosin, Pigments, Red pigment, Microbial pigments*

Introduction

Pigments are colored substances produced by living organisms that absorb specific wavelengths of light while reflecting the rest of the visible spectrum (380-750 nm) (Ramesh *et al*., 2019). These compounds originate from a diverse array of sources, including various plant species (such as saffron and indigo), certain insects (like cochineal beetles and lac scale insects), a range of animals (including some mollusks and shellfish), as well as minerals (such as ferrous sulfate, ochre, and clay) and microorganisms, which encompass algae, bacteria, and fungi (Affat*et al*., 2021; Mantri *et al*., 2022).Though numerous sources of pigments have been recognized, with microbial pigments originating from bacteria, algae, and fungi presenting considerable advantages over alternative sources.

Microbial pigments, while derived from various natural sources, offer several unique advantages, including a short life cycle, rapid growth in cost-effective media, resilience to climatic fluctuations, ease of genetic modification, and straightforward processing (Manikprabhu and Lingappa, 2013; Narsinga Rao *et al*., 2017). Examples of microbial pigments include melanins, pyocyanins, prodigiosin, glaukothalin, quinines, canaxanthins, flavones, violaceins, monascins, carotenoids, phenazines, astaxanthins, and xanthomonadins (Mantri *et al*., 2022). Bacteria, in particular, demonstrate significant potential for the production of a wide array of pigments, which can be categorized as extracellular (released into the surrounding medium) or intracellular (contained within the cell) based on their accumulation and secretion processes.

The distinctive characteristics and benefits of these pigments facilitate their extensive application across multiple industries, including cosmetics, pharmaceuticals, food, and textiles (Agarval*et al*., 2023). While pigments can be derived from numerous natural sources, microbial pigments offer specific advantages such as a short life cycle, rapid growth in cost-effective media, resilience to climatic fluctuations, ease of genetic modification, and straightforward processing (Manikprabhu and Lingappa, 2013; Narsinga Rao *et al*., 2017). Prominent examples of microbial pigments include melanins, pyocyanins, prodigiosin, glaukothalin, quinines, canaxanthins, flavones, violaceins, monascins, carotenoids, phenazines, astaxanthins, and xanthomonadins (Mantri *et al*., 2022).

Bacteria possess significant capabilities for synthesizing a wide variety of pigments, which can be categorized as either extracellular, meaning they are secreted into the surrounding medium, or intracellular, indicating they are contained within the bacterial cell. The distinctive characteristics and benefits of these pigments facilitate their extensive application across multiple industries, such as cosmetics, pharmaceuticals, food, and textiles (Agarval*et al*., 2023).

Microbes produce Pigments for different reasons

The production of pigments by bacteria serves various functions, often linked to their survival and adaptation. Cyanobacteria, recognized for their photosynthetic capabilities, synthesize pigments such as bacteriochlorophylls, proteorhodopsin, and bacteriorhodopsin, which are analogous to those utilized by plants in photosynthesis (Song *et al*., 2006). In contrast, certain bacterial species have evolved to produce pigments that serve a protective role against ultraviolet (UV) radiation (Agogue*et al*., 2005). For example, some strains of *Vibrio* are capable of synthesizing prodigiosin, which confers a protective advantage against UV exposure, enhancing survival rates by a factor of 1000 compared to non-pigmented variants (Boric *et al*., 2011). Additionally, a subset of bacteria produces phenazines, a broad category of nitrogen-containing heterocyclic compounds, with pyocyanine being the well-studied example, derived from the common soil bacterium *Pseudomonas aeruginosa*.Phenazines have been identified as significant contributors to biofilm formation and gene expression, thereby enhancing the survival of bacteria (Pierson and Pierson, 2010). These compounds are synthesized by both Gram-positive and Gram-negative bacteria, including genera such as *Brevibacterium, Nocardia, Burkholderia, Pelagiobacter, Vibrio, Erwinia,* and *Pantoeaagglomerans* (Pierson and Pierson, 2010). Additionally, certain pigments, such as carotenoids, are produced by bacteria to mitigate the effects of toxic free radicals, including reactive nitrogen species (RNS) and reactive oxygen species (ROS) (Mandelli *et al*., 2012). Melanin pigments, for instance, can neutralize polyphenolic compounds and provide protection against hyperosmotic stress, elevated temperatures, and starvation, as observed in *Vibrio cholera* (Coyne and al-Harthi, 1992). Notable melanin-producing microorganisms include *Aspergillus fumigatus, Alteromonasnigrifaciens, Cryptococcus neoformans*, *Colletotrichum lagenarium, Magnaporthe grisea*, and *Streptomyces species*, among others (Behera *et al*., 2021). The C50-carotenoids synthesized by extremophiles such as *Halococcusmorrhuae, Thermus filiformis*, and *Halobacterium salinarium* play a crucial role in stabilizing their cellular membranes (Mandelli *et al*., 2012). In natural thermal environments, *Thermus* strains produce yellow pigments as a protective mechanism against sunlight (Rosenberg, 2014). Similarly, carotenoid pigments produced by Antarctic bacteria enable them to endure cold conditions (Dieser *et al*., 2010). Furthermore, a violet pigment generated by *Chromobacteriaviolaceum* aids in the protection of lipid membranes and induces cell death in bacterivores such as *Spumellasp*., *Ochromonassp*., and *Bodosaltans* (Matz *et al*., 2004). Pyoverdins, another type of pigment, facilitate iron transport in *Pseudomonas fluorescens* (Visca *et al*., 2007). Additionally, the fungus *Claviceps purpurea* produces a variety of colors, including black, orange, yellow, and red, which serve as warning signals to potential predators (Lev-Yadun and Halpern, 2007).

Applications of Microbial pigments

1. Pigments in textile industry

Textile industry is the leading industry using around 1.3 million tons of synthetically prepared pigments, dyes and dye precursors which costs about 23 billion US dollars. The countries China, Germany, Malaysia and India are leading producers and consumers of azodyes in textile industries. At different stages of the fabric processing like sizing, softening, desizing, brightening and finishing the textile industries use toxic chemicals (Kishore *et al*., 2021). After application, the dyes do not bind firmly to fabrics and are discharged into the rivers, streams, lakes and ponds casing severe threats to aquatic life (Parmar*et al*., 2022).

On consumption of fish and other aquatic life growing in these polluted water bodies, humans suffer from fever, cramps and hypertension (Amer *et al*., 2022; Sharma *et al*., 2022).On the other hand, these polluted waters are high in biological oxygen demand (BOD), chemical oxygen demand (COD) and total organic carbon (TOC), and high in suspended solids which interfere with fish gills and prevent gas exchange resulting in death (Berradi*et al*., 2019). Recently, the use of natural colors of microbial origin has gained attention in textile industry.Prodigiosin, a red pigment from *Vibrio*sps. is used successfully for dyeing wool, mant silk, fibres and nylons (Alihosseini*et al*., 2008).Similarly, polyster, silk, cotton and polyester microfiber are colored by pigment produced by *Serratia marcescens* (Venil*et al*., 2013).The pigments of *Janthinobacteriumlividum* could withstand conditions like rubbing/crocking, washing and perspiration of wool, silk, nylon, vinylon, cotton fibres dyeing (Hiroshi, 2000).Both the pigments prodigiosin and violacein are used for dyeing pure rayon, jacquard rayon, acrylic and silk. Similarly, for making designs on gown-like dress prodigiosin and violacein are used (Ahmed *et al*., 2012).

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2. Application of pigments in Food Industry

Coloring of food is supposed to have originated back in 1500 BC (Burrows, 2009). Colorings of drugs and wine was shown in Roman and Egyptian writings using natural sources like saffron, indigo, paprika, turmeric and various flowers (Aberoumand, 2011; Gulrajini, 2001).Perkin's Mauve was the first synthetic pigment seen in 1856 (Burrows, 2009). Later, synthetic colors were used due to their less production cost, stability etc. but, due to side effects like hyper acidity, allergy, toxicological and carcinogenic issues these dyes were banned and shifted to use of natural colors. Coloring of food is supposed to have originated back in 1500 BC (Burrows, 2009). Colorings of drugs and wine was shown in Roman and Egyptian writings using natural sources like saffron, indigo, paprika, turmeric and various flowers (Aberoumand, 2011;Gulrajini, 2001). Perkin's Mauve was the first synthetic pigment seen in 1856 (Burrows, 2009). Later, synthetic colors were used due to their less production cost, stability etc. but, due to side effects like hyper acidity, allergy, toxicological and carcinogenic issues these dyes were banned and shifted to use of natural colors (Mc Cann*et al*., 2007; Stachowiak, 2015). Microorganisms are the best source of natural colors compared to other sources as they produce different color pigments, easy genetic manipulation, no seasonal variation, easy extraction of pigments, can be grown in cheap media with high yield in short time and are ecofriendly (Malik *et al*., 2012). Bacterial pigments are preferred to use as colorants in food products due to their ecofriendly and probiotic health benefits (Nagpal *et al*., 2011).

3. Therapeutic applications of Pigments

The role of microbial pigments in the treatment of a range of diseases is highly significant, as they exhibit numerous beneficial properties, including antimicrobial, anticancer, cytotoxic, and immunosuppressive activities. Moreover, these pigments are acknowledged for their outstanding effectiveness against Leishmaniasis and their remarkable antioxidant functions.

Prodigiosin

Among bacterial pigments, most fascinating pigment with wide applications is prodigiosin which is a red color pigment, a secondary metabolite alkaloid (323.44 Da) belonging to the tripyrrole family with a pyrro methane skleton containing a 4-methoxy, 2-2 bipyrrole ring produced mainly by *Serratia marcescens, S. rubidaea, pseudomonas magneslorubra, Vibrio gazogenes, Vibrio psychroerythrous, Alteromonas rubra, Rugamona rubra* and gram positive actinomycetes like *Streptomyces longisporus* and *Streptoverticilliumrubrireticuli.* Other microbial groups reported to produce prodigiosin are *Phaeocystis, Microcystis, Hahella, Janthinobacterium*(Mukhia*et al*., 2023; Koksal Karayildirim*et al*., 2024).

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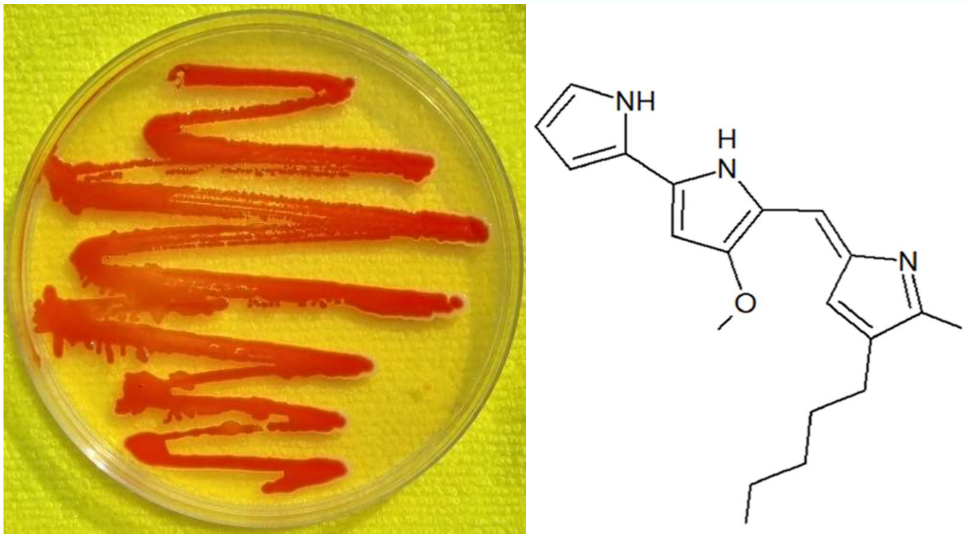

Fig.1. Chemical Structure of Prodigiosin

The structure of prodigiosin consists of 2-methyl-3-pentyl-6-methoxyprodiginine which is a tri-pyrrole ring showing red fluorescence and basic nature. Other members of prodigiosin contain a linear chain like undecyl prodigiosin. Similarly, few others are cyclic derivatives like streptorubin B, cyclononyl prodigiosin, cyclo prodigiosin and butyl-meta-cycloheptylprodigiosin (Williamson *et al*., 2006; Manonmani, 2015).

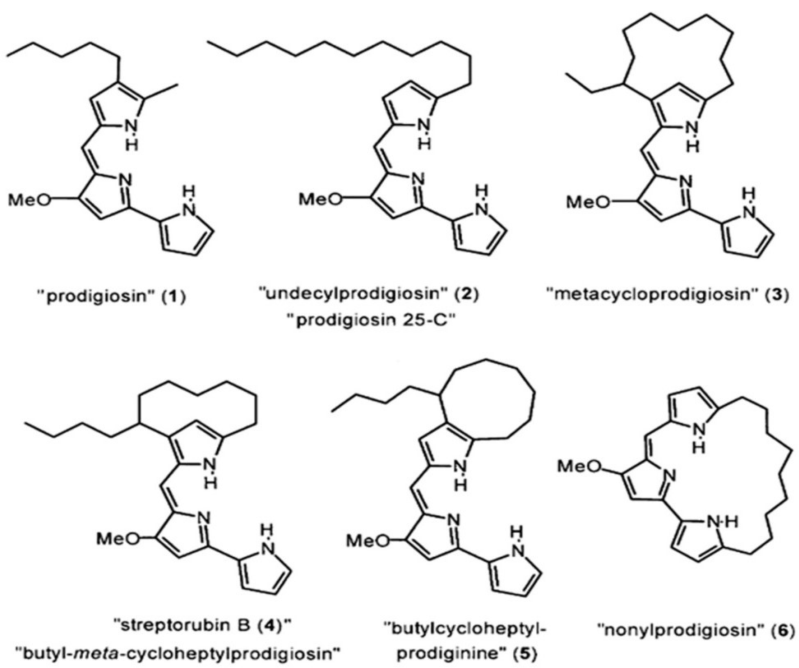

Fig.2 Different types of Prodigiosin

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Biosynthesis of prodigiosin

Prodigiosin is a red pigment with molecular formula $C_{20}H_{25}N_3O$ and molecular weight of 323.1968g/mol. It is distinguished by a huge combined system of a methyl tri pyrrole ring where two rings are linked directly and the third ring structure is connected through methyl group (You *et al*., 2014).The precursors for biosynthesis of prodigiosin were reported to be acetate, alaline, serine, methionine and prolone. The synthesis of prodigiosin was found to be a bifurcated method where a mono and bipyrrole precursors were synthesized independently and are joined forming prodigiosin (Shaikh, 2016). A dual pathway has been suggested for the biosynthesis of prodigiosin, leading to the enzymatic condensation of the end products from both pathways, namely4-methoxy-2, 2′-bipyrrole-5-carbaldehyde (MBC) and 2-methyl-3-n-amyl-pyrrole (MAP) Fig.2.

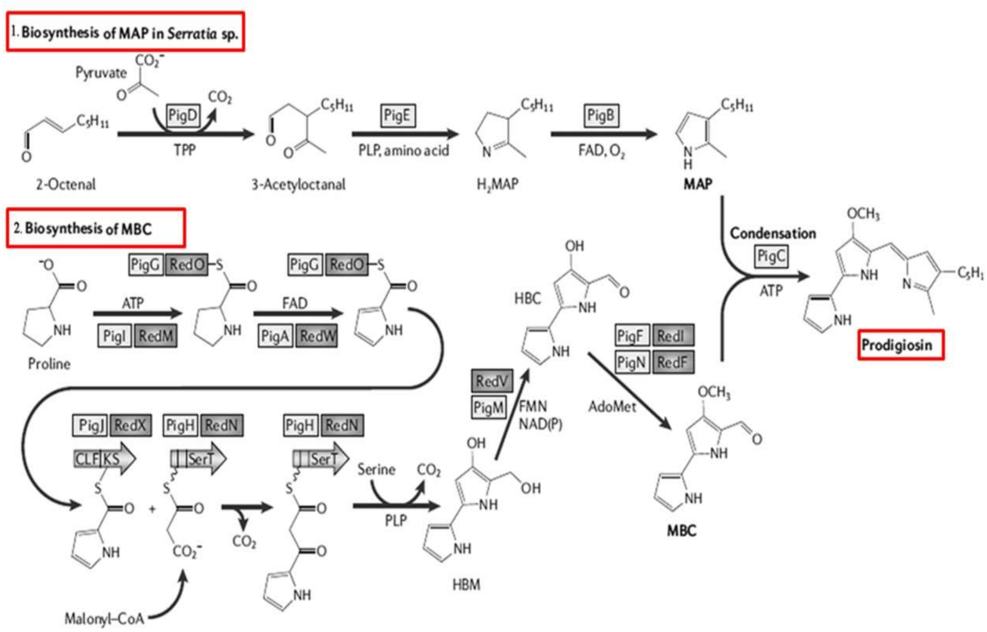

Fig.3 Biosynthesis of Prodigiosin

Biological activity of prodigiosin

Prodigiosin (PG) has been documented to exhibit a wide range of biological activities.
Some of the biological activities shown by prodigiosin are:

- **Antibacterial activity**

  Prodigiosin exhibits a significantly greater inhibitory effect on Gram-positive bacteria viz. *Bacillus subtilis, Enterococcus avium, Staphylococcus aureus, Staphylococcus saprophyticus*, and *Streptococcus pyogenes*, compared to Gram-negative bacteria such as

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Aeromonas hydrophila, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Proteus mirabilis* (Mekhael and Samira, 2009). The antibacterial properties of prodigiosin (PG) can be attributed to its capacity to penetrate the outer membrane and inhibit critical enzymes, specifically DNA gyrase and topoisomerase IV, thereby impeding cellular growth (Berlanga *et al*. 2000).

- **Antifungal activity**

Prodigiosin, undecylprodigiosin, and cycloprodigiosin have been documented to demonstrate antifungal properties against various fungi, including *Aspergillus, Cryptococcus, Didymella, Histoplasma, Penicillium, Saccharomyces, Trichophyton, and Verticillium* (Stankovic *et al*., 2014).

- **Immunosuppressive activity**

The immune functions mediated by T-cells, such as the local graft versus host reaction and proliferation triggered by concanavalin-A, are suppressed by non-toxic levels of prodigiosin (Han *et al*., 1998).

- **Anticancer activity**

Prodigiosin has been evaluation against over 60 cancer cell lines, revealing an average inhibitory concentration of 2.1 μM (Manderville, 2001; Williamson *et al*. 2007). PG has demonstrated significant anti-cancer properties, exhibiting proven effectiveness in the treatment of melanoma, breast cancer, lung cancer, lymphocytic leukemia, and glioblastoma (lu*et al*., 2024). Prodigiosin exhibits multiple cellular targets, leading to ambiguity regarding the precise mechanism by which prodiginines promote apoptosis. Furthermore, prodiginines present a compelling therapeutic option as they remain unaffected by various multidrug resistance pumps that often lead to resistance in other anticancer therapies (Soto-Cerrato *et al*. 2004; Llagostera*et al*. 2005). These compounds are characterized as proapoptotic agents, capable of inducing cellular stress responses, including cell cycle arrest, DNA damage, and alterations in intracellular pH (pHi), all of which can trigger apoptotic pathways.

- **Antiviral activity**

Prodigiosin exhibits antiviral properties when evaluated against cells infected with Bombyx mori nucleopolyhedrovirus (BmNPV), a viral pathogen responsible for considerable economic detriment to the silk industry. It inhibits the initial transcription of viral genes and selectively kills infected cells. Furthermore, it obstructs the synthesis of viral DNA and neutralizes the fusion proteins that are activated by the virus (Zhou *et al*., 2015).

In a computational study utilizing homology modeling and docking analysis (Suba *et al*.,2013) investigated the efficacy of PG against several viral target proteins, including those from the hepatitis B virus (HBV), human immunodeficiency virus (HIV), hepatitis C virus (HCV), and influenza A virus (H1N1). The results indicated that PG exhibits significant antiviral activity against HBV, HIV, and H1N1, while showing no effectiveness against HCV. Nonetheless, it is essential to validate these results through in vitro and/or in vivo studies.

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- **Antioxidant activity**

Prodigiosin and violacein, derived from *S. marcescens* and *C. violaceum*, are utilized in the cosmetic sector for sunscreen formulations due to their inherent antibacterial and antioxidant capabilities that are comparable to those of ascorbic acid, with concentrations of 30% for prodigiosin and 20% for violacein (Suryawanshi*et al*. 2015).

Apart from these activities, Prodigiosin was also found to have antimalarial, algicidal, amebiasis activities.

Other applications of Prodigiosin

- **Dyeing property of prodigiosin**

Various materials such as silk, acrylics, wool, fibers, and nylons are dyed using prodigiosin dye (Alihosseini*et al*. 2008). Additionally, fabrics like polyester, cotton, and polyester microfiber, can be colored with pigments derived from Serratia marcescens (Venil*et al*., 2013).Similarly, In Asia, the creation of floral, foliar, and geometric patterns on gown-like garments involves the utilization of violacin and prodigiosin (Ahmad *et al*. 2012).

- **Prodigiosin as Sunscreen**

The incorporation of prodigiosin has been shown to elevate the sunscreen protection factors (SPF) in commercially available sunscreens. This compound was employed as an additive alongside extracts derived from Aloe vera leaves and *Cucumis sativus* (cucumber) fruit, both recognized for their photo-protective capabilities, in conjunction with standard commercial sunscreen formulations (Darshan *et al*., 2015).

Though prodigiosin has wide therapeutic applications, its production is limited due to high cost of synthetic media used. Hence, researchers are in search of alternate cheap medium. Interestingly, agro waste and its organic contents is a rich source of nutrients, provide suitable environment for growth of microorganisms that can be used for production of value added products (Martins *et al*. 2011; Sadh *et al*., 2018; Ravindran *et al*. 2018) which not only reduces the production cost but also solve the environmental issues caused by untreated agro waste. Different researchers (Araujo *et al*., 2010; camilios-Neto *et al*., 2011; Naik *et al*., 2012; Aruldass*et al*., 2014; Elkenawy*et al*., 2017; Rodriguez *et al*., 2018; Bhagwat *et al*., 2020) reported production of prodigiosin from *Serratia marcescen*s and other microorganisms using agro waste. Similarl

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y, different researchers also tried different cheap media for enhanced yield of prodigiosin (table 1).

Table-1: Production of Prodigiosin using cheap media

S. No	Name of the Microorganism	Cheap substrate used	Pigment produced	Yield of the pigment
1	*Serratia marcescens* NITDPER1	Paper mill sludge	Prodigiosin	30.05±1.7mg/gm
2	*Chromobacteriumviolaceum* UTM5	Pineapple waste	Violacein	16256±440 mg/L
3	*Chryseobacteriumartocarpi* CECT8497	Liquid pineapple waste	Flexirubin	152 mg/L
4	*Planococcus* sp.TRC1	Sugarcane bagasse	β-Carotene	47.13±1.9mg/g
5	*Serratia marcescens*NITDPER1	Fatty acid media	Prodigiosin	5.36±0.81 g/L
6	*Rhodotorulaglutinis* YB-252	Polyurethane foam	Lycopene	340mg/L
7	*Monascus purpureus* ATCC16436	Corn cob and glycerol	Orange pigment	133.77 units/ml
8.	*Monascus purpureus* ATCC16436	Corn cob and glycerol	Red pigment	108.02 units/mL
9	*Blakesleatrispora*MTCC 884	Fruits and vegetable waste	B-Carotene	0.127mg/mL

Conclusion

Natural pigments obtained from microbial sources such as bacteria, fungi, and microalgae are gaining recognition for their enhanced value and demand relative to synthetic counterparts. Prodigiosin, a red pigment, has been documented to possess a diverse range of biological activities applicable in pharmaceutical, food, cosmetic, and textile industries, but commercially unexplored. Presently, there is a notable focus on the marine environment for the identification of both new and well-known natural pigments that demonstrate a broad spectrum of biological functions.

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NON–TIMBER FOREST PRODUCTS FOR LIVELIHOOD OF TRIBAL PEOPLE IN TELANGANA STATE, INDIA

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Abstract:

Non-Timber Forest Products (NTFPs) play an important role in the livelihoods and development of millions of rural people across the globe and about 500 million people in India dependent on the supplementary income and 50 to 70% of forest export revenue comes from unprocessed NTFPs. In tribal areas when people are highly depending upon forest products, women have greater contribution for its extraction. In Telangana majority of tribal people lives in and around the forest and collect, process and getting NTFPs ready for market and its consumption locally for their food, shelter, medicine and commerce. A study conducted in the state of Telangana has revealed that the NTFPs species collected seasonally from forest (plant parts like tapsi gum (*Sterculia urens*), Musti seeds (*Strychnos nux-vomica*), chilla seeds (*Strychnos potatorum*), Kanuga seeds (*Pongamia pinnata*), Ippa seed and kernel (*Madhuca indica)*, soap nut (*Sapindusemarginatus*), broom sticks (*Thysanolaena maxima*). The house hold income and forest resources are related to each other in tribal areas. So, the focus on policy making favourable to women, establishment of skill development centers, other value addition techniques to the NTFPs products and marketing facilities definitely have scope to increase livelihood of tribal people in telangana state.

Keywords:*Non-Timber Forest Products (NTFPs), Livelihood, Tribal people, Telangana*

Introduction:

Non-timber forest products include a wide variety of plant and animal-based resources that are taken from forests and other natural landscapes and these NTFPs are essential to the livelihood of tribal communities. And it is estimated that about 275 million poor rural and tribal people in India depend on NTFPs for their daily needs and source of income. The NTFPs can act as a crucial safety net for a living during difficult times. The majority of NTFP gatherers and earners are women. In India, NTFPs employ 55% of the forestry industry's workforce and bring in $2.7 billion annually. About one-third of India's rural population depends on forestry sector for 50 percent of their household income.

Material and Methods:

The present study was carried out in Telangana State from 2021 to 2023 covering all types of forest of tribal habitats. The study covers the majority of tribal villages where the tribes subsist on NTFP products from the surrounding forests. The study draws both primary and secondary sources of data. The primary data were collected through questionnaires, interviews, household survey, vegetation studies, etc. and the secondary data were gathered from forest officials, Girijan Co-operative Corporations, Non Government Organizations (NGO), forest working plans, etc

Status of NTFPs:

In India, 90% of the plant based materials supplied to the international market are from the wild stock (Mishra et al. 2009). Hence, sustainable extraction is important and need to develop appropriate management strategies and practical plans before these elements are lost forever. NTFPs are of socio-economic and cultural importance for the forest dwelling communities, particularly for the tropical countries like India. The status of NTFPs includes the knowledge about the plant parts, habit, habitat, uses and availability. In India nearly 60% of all recorded forest revenue from NTFPs and provide about 70% of employment in the forestry sector (FAO, 2003). India is home to an amazing diversity of plants, with over 46,000 plant species recorded and many of these species are used for medicinal, with approximately 760 species (Jain 2004).

Potential resources of NTFPs:

In India forest management generally focused on timber and in most of the forest working plans do not take in account the sustainable management of NTFPs (Giri etal., 2005). A number of impediment need to be overcome for better utilization, help the rural livelihood and boost the economy of local dependents. Forests have been one of the important natural resource, the sustainable management of NTFPs concept focuses on social, ecological and economical aspects, for strengthening the welfare of rural and tribal population and to meet local and national needs. Hence, the NTFP's availability, utilization, commercialization, exploitation, management practices, policies and tenure systems in different parts of India have high diversity and variability. There is concern, however, that collection methods for most of NTFP species are destructive and wild populations are declining as a result.

NTFPs as livelihood for tribal people:

Forest is the source of natural wealth, and the economic value of forest products has long been recognized. The forest tree taxa that provide a variety of NTFPs are play vital role in terms of tribal economic subsistence. The studies relating to NTFPS and dependent local tribal communities*vis-a-vis* upon which their subsistence depends are need to emphasis. Tribals are local aboriginal people living in or near the forest since ages. In course of time they are living in isolation from the mainstream life, had a symbiotic relationship with the forest and relay on forest products. Tribal livelihood systems vary considerably at different regions as also among the various ethnic groups, depending on ecological, historical and cultural factors. These communities depend on NTFPs primarily for meeting their subsistence needs like food, fodder, medicine, Their living style linked with the forest resources to meet livelihood and subsistence, which include socio-economic contribution of forest products. The socio-economic, cultural, and ecological facets of tribal populations' life are significantly shaped by NTFPs. NTFPs have many kind of significant effects on tribal livelihoods Over 60% of forest dwellers in Telangana dependson NTFPs. As per Government of India report,

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at least 35 million man-days of employment were generated in the NTFPs trading which includes collection and processing which provide substantial inputs to the livelihoods of forest dependent population, many of whom have limited non agricultural income opportunities (MOEF., 2006).

In India, forest management generally focussed on timber and in most of the forest working plans do not take in account the sustainable management of NTFPs (Giri et al., 2001). A number of impediment need to be overcome for better utilization, help the rural livelihood and boost the economy of local dependents. Forests have been one of the most important natural resources, the sustainable management of NTFPs concept focuses on social, ecological and economical aspects, for strengthening the welfare of rural and tribal population and to meet local and national needs. Hence, the NTFP's availability, utilization, commercialization, exploitation, management practices, policies and tenure systems in different parts of India have high diversity and variability. There is concern, however, that collection methods for most of NTFP species are destructive and wild populations are declining as a

Table -1: Major NTFPs in Telangana for livelihood of tribal people.

Sl. No	Name of the taxon	Local name	Plant part	Use value
1	*Bambusa bambos*	veduru/bamboo	stem/ culms	Commercial
2	Butea monosperma *Butea monosperma*	moduga	leaves	Commercial
3	*Diospyros melanoxylon*	tendu/beedi	leaves	Commercial
4	*Firmiana simplex*	tapsi	gum	medicinal and commercial
5	*Madhuca indica*	ippa	kernels	medicnal and food
6	*Pongamia pinnata*	kanuga	seeds	Commercial
7	*Sapindusemarginatus*	soap nut/kunkudu	fruits	medicinal and commercial
8	*Strychnos nux-vomica*	musti	seeds	Medicinal
9	*Strychnos potatorum*	chilla	seeds	Medicinal
10	*Thysanolaena maxima*	broom stick	stem	local/commercial

Discussion and Conclusion:

The role of many NTFPs in tribal livelihoods has not been comprehensively examined, despite of growing understanding of the importance of NTFPs. The economic life of tribals largely depends on the availability of natural resources of their habitats. The NTFPs are integral part of the sustenance of resources dependent communities and provide employment during different seasons. The local tribal people used to collect leaves and fruits of *Bambosa*


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bamboos, *Diospyros melanoxylon* (tniki) *Firmiana simplex* (tapsi), *Strychnos potatorum, S.nux-vomica* are the major source for livelihood and followed by *Madhuca longifolia,Sapindusemarginatus, Thysanolaena maxima.* The use value of the NTFPs mainly for local medicinal, food and commercial. The substantial income generation is highest with bamboo and beedi leaves. In addition to the above many other plants collected for local food, medicine, forage, fiber, fuel and other miscellaneous uses.

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The local rural people used to collect leaves and fruits of Diospyyros melanoxylon (tuniki), Firmiana simplex (karaya gum) gum, gum of Boswellia serrata (anduga), seeds of Strychnos potatorum (chilla), S. nux-vomica (vishamushti), seedsand □owers of Madhuca longifolia var. latifolia (ippa), bamboo (Bambusa/Dendrocalamus). TThe local rural people used to collect leaves and fruits of Diospyyros melanoxylon (tuniki), Firmiana simplex (karaya gum) gum, gum of Boswellia serrata (anduga), seeds of Strychnos potatorum (chilla), S. nux-vomica (vishamushti), seedsand □owers of Madhuca longifolia var. latifolia (ippa), bamboo (Bambusa/Dendrocalamus). TThe local rural people used to collect leaves and fruits of Diospyyros melanoxylon (tuniki), Firmiana simplex (karaya gum) gum, gum of Boswellia serrata (anduga), seeds of Strychnos potatorum (chilla), S. nux-vomica (vishamushti), seedsand □owers of Madhuca longifolia var. latifolia (ippa), bamboo (Bambusa/Dendrocalamus).

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COMPARATIVE STUDY OF ORGANOPHOSPHATE PESTICIDE (METHYL PARATHION) EFFECTS ON ESTERASE ISOZYME IN GILL TISSUE OF *HETEROPNEUSTES FOSSILIS* AND *CHANNA PUNCTATUS*

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ABSTRACT

The present study was under taken to assess the toxicological effect of Methyl Parathion (an Organophosphate) on esterase isozyme banding patterns in gill tissue of freshwater cat fish *Heteropneustes fossilis* (Bloch) and *Channa puntatus* at different time intervals i.e. 24,48,72 and 96hrs and was compared with control. The esterase isozymes were quantitatively analyzed by using 7.5٪ native polyacrylamide gel electrophoresis (PAGE) stained with α-naphthyl acetate as substrate. Three different esterase bands were detected and named as Est-1; Est-2 and Est-3 with different relative mobilities such as 0.60; 0.40; 0.30 in gill tissue of *Heteropneustes fossilis* and Three different esterase bands were detected and named as Est-1; Est-2 and Est-3 with different relative mobilities such as 0.60; 0.40; 0.30 in gill tissue of *Channa puntatus* . Est-1 is deeply stained, Est-2 is moderately stained, Est-3 is faintly stained and in both fishes. Two fishes exhibits Decreasing of Esterase bands intensity is observed.

Keywords: *Esterase, isozymes, PAGE, H.fossilis, Channa puntatus Methyl Parathion,Gill Tissue*

INTRODUCTION:

The fish *H.fossilis* is commonly known as Stinging Catfish (for poisonous pectoral spine), locally called Shing or Shingi (Rahman, AKA.) Ingilayee, mapujella and marpu (A.P), shing, (Bangladesh). Singee and sheene (Assam), singhi (West Bengal) Kamacha singhi, Bitchu, Tailia, and singee(U.P), Lahoord and Nulli (punja), singee and singhi (Osrissa), Thaylee and Thaimeen (T.N). It is a very wide range (Pakistan, India, Sri Lanka, Nepal, Bangladesh, Myanmar, Thailand and Laos) and has been introduced elsewhere. Whilst it is heavily utilized for food and for medicine in many parts of its range, and it may be threatened by over exploitation and habitat loss and degradation (especially from pollution and dams), it is considered least concern at present. Related synonym is Saccobranchus microcephalus (Gunther, 1864). The Greek word Sacco means a sack, a bag and branchus means respiratory organ, gill pertaining to additional respiratory sack along with gill. It is commonly known as Stinging Catfish (for poisonous pectoral spine), as suggested by its common name - stinging catfish, Heteropneustes fossilis can deliver a Painful sting via the spines on its pectoral fins. In the above scenario we investigate the Effect of Methyl Parathion (An Organophosphate) on tissue specific esterase patterns in Indian cat fish Heteropneustes fossilis (Bloch).

The stinging cat fish H. fossilis (Bloch) is locally called as Ingilayee or Marpujella. It is an important air sac cat fish indigenous to many Asian countries. It inhabits in fresh water and able to tolerate brackish water too. It is very popular not only for its good taste but also highly nutritional and medicinal point of view. H. fossilis is found mainly in ponds, ditches, swamps, and marshes, but sometimes occurs in muddy rivers. It is omnivorous. It is in great demand due to its medicinal value (Froese et al., 2011). The stinging catfish is able to deliver a painful sting to humans. Poison from a gland on its pectoral fin spine has been known to be extremely painful. It is also farmed and found in the aquarium trade (Froese et al., 2011). Fish reproduction is a periodic phenomenon and is controlled by environmental (exogenous) as well as internal (endogenous) regulatory mechanism. It acts of breeding occur under optimal environmental conditions that are favorable to the survival of the young ones. Environmental stimuli are detected by sensory organs, relayed to brain, that triggers endogenous mechanism into action.

MATERIALS AND METHODS

The fresh water cat fish *H. fossilis* were collected from local fresh water tanks within the radius of 15km from the laboratory by netting with the help of local fisher man. The fishes having an average length of 15 ± 1cm and weighed about 50±5gm were brought to the laboratory and transferred in to a plastic buckets(30X30X60cm) and disinfected with potassium permanganate and washed thoroughly prior to introduction of fish (to prevent fungal infection). The fishes were acclimatized for about 10 to 15 days prior to experimentation. They were regularly feed with commercial fish food and the medium (tap water) was changed daily to remove feaces and food remnants. The healthy fishes were grouped into five batches containing six each and were exposed to different concentrations of organophosphate methyl parathion at different time intervals to calculate the medium lethal concentration less value using probit analysis method

Toxicological Studies:

The toxicity tests were conducted in accordance with standard method. An organophosphate methyl parathion was dissolved in acetone to yield a concentration of 100mg/ml which were further diluted with distilled water to required concentrations. The fishes (five batches) were exposed to sub lethal concentrations (0.5ppm to 1ppm) of Methyl Parathion for 24, 48, 72 and 96 hrs respectively, and recorded the mortality rate of fishes. Another group of fish was maintained as control without pesticide.

Preparation of samples for study:

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At the end of each exposure period fishes were sacrificed, the tissues such as Liver Intestine and brain were dissected out and was blotted to free from blood clots and other adherent tissues and weighed to nearest milligram and were homogenized in 10% 0.01M Tris-HCl buffer (pH 7.4) containing 0.9% NaCl. The homogenates were centrifuged and the supernatants were diluted 1:1 with 20% sucrose containing 0.01% bromophenol blue as tracking dye. An aliquote of 0.1ml of these solution was loaded directly on to the separating gel.

Electrophoretic study and staining of gels:

Esterase patterns were separated on thin layer (1.5mm thickness, 8X8 cm) polyacrylamide gels (7.5%). The gel mixture was prepared according. Gelling was allowed for 45minutes. After (10-20 µl) loading on the gel, the samples were overload with electrode buffer containing Tris (0.05M), glycine (0.38M), pH was 8.3 adjust with 1N Hcl and gel plates were connected to the electrophoretic tank. Power supplied 50 volts for the first 15minutes followed constant 150 volts for the rest of the run during electrophoresis. The electrophoretic run was terminated when the tracking dye migrated to the distance of 8.0 cm from the origin. Esterases were visualized on the gels by adopting the staining procedure.

RESULTS

Gill tissue of *Heteropneustes fossilis*

The gill showed two esterase isozymes at 24h with Rm value 0.60 and 0.40; while at 48h it showed two esterase isozymes with Rm value 0.60 and 0.40; and at 72h it showed one esterase isozymes with Rm value 0.60 and it showed two esterase isozymes at 96h with Rm value 0.60 and 0.40. Est-1 showed more intensity compared with others.Est-1 showed deeply stained bands Est-2 Showed moderate bind intensity and Est-3 showed faintly stained bands.

Table.1. Esterase Band intensity in Gill tissue of *Heteropneustes fossilis* after exposure to Organophosphate Methyl Parathion at different time intervals

EST/Rm Value	**EST-1(0.6)**	**EST-2(0.4)**	**EST-3(0.3)**
Control (Gill)	+++	++	+
24H	++	++	+
48H	+	++	-
72H	+	+	-
96H	+	+	-

+ = Faint; ++ = Moderate ; +++ = Deeply stained

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Gill Tissue of *Heteropneustes fossilis*

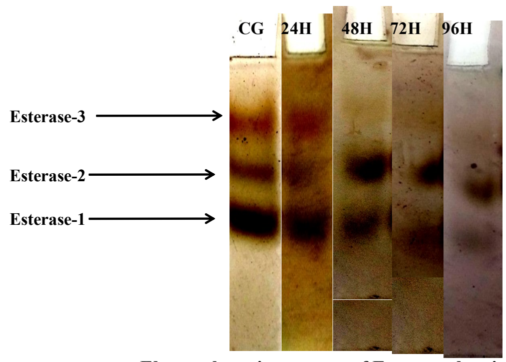

Fig.1. Electrophoretic patterns of Esterase showing band intensity of Gill after exposure of Methyl Parathion

Gill tissue of *Channa puntatus*

The gill showed three esterase isozymes Controll but , at 24h gill showed two esterase isozymes with Rm value 0.60 and 0.40; while at 48h it showed two esterase isozymes with Rm value 0.60 and 0.40; and at 72h it showed two esterase isozymes with Rm value 0.60,and 0.40 and it showed one esterase isozyme at 96h with Rm value 0.60 .Est-2 showed more intensity compared with others.Est-2 showed deeply stained bands Est-1 Showed moderate bind intensity and Est-3 showed faintly stained bands.

Table.2. Esterase Band intensity in Gill tissue of *Channa puntatus* after exposure to Organophosphate Methyl Parathion at different time intervals

EST/Rm Value	EST-1(0.6)	EST-2(0.4)	EST-3(0.3)
Control (Gill)	++	++	+
24H	+	+++	-
48H	+	++	-
72H	+	+	-
96H	+	-	-

+ = Faint; ++ = Moderate ; +++ = Deeply stained

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Gill Tissue of Channa puntatus

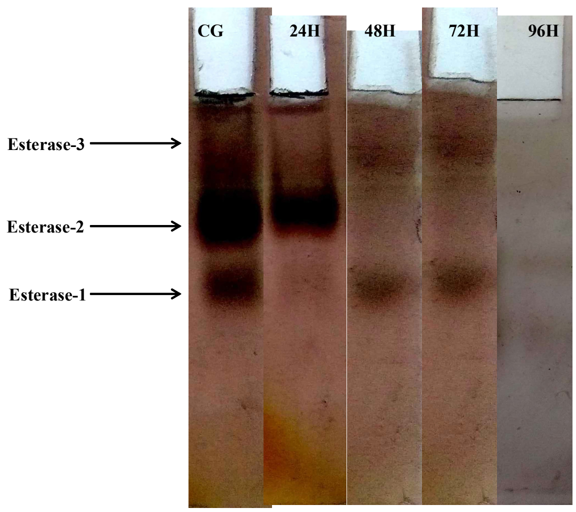

Fig.2. Electrophoretic patterns of esterases after exposure of Methyl Parathion

DISCUSSION:

In the present study among three esterases Est-2 is found in and liver to be more abundant with deeply stained (+++). And Est-1 was moderatly stained (++) in all tissues The intensity of Est-2 were deeply stained (+++) in kidney, heart and liver and. The Est-3 was deepaly stained (+++) in liver tissue and moderately stained (++) in kidney,heart. The liver tissue showed in all the three esterases zone i.e (Est-1; Est-2; and Est-3) were deeply (+++) stained. In Est-2 &3 esterases zone of liver, kidney were deeply (++) stained. Est -1 and Est-3 esterase zone was moderately (++) stained.

Esterases are a group of hydrolytic enzymes occurring in multiple forms with broad substrate specificity. Esterases comprise a diverse group of enzymes catalyzing the hydrolysis of organic esters. Esterases (EST, 3.1.1.1) are obiquitous in living organisms. Several esterases have been isolated from various tissues of microbes, plants and animals and investigated for their biochemical properties.

The present study reports that the variability of patterns of esterase isozymes describes electro morphs of an individual, representating expression of tissue specific esterase isozymes, which showed differential banding patterns that could be used in toxicological study. It can be concluded that the tissue wise variation in the banding patterns of esterase may be used for the development of genetic molecular markers. Thus, Present study has concluded that the long term exposure of Methyl parathion becomes a continuous health hazard for the fish population. Therefore it is required to monitor the aquatic system and predict the toxic effect of pesticides on fish. After exposure of Methyl parathion we observed that esterase activity in different tissues of *H. fossilis* was gradually decreased with increasing the time intervals. Similar results were observed by mores *et al*., 2000.The esterase activity was most abundant in liver to compare with other tissues such as intestine and brain.

From the above Table I, II and III it was observed that the intensity of esterase bands was differing from tissue to tissue and species to species even in the different region of the body of the same individual. The binding patterns of esterases in different tissues have good potentiality for species identification. AChE esterase activity was observed to be reducing in liver and kidney (Shaid Nahboob KA.,Ghazala Ghazala 2016).The tissue and species specific distribution of esterase were earlier reported from two catfishes and toad (Shahijahan R M., Karim A., Begum RA., Alam MS., Begum a 2008). AChE Esterase activity revealed that subleathal concentration of Methyl Parathion inhibited esterase activity, the order of decrease AChE esterase activity in *H.fossilis* was recorded as Liver > Intestine > Brain. An organism develops the resistance against the insecticide could not function (Holmes RS 1970).Isozyme patterns exhibits differences in the various fish populations(Barua S et al.,2004) and also used to develop genetic sexing system (Robinson AS,1986). The results of present study is coincide with results of Venkateswara Rao et al.,2022, Venkateswara Rao et al.,2023, Shankar et al 2019).

CONCLUSION:

The present study reports that the variability of patterns of esterase isozyme describes electromorphs of an individual. It can be conclude that each tissue has specific esterase banding pattern which may be used for the development of genetic molecular makers for proper identification of fish species. The long term exposure of methyl parathion becomes a continuous health hazards for the fish population. Therefore it is required to monitor the aquatic system and predict the toxic effect of pesticides on fish.

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