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Research and Reviews in Plant Science

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Preface

We are happy to welcome the idea of publishing a book on relevant topic, "Research and Reviews in Plant Science". Further, it is good that the articles from various sub-disciplines are included in the book. The scholars from Botany or biological science have attempted to identify the current trend and to provide ideas to doing the recent study.

The Spatial Dynamics, Phytoremediation tools, Medicinal Plants, Indoor Plants and their role in Removing Air Pollutants, Review of Genus Alysicarpus Desv. family-Fabaceae, Adsorptive removal of dye from waste water, rhizosphere fungi and rhizoplane fungi, Plant Ecology, Fundamentals of Genetics, Formulation Herbal Cream, Inbreeding Depression and Heterosis, Vulnerability and Adaptation to Climate Change, Role of Modern Plant Propagation Techniques, An ethnobotanical study, Natural Resources and Sustainable Development etc.

This exhibits how variety of topics have been discussed in the book. The book provides open forum for the scholars and even graduate students to discuss further so that they can think about strategic planning to use emerging strategies in sciences.

Renowned researchers, scientists, educators, and business professionals have contributed pieces to the book. We would especially want to express our gratitude to the researchers and specialists whose contributions have made this book better.

Date: *15 August 2024*

Editors

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Indoor Plants and their role in Removing Air Pollutants

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Abstract

Environmental pollution, particularly indoor air pollution, has emerged as a significant global issue affecting various aspects of life. Both natural and anthropogenic substances contribute to indoor air pollutants, leading to ecosystem degradation and adverse health effects in humans. Cost-effective, plant-based strategies offer promising solutions for improving indoor air quality (IAQ), regulating temperature, and mitigating health risks. Plants, along with their associated microbial communities, offer a natural and cost-effective solution for reducing indoor air pollution. Despite the promising potential, further research utilizing advanced omics technologies is necessary to fully comprehend and enhance the molecular mechanisms involved in plant-based pollutant reduction. This knowledge will pave the way for more efficient and tailored phytoremediation strategies to improve IAQ and protect human health.

Keywords: Environmental pollution, air pollutants, IAQ, human health, phytoremediation.

Introduction

Air pollution, particularly indoor air quality (IAQ), has become a significant global issue due to its detrimental effects on both the environment and human health. Both man-made and natural substances contaminate indoor and outdoor air, posing hazards to plants, animals, and humans alike (Bhargava et al. 2020). Since the energy crisis of 1973, there have been substantial changes in the design and construction of buildings aimed at reducing energy consumption. These changes have often resulted in more confined living spaces, which can exacerbate the generation and accumulation of indoor air pollutants (Aydogan and Montoya 2011). The adverse effects of indoor air pollution are widespread and significant. Contaminants in the air, whether they originate from outside or inside sources, pose serious health risks to all living beings. This includes not only direct respiratory and cardiovascular health impacts but also a range of symptoms

collectively known as sick building syndrome (SBS). Symptoms of SBS include headaches, eye and respiratory irritation, dizziness, nausea, fatigue, drowsiness, and general impatience. Given the profound impact of indoor air pollution on health and the environment, it is crucial to develop and implement effective strategies to improve IAQ. These strategies can include advancements in building design, increased ventilation, the use of air purifiers, and the adoption of plant-based approaches to purify indoor air.

Addressing indoor air quality is a pressing global concern that requires a multifaceted approach, including improvements in building design, increased awareness, and innovative solutions such as plant-based air purification. The continued study and implementation of these strategies are vital for safeguarding human health and maintaining a healthy environment.

Poor air quality remains a significant global issue, impacting both environmental sustainability and public health (World Health Organization 2014). Indoor air quality (IAQ) is particularly crucial as it directly affects the health and productivity of occupants within buildings (Hashim et al. 2019). Various internal and external factors contribute to IAQ, including emissions from both indoor and outdoor sources, temperature, humidity levels, and ventilation rates (Moya et al. 2018). Modern building practices often prioritize energy efficiency, resulting in reduced ventilation and increased airtightness, which can lead to elevated concentrations of indoor air pollutants. Indoor environments are often contaminated with particulate matter (PM), volatile organic compounds (VOCs) such as benzene, toluene, ethylbenzene, xylene (BTEX), formaldehyde, polyaromatic hydrocarbons (PAHs), and inorganic pollutants like ozone (O3), nitrogen oxides (NOx), carbon dioxide (CO2), and sulfur dioxide (SO2). Excessive concentrations of these pollutants can contribute to Sick Building Syndrome (SBS), characterized by respiratory dysfunction, headaches, eye and skin irritations, allergies, fatigue, and metabolic abnormalities (Nezis et al. 2022). Indoor plants offer a natural and aesthetically pleasing solution to improve IAQ. They have been shown to effectively reduce levels of various indoor air pollutants through processes such as absorption, adsorption, and metabolic breakdown (Su et al. 2015). Plants can particularly help in mitigating VOCs and other pollutants by incorporating them into their tissues or soil microbiome.

Volatile Organic Compounds (VOCs) encompass a diverse group of molecules present in various everyday products such as paints, solvents, adhesives, cleaning agents, and building materials. Extended exposure to VOCs can lead to a range of health effects including irritation of the eyes, nose, and throat, nausea, loss of coordination, headaches, and in some cases, serious organ damage including impacts on the liver, kidneys, and central nervous system (USEPA). Formaldehyde is among the most prevalent VOCs found indoors. It is a colorless gas with a sharp and bitter odor. Commonly used in building materials like plywood, particleboard, and glues, formaldehyde can also be produced indoors as a secondary

pollutant through the oxidation of other VOCs and interactions between outdoor ozone and alkenes, particularly terpenes (Rika Funaki et al. 2003).

According to the International Agency for Research on Cancer (IARC), formaldehyde is classified as a Group 1 carcinogen, indicating it is known to cause cancer in humans. Higher concentrations of formaldehyde can lead to acute health effects such as nausea, vomiting, coughing, chest tightness, and aggravation of asthma. Prolonged exposure to elevated levels of formaldehyde (above 6.5 mg/m3) can result in more severe respiratory issues including pneumonia and pulmonary edema, and in extreme cases, mortality (Su et al. 2015).

Indoor plants offer a natural and effective means to mitigate formaldehyde and other VOCs from indoor air. Through mechanisms like absorption, adsorption, and metabolic breakdown, plants can reduce concentrations of these pollutants, thereby improving indoor air quality and creating healthier living environments (Su et al. 2015). Incorporating indoor plants in spaces where formaldehyde emissions are a concern can provide both aesthetic benefits and significant health advantages.

The advantages of indoor plants for human comfort and health

Looking back at evolutionary history, plants were necessary for survival. For humans, plants functioned as a food supply, a defense mechanism, and a signal that water was nearby. Inside plants are employed for psychological and physiological well-being because of their ability to filter the air (Kavathekar et al., 2022). According to Moya et al. (2018), evapotranspiration by plants reduces the surrounding temperature, which can be utilized for air cooling and humidity control. Numerous studies have found that engaging with plants and working in biophilic spaces can influence people's attitudes and behaviors while also boosting productivity and mental well-being (Kavathekar et al., 2022; Hashim et al., 2019).

Indoor plants could be beneficial in several fields, such as solar energy, acoustics, sensing, human health, and comfort (Deng et al. 2018). Plants utilize a variety of strategies to absorb hazardous pollutants, such as soil sorption, leaf sorption, and microorganisms that break down close to the roots of the plant (Su et al. 2015). During photosynthesis, when they are absorbing more CO2, plants also absorb contaminants through their stomata. The amount of artificial or natural light, leaf size, and other elements influence the plant's ability to absorb CO2 and emit O2 (Kavathekar et al. 2022). Fig. 1 illustrates how indoor plants improve human comfort and health.

Temperature affects the VOC emissions from building materials along with humidity and air velocity. Likewise, formaldehyde emissions from particle board are influenced by relative humidity. Thus, in addition to cleansing the air through photosynthesis and phytoremediation, plants are able to regulate temperature and relative humidity, which in turn can regulate airborne toxins. Kim and colleagues (2020; Gubb et al., 2018), They proposed that during their investigation into the potential uses of plants to purify water and air, retired NASA scientist

Bill Wolverton made an intriguing discovery: plants function significantly better as air filters when air circulation to their roots is boosted. It has been found in several research that rhizosphere bacteria, which are common in growth media, are significant as direct agents of VOC elimination, which is vital for biofiltration (Moya et al. 2018).

Particulate Matter (PM) in indoor and outdoor environments primarily deposits on the surface of plant leaves through wet or dry deposition processes. Studies indicate that the adaxial (upper) surface of leaves tends to accumulate more PM compared to the abaxial (lower) surface. Additionally, the cuticle of leaves serves as a pathway for lipophilic contaminants, including aromatic hydrocarbons, to enter the leaf structure (Wroblewska et al., 2021).

Processes Within the Plant to Mitigate Contaminant Toxicity

Once xenobiotics (foreign substances) such as PM enter the leaf, plants employ various protective mechanisms to mitigate their toxicity. These processes include:

Excretion: Plants can excrete contaminants back into the environment through processes like guttation and transpiration.

Conjugation: Xenobiotics may undergo conjugation with endogenous compounds, rendering them less toxic.

Compartmentalization: Plants can sequester contaminants in vacuoles or other cellular compartments, reducing their impact on vital cellular processes.

Metabolic Reduction: Some contaminants may be metabolized into simpler, less harmful substances within plant cells (Wroblewska et al., 2021).

Impact on Thermal Comfort

Research by Kavathekar et al. (2022) has demonstrated that plants significantly enhance thermal comfort in indoor environments. This effect persists over time and is not diminished by seasonal changes. The presence of plants can help regulate indoor temperatures by providing shading, reducing direct sunlight, and enhancing natural ventilation. These factors contribute to a more comfortable indoor climate, promoting well-being and productivity among occupants.

Commonly Used Indoor Plants to Reduce Air Pollutants

1. Areca Palm

Areca palm (Chrysalidocarpus lutescens) is indeed a versatile indoor plant known for its air-purifying capabilities and aesthetic appeal. Here are some key points summarizing its effectiveness in removing indoor air pollutants:

Pollutants Removed: Areca palm is effective in removing a variety of indoor air pollutants including acetone, CO2, xylene, toluene, benzene, trichloroethylene, carbon monoxide, and formaldehyde. These pollutants are commonly released from petroleum products, paints, wooden furniture, etc.

Mechanisms of Removal: Areca palm removes pollutants through several mechanisms. It can absorb pollutants through stomatal absorption and sorption to the plant cuticle. Additionally, its microbiome plays a role in non-stomatal adsorption of pollutants.

CO2 Reduction: Studies have shown significant reduction in CO2 levels by Areca palm. For instance, chamber tests indicated a reduction of CO2 by 88.5%, highlighting its effectiveness in improving indoor air quality by lowering this greenhouse gas.

Comparison with Other Plants: Compared to other common indoor plants like Song of India and Lady palm, Areca palm has been found to have a greater potential for absorbing CO2.

Effectiveness in Indoor Settings: Research has demonstrated practical benefits of using Areca palm potted plants indoors. Installation of 6 to 9 potted Areca palms resulted in notable decreases in total volatile organic compounds (TVOCs), CO2, and CO levels. Reduction rates reported were as high as 95.70% for TVOCs, 35.5% for CO2, and 83% for CO.

Areca palm is not only aesthetically pleasing but also highly effective in improving indoor air quality by reducing a wide range of pollutants. Its ability to thrive in low light conditions and its ease of maintenance make it a popular choice for indoor spaces seeking cleaner air and a greener environment.

2. Peace Lily

Peace Lily (Spathiphyllum wallisii) is renowned for its elegant appearance and its exceptional ability to purify indoor air. Here are the key points summarizing its effectiveness in removing indoor air pollutants:

Pollutants Removed: Peace Lily is highly effective at removing airborne Volatile Organic Compounds (VOCs) such as formaldehyde, trichloroethylene, and benzene. These pollutants are commonly found in indoor environments due to paints, solvents, furniture, and other household products.

Air Purification Mechanisms: Peace Lily purifies air primarily through its leaves. Studies have shown significant reductions in benzene (93-94%) within 75 minutes of exposure to Peace Lily leaves. It also reduces toluene and 2-ethylhexanol by 15%.

CO2 Reduction: Peace Lily contributes to lowering CO2 levels indoors. Research indicates that Peace Lily plants can reduce approximately 361 ppm of CO2 per hour under controlled conditions.

Environmental Requirements: Peace Lily thrives in indoor environments with average daily temperatures of 20°C to 22°C and relative humidity of 60–70%. It can tolerate low light levels, making it suitable for indoor spaces with limited natural light.

Living Wall Applications: Peace Lily is well-suited for use in living wall designs due to its ability to thrive and effectively reduce pollutants even in environments with lower light intensity (200 μmol m^{-2} s^{-1}).

Overall Effectiveness: Based on studies, Peace Lily emerges as one of the best indoor plants for efficiently reducing a wide range of air pollutants, enhancing indoor air quality, and contributing to a healthier indoor environment.

Peace Lily not only adds aesthetic value to indoor spaces with its lush foliage and elegant white blooms but also plays a crucial role in improving indoor air quality by effectively removing harmful VOCs and reducing CO2 levels. Its adaptability to low light conditions and its air-purifying capabilities make it a popular choice among indoor plants for promoting a healthier living environment.

3. Dumb cane

Dieffenbachia seguine, commonly known as Dumb Cane, is a popular indoor plant appreciated for its attractive variegated leaves and ease of

maintenance. Here's an overview of its capabilities and benefits in relation to indoor air quality:

Air Purification: Dumb Cane is effective at reducing indoor air pollutants, particularly carbon dioxide (CO2). Studies indicate that Dumb Cane can remove approximately 216.5 ppm of CO2 per hour under controlled conditions. This makes it beneficial for improving indoor air quality by reducing CO2 levels, which can contribute to a more comfortable and healthier indoor environment.

Environmental Preferences: Dumb Cane thrives in indoor environments with average temperatures ranging from 20°C to 25°C and relative humidity of 60% to 70%. It prefers moderate light conditions, making it suitable for indoor spaces with indirect sunlight or artificial lighting.

Origin and Adaptation: Native to tropical America, Dumb Cane naturally grows in shady and humid conditions. It has adapted well to indoor environments and is commonly found in homes, offices, and other indoor settings where it can thrive without direct exposure to harsh sunlight.

Maintenance: Known for its resilience and ease of care, Dumb Cane is a low-maintenance plant suitable for indoor gardening enthusiasts of all skill levels. It requires regular watering and benefits from occasional pruning to maintain its appearance and health.

Indoor Air Quality Benefits: By reducing CO2 levels, Dumb Cane helps create a healthier indoor atmosphere, potentially reducing the need for excessive air conditioning and lowering the overall carbon footprint of indoor spaces. This aspect underscores its role not only as a decorative plant but also as a functional contributor to indoor air quality improvement.

Dieffenbachia seguine, or Dumb Cane, stands out as an indoor plant that combines aesthetic appeal with practical benefits for indoor air quality enhancement. Its ability to lower CO2 levels and its adaptability to indoor conditions make it a valuable addition to indoor environments seeking improved air quality and a greener footprint.

4. English Ivy

English Ivy (Hedera helix) is a versatile and effective indoor plant known for its ability to improve indoor air quality. Here are some key points about English Ivy and its benefits:

Air Purification: English Ivy is renowned for its capability to remove volatile organic compounds (VOCs) from indoor air, including formaldehyde. Studies have shown that potted English Ivy can significantly accelerate the removal of gaseous formaldehyde compared to natural dissipation rates. It can reduce formaldehyde levels by 81-96% over a 24-hour period, making it one of the top plants for VOC elimination in indoor environments.

Environmental Preferences: Hedera helix thrives in moist, shaded environments and prefers indirect sunlight or moderate light conditions. Ideal temperatures range from 22°C to 26°C, with relative humidity levels between 40% and 60%. These conditions mimic its natural habitat and support optimal growth and air purification capabilities indoors.

Effect on CO2: English Ivy also contributes to reducing carbon dioxide (CO2) levels indoors. While specific figures vary, research indicates that it

can help in absorbing CO2, thereby potentially improving indoor air quality and reducing the carbon footprint of indoor spaces.

Decorative and Versatile: Beyond its air purification benefits, English Ivy is valued for its aesthetic appeal as a climbing vine. It is commonly used as a decorative plant in homes and offices due to its attractive foliage and ability to grow in various containers or as a hanging plant.

Maintenance: Like other indoor plants, English Ivy requires regular watering to keep the soil moist but not waterlogged. It benefits from occasional misting to maintain humidity levels, especially in drier indoor environments. Pruning is also recommended to control its growth and enhance its appearance.

Research Findings: Studies have demonstrated that increasing indoor light levels can enhance English Ivy's capacity to absorb CO2. This highlights its adaptability and responsiveness to environmental factors, making it a practical choice for indoor spaces seeking air quality improvement.

In summary, Hedera helix, or English Ivy, stands out as an effective indoor plant for reducing VOCs like formaldehyde and potentially lowering CO2 levels. Its ability to thrive in indoor conditions while providing aesthetic and air quality benefits makes it a popular choice among indoor gardeners and those looking to enhance their indoor environment.

5. Bird Nest fern

Bird's Nest Fern (Asplenium nidus) is a tropical plant known for its unique appearance and air-purifying capabilities. Here are the key points about Bird's Nest Fern and its benefits for indoor air quality:

Air Purification: Bird's Nest Fern is effective at reducing indoor levels of carbon dioxide (CO2) and formaldehyde (HCHO). Research indicates that it can lower CO2 levels by approximately 0.3 ppm per hour per pot. This capability makes it beneficial for improving indoor air quality by reducing CO2 concentrations, which can contribute to a more comfortable and healthier indoor environment.

Continuous Air Cleaning: Unlike some plants that primarily photosynthesize during the day, Bird's Nest Fern has been observed to continue photosynthesizing under artificial lighting at night. This continuous activity suggests that it can provide ongoing air purification benefits by removing gas pollutants like CO2 and HCHO over extended periods.

Environmental Preferences: Asplenium nidus naturally thrives in tropical rainforests, indicating a preference for indirect light and higher humidity levels. It can adapt to indoor environments with moderate light conditions and benefits from regular misting to maintain humidity, especially in drier indoor settings.

CO2 and HCHO Reduction: Experimental studies have demonstrated that Bird's Nest Fern can effectively lower CO2 levels from 2000 ppm to a safer 800 ppm at a rate of approximately 1.984 ppm/h per pot. Similarly, it reduces HCHO concentrations from 2 ppm to a safe threshold of 0.1 ppm at an average rate of 0.003 ppm/h per pot. These findings underscore its role in improving indoor air quality by actively removing harmful gases.

Maintenance: To thrive indoors, Bird's Nest Fern requires well-draining soil and regular watering to keep the soil consistently moist but not waterlogged. It benefits from occasional feeding with a balanced fertilizer during the growing season to support its growth and air purification capabilities.

Decorative Appeal: Beyond its air purifying benefits, Bird's Nest Fern is appreciated for its lush, vibrant foliage that adds a tropical touch to indoor spaces. It is commonly used as a decorative plant in homes, offices, and indoor gardens due to its aesthetic appeal and air-cleaning properties.

Bird's Nest Fern (Asplenium nidus) stands out as an effective indoor plant for reducing CO2 and formaldehyde levels while enhancing indoor air quality. Its ability to thrive in indoor conditions and provide continuous air purification makes it a valuable addition to indoor environments seeking to improve air quality and create a healthier living or working space.

6. Snake Plant

Snake Plant (Sansevieria trifasciata) is a widely recognized indoor plant known for its air-purifying qualities and ease of care. Here's a detailed overview of Snake Plant and its benefits for indoor air quality:

Air Purification: Snake Plant is highly effective at removing several airborne pollutants commonly found indoors, including formaldehyde, nitrogen oxide, benzene, xylene, and trichloroethylene. These pollutants can originate from sources such as paints, furniture, cleaning agents, and plastics. Snake Plant's ability to absorb and metabolize these pollutants helps improve indoor air quality significantly.

CO2 and O2 Exchange: Snake Plant performs photosynthesis during the day, converting carbon dioxide (CO2) into oxygen (O2) as most plants do. What sets Snake Plant apart is its ability to also carry out a type of photosynthesis known as Crassulacean Acid Metabolism (CAM) at night. This process allows Snake Plant to continue absorbing CO2 and releasing O2 even when there is no sunlight, making it beneficial for maintaining oxygen levels indoors around the clock.

Environmental Preferences: Snake Plant thrives in indoor environments with moderate temperatures, preferring an air temperature around 24°C (75°F), relative humidity of about 40%, and a light intensity of approximately 1500 lux. It can tolerate low light conditions, which makes it suitable for various indoor settings including offices, living rooms, and bedrooms.

Photosynthetic and Oxygen Release Potential: Studies have shown that Snake Plant exhibits a robust photosynthetic capacity, capable of absorbing carbon dioxide at a rate of 0.201 ppm per square centimeter of leaf area. This efficiency contributes to its effectiveness in reducing CO2 levels indoors. Additionally, Snake Plant releases oxygen during both light and dark conditions, indicating its continuous contribution to improving indoor air quality.

Maintenance: Snake Plant is known for its resilience and requires minimal maintenance. It prefers well-draining soil and only needs occasional watering, allowing the soil to dry out between waterings to prevent root rot. It is tolerant of neglect and can thrive in indoor environments with minimal care.

Decorative Appeal: Beyond its air purifying benefits, Snake Plant is prized for its architectural foliage, characterized by tall, upright leaves with variegated patterns. Its aesthetic appeal makes it a popular choice for interior decoration, adding a touch of greenery to indoor spaces while contributing to cleaner air.

Snake Plant (Sansevieria trifasciata) is an excellent choice for indoor environments seeking to improve air quality naturally. Its ability to remove various indoor pollutants, perform both daytime and nighttime photosynthesis, and thrive in low-light conditions make it a versatile and beneficial addition to homes, offices, and indoor gardens.

7. Golden Pothos

Golden Pothos (Epipremnum aureum), also known as devil's ivy, is a popular indoor plant valued for its air-purifying capabilities and ornamental qualities. Here's an overview of Golden Pothos and its benefits for indoor air quality:

Air Purification: Golden Pothos is highly effective at removing various indoor air pollutants such as benzene, trichloroethylene, xylene, and formaldehyde. These pollutants commonly originate from sources like paints, furniture, cleaning agents, and synthetic materials. The plant's ability to absorb and metabolize these pollutants helps in improving indoor air quality significantly.

CO2 Reduction: Studies have shown that Golden Pothos contributes to reducing carbon dioxide (CO2) levels indoors. For instance, green walls or arrangements with Golden Pothos placed perpendicular to windows and exposed to sufficient light can achieve a CO2 reduction rate of 1.74 ppm/min. This highlights its role in enhancing indoor air freshness by lowering CO2 concentrations.

Particulate Matter Reduction: Golden Pothos has been observed to reduce various sizes of particulate matter (PM) suspended in the air. It can lower 85% of total suspended particles, 75.2% of PM2.5 (fine particles with a diameter of 2.5 micrometers or smaller), and 71.9% of PM10 (larger inhalable particles with a diameter of 10 micrometers or smaller). This capability contributes to cleaner and healthier indoor environments.

Environmental Preferences: Golden Pothos thrives in indoor environments with moderate lighting, preferring light intensities around 300 lux, temperatures between 22°C to 27°C (72°F to 81°F), and relative humidity levels ranging from 50% to 70%. It is adaptable and can tolerate variations in environmental conditions, making it suitable for a wide range of indoor settings.

Maintenance: Known for its resilience and low maintenance requirements, Golden Pothos can grow in soil or even in water-filled pots without soil. It prefers well-draining soil and only needs occasional watering, allowing the soil to dry out between waterings to prevent overwatering and root rot. Its ability to thrive under neglect makes it a popular choice for indoor spaces.

Decorative Appeal: Beyond its air-purifying benefits, Golden Pothos is appreciated for its lush, trailing vines adorned with heart-shaped leaves variegated in shades of green and yellow. It adds a touch of natural beauty and elegance to indoor spaces, enhancing aesthetic appeal while contributing to better air quality.

In conclusion, Golden Pothos (Epipremnum aureum) is an excellent indoor plant choice for those seeking to enhance indoor air quality naturally. Its capacity to remove air pollutants, reduce CO2 levels, and lower particulate matter, coupled with its easy maintenance and decorative appeal, makes it a valuable addition to homes, offices, and indoor environments aiming for cleaner and fresher air.

Table 1: Common indoor plants that can eliminate indoor pollutants

Indoor Plant Common Name	**Scientific Name**	**Pollutants That Can Be Removed**	**Reference**
Areca palm	*Chrysalidocarpus lutescens*	CO2, Benzene, Toluene, Carbon monoxide, Formaldehyde, Xylene, Trichloroethylene	Bhargava et al. 2020
Song of India	*Dracaena reflexa*	Xylene, Toluene, Trichloroethylene, and Formaldehyde	Kavathekar et al. 2022
Peace lily	*Spathiphyllum wallisii*	Toluene, CO2, and Compounds (formaldehyde, benzene etc.)	Dominici et al. 2021, Kulkarni et al. 2018
Dumb cane	*Dieffenbachia seguine*	CO2, Formaldehyde, and Toluene	Tan et al. 2022
Weeping fig	*Ficus benjamina*	Octane, Terpene, Formaldehyde and CO2	Deng et al. 2018,
Aloe vera	*Aloe barbadensis miller*	Formaldehyde, CO2 and Benzene	Shishegaranet al. 2020
English ivy	*Hedera Helix*	Formaldehyde, Octane CO2, Benzene, Toluene, Terpene, and Trichloroethylene	Lin et al. 2017, Deng et al. 2018
Spider plant	*Chlorophytum comosum*	Formaldehyde, CO2, Terpene, ozone and VOCs	Moya et al. 2018
Bird nest fern	*Asplenium Nidus*	CO2 and Formaldehyde	Su et al. 2015

Snake plant	*Sansevieria Trifasciata*	Benzene, Formaldehyde, Toluene and CO2	Kavya 2017
Golden pothos	*Epipremnum Aureum*	Formaldehyde, Toluene, PM 2.5, PM 10,Xylene, Ozone, Ketones, and CO2	Taemthong et al. 2022, Deng et al. 2018
Dracaena	*Dracaena Compacta*	CO2, Carbon monoxide, TVOCs	Tan et al. 2022

Conclusion

This review explores the potential of commonly used indoor plants to reduce indoor air pollution, such as formaldehyde and carbon dioxide, and improve indoor air quality. Indoor plants can minimize additional pollutants such PM 2.5, PM 10, carbon monoxide, toluene, and trichloroethylene in addition to lowering formaldehyde and CO2. They can also help maintain relative humidity. Indoor plants lower CO2 and formaldehyde through photosynthetic processes and the microbial matrix in their roots. The most well-liked and efficient indoor plants are Golden Pothos, Snake Plant, and Areca Palm after an analysis of the effectiveness of the listed small-scale botanicals in enhancing indoor air quality revealed that they outperform other indoor plants and can reduce the majority of indoor pollutants (Formaldehyde, Toluene, PM 2.5, PM 10, Xylene, Ozone, Ketones, and CO2). Since aloe vera emits oxygen and maintains the highest possible indoor air quality, it is the ideal indoor plant for nighttime use.

Thus, rather than using other devices like air purifiers, we conclude that growing indoor plants is the most efficient and economical option to improve indoor air quality.

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A Comprehensive Review of Genus Alysicarpus Desv. family-Fabaceae reference to flora of Marathwada.

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Abstract
Present paper views and updating current status of genus Alysicarpus Desv. In the Flora of Marathwada. During taxonomic survey authors collected several plants specimens from various parts of Maharashtra, after critical identification authors came to conclusion some taxa of genus Alysicarpus Desv. extends their distribution as well as these are new report to Flora of Marathwada. Detail morphology, illustration, extended geographic distribution, map provided.

Keywords: Alysicarpus, present status, Flora of Marathwada, description, key.

Introduction

The genus Alysicarpus Desv. (Leguminosae: Papilionoideae) comprises 34 species distributed in the tropical and sub-tropical parts of the Old World (Verdcourt 1971, 1974; Endo and Ohashi 1990; John and Thengane 1994; Pedley 2001; Huang and Ohashi 2010; The Plant List 2010). Which is mostly diversified in southern Asia, especially India (Chavan et al. 2013). In India, the genus is represented by 27 taxa, especially in the dry zones of the states of Maharashtra, Andhra Pradesh, Gujarat, Karnataka, Kerala and Tamil Nadu (Pokle 1999, 2002). Pramanik & Thothathri (1982), Almeida & Almeida (1988), Pokle (1999) Chavan et al. (2013) described eight species and five varieties of Alysicarpus from the Indian peninsula.

In the Flora of Marathwada 13 species and 1 variety were reported (Naik 1998). Among the collectors Pokle 1999, 2002) described three new species and to new varieties i.e. Alysicarpus luteo-vexillatus, Alysicarpus naikianus, Alysicarpus saplianus, Alysicarpus longifolius var. major, Alysicarpus longifolius var. pygmeaus. Out of these five taxa, two species and two varieties extended distribution in region of

Marathwada. In the course of exploration of genus Alysicarpus authors collected five taxa and new reported to Flora of Marathwada (Chavan et.al. 2013). The outcomes of exploration of genus Alysicarpus Desv. from 20 years reveals that 15 species and 6 varieties occure in region of Marathwada. This can be considered as origin of genus Alysicarpus in India particularly in Marathwada. The present paper focused on current taxonomic account of genus Alysicarpus Desv., detail morphology, illustration and geographical map.

Alysicarpus bupleurifolius (L.) DC., Prodr. 2:352. 1825. Baker in Hook. f., Fl. Brit. Ind. 2:158. 1876; Cooke, Fl. Bomb. Pres. (reprint ed.) 1:370.1958; (Repr.); van Meeuwen et al. in Reinwardtia 6:88. 1961; Naik Fl. Osmanabad 100. 1979; Sanj. Legumes of India 77. 1991; Naik Fl of Marathwada 243. 1998. Hedysarum bupleurifolium L. Sp. Pl. 745.1753.

Erect, appressed hairy, annual herbs, 15-45 cm tall; branches slender, ascending. Leaves unifoliolate; petioles 1-2.5 mm long; stipules linear 8-10 mm long, acute, glabrous. Leaflets lanceolate, 1.2-4.5 x 0.5-1.5 cm, acute glabrous or nearly so. Flowers in 10-20 distant pains on erect, lax racemes; pedicels short. Calyx 5-6 mm long, much longer than the first joint of pod; tube glabrous; teeth acute, ciliate. Petals deep pink, red or pink purple. Pods cylindric, 10-12 mm long, 4-8 jointed, joints as broad as long, reticulate, glabrous.

Note: Common in grasslands, under the shade of trees, along stream bank etc.

Flowering and fruiting: July to September

Distribution: In all district.

Exsiccata: Naik, Papnas, 390, 876; Pokle, Soygaon, 3512; Zate, Kinwat, 990; ASD 920 Aurangabad, DSP A002 Daultabad, DSP 009 Nanded, DSP A105 Appachiwadi, DSP A108 Kolhapur, DSP A120 Kolhapur, DSP A158 Hyderabad, MAW 268 Mahadev ghat Bhokar, MAW 1339 Bhokar, SYC 115 Gogababa Hill, Aurangabad, SYC 012 Gogababa Hill Aurangabad, SYC 056 SUK University campus, Kolhapur, SYC 089 Kagajipura Aurangabad.

A.bupleurifolius (L.) DC. var. gracilis Baker. Journal of the Asiatic Society of Bengal. Part II. Natural History 21: 170. 1853. (J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. Alysicarpus gracilis Edgew).

Erect, unbranched, herbs, glabrescent, 10-25 cm tall. Leaves unifoliolate, petioles ca 1-3 mm long, glabrous. Stipules 5-6 × 0.8-1 mm long, tapering, deltoid, acute, tailed, slightly curved, striate, ciliate along the margin, stipels ovate, oblong, acute, ciliate, minutely hairy, 1.8-2.2 × 0.5mm. Leaflet unifoloilate, lanceolate to elliptic-oblong, 1.4-2.2 × 0.6-0.9 cm, Flower ca 4-8 distant pair, on rigid, erect, spicate, lax racemes. Pedicel short, ca 2 mm long, primary bracts, ca 3.2-3.4 × 1.2-1.4 mm, ovate-narrow towards tip, acuminate, striate, secondary bracts two, lateral, ovate, oblong, acute, ca 2.2-0.5-0.7 mm, ciliate, striate. Calyx 4.2-1.2 mm long, gamosepalous, calyx tube 1-2 mm long, sepal lobes triangular, acuminate, imbricate. Corolla monocoloured, deep pink, red, standard ca 3.8-4.2 × 1.4-1.8 mm. Pod cylindric, moniliform, tomentose, 4-6 mm long, articles 2-3 as broad as long, shining obscurely reticulates, tomentose.

Note: Typical unbranched, mostly found under tree shades, hill slope on rocky soils.

Flowering & fruiting: July to November.

Distribution: Common Aurangabad, Nanded district.

Exsiccata: ASD 952B Kannad forest, BRZ 990 Kinwat, BRZ 1522 Amboli, MAW 343 Sitakhandi, MAW 1373 Wakad, VNN 1193 Sitakhandi, SYC 019 Jaitkheda, Aurangabad, SYC 019 Savkheda, Aurangabad, SYC 018 Rushikund, Aurangabad. ASD 918 Gautala, ASD 952A Kannad forest, ASD 995 Gautala, BRZ 1460 Fugadigutta Nanded, DSP 3109 Wadi fort, DSP 3512D Soygaon, MAW 1855 Sitakhnadi, MAW 1870 Sitakhandi, VNN 1193 Sitakhandi, VNN 1339.

Alysicarpus heyneanus Wt. & Arn, Prod. 1:234.1834; Shah, Fl. Gujrat state 179. 1980. A. rugosus (Willd.) DC. var. heyneanus (Wt.&Arn.) Baker in Hook. Fl. Brit. India 2: 159.1876; Naik.Fl. Osmanabad 99,1979; Naik.Fl. Marathawada 244.1998. Singh & Karthikeyan. Fl. Maharashtra Vol.I 601, 2000.

Stout, erect or diffuse herbs up to 1 m tall; stems and branches densely pubescent. Leaves 1-foliolate, petioles 2-10 mm long, striate, with long silky hairs; stipule lanceolate-subulate, 5-15 mm long, membranous, minutely hairy. Leaflets elliptic to oblong-lanceolate, 1.5 x 0.7-3 cm, margin narrowly cartilaginous. Flowers in axillary and terminal racemes 5-20 cm long, in close in pairs; pedicels 2-4 mm long, bract ovate acuminate, 2-3 mm long. Calyx 6-8 mm long, divided to the base; sepals glabrous or ciliate on keels only. Petals pink or deep red. Pods 8-12 mm long, 3-5 jointed, moniliform, apiculate, joints suborbicular, glabrous or sparsely ciliate along margin, deeply transversely rugose, black.

Note: Common, weed of fields and on wet lands, one of the common species of the genus. It shows great variation in habit and leaf size.

Flowering and fruiting: October to February

Distribution: In all district.

Exsiccata: Naik, Ghatangri, Naik 992; W. Khan, Bhokar, 722; Rothe, Paralighat, 5405.

A.heyneanus Wt. & Arn. var. ludens (Baker) Pramanik & Thoth. Pramanik & Thoth. In Bull. Bot. Surv. India 24:112.1983; Sanj. Legumes of India 2: 159.1876. A. glumaceous var. ludens (Baker) Sant. In Rec., Bot., Surv. India 16:60.1967 (3rd. Rev.ed.); Singh & karthikeyan. Fl of Maharashatra Vol.I. 602. 2000.

Erect, stout, branched herbs up to 10 feet tall, stem and branches densely pubescent, striate. Leaves unifoliolate, petiolate, stipulate, petioles ca 2-10 mm long, pubescent, stipulate. Leaflets elliptic-obovate to linear-lanceolate ca 3-6 × 0.2-0.8 cm.

Flowers numerous in close pairs on axillary and terminal racemes; reaching up to 5-20 cm long, the apical portions of inflorescence triangular or quadrangular. Pedicels ca 2-5 mm, secondary bracts absent. Calyx 6-8 mm long, gamosepalous. Corolla bicolored, standard lemon yellow, wings and keel pinkish purple. Stamens 9+1, diadelphous, basifixed, ca 5-7 mm long. Ovary 2-4 mm long. Pods compressed, moniliform, 8-12 mm long, articles sub orbicular, deeply transversely rugose, turning black at the maturity.

Note: Erect 10 feet tall plant, branched, stem woody, stout, pubescent, it differs from Alysicarpus heyneanus leaves linear lanceolate, abruptly acute, obtuse, apical portion of the inflorescence triangular or quadrangular. (It differs being the characters the shape of leaves & inflorescence patterns).

Flowering & fruiting: October to January.

Distribution: Occasional in cultivated fields. (Only in Aurangabad & Beed district reported).

Exsiccata: SYC 147 Zarighat, Nashik; SYC 173 Khultabad, Aurangabad; SYC 007 Niphad, Nashik.

A. longifolius (Rottl.ex Spreng.) Wight. & Arn. var. longifolius. Prodr. 233. 1834; Baker in Hook. Fl. Brit. India 2: 159. 1876; Cooke, Fl. Pres. Bombay 1: 370. 1958; Ali in Biologia 12:35.1966; (Repr.); Legumes of India 79. 1991. Hedysarum longifolium Rottl. Ex Spreng. Syst. Veg. 3: 319.1826; Naik. Fl. Osmanabad. 100.1979. Singh & Karthikeyan. Fl. Maharashtra. 602.2000.

Erect, woody, annual herbs, 30-90 cm tall, stem and branches appressed pubescent. Leaves 1- foliolate, petioles 3-9 mm long, stipules scariosus, lanceolate, 1-2 cm long, acute. Leaflets oblong lanceolate, 5-15 cm long, subcordate at base, obtuse or subacute, glabrous above, appressed hairy on the nerves beneath; petiolules short, stipel linear. Flowers in pairs, erect, appressed to the rachis, in dense spicate racemes 15-30 cm long; pedicels 2-3 mm long, hairy, bracts ovate-acuminate, 10-15 mm long, silky outside, ciliate, concealing the buds, deciduous. Calyx 6-10 mm long, pubescent, longer than the first joint of the pod; tube funnel shaped, plicate; teeth much longer than the tube. Corolla uniformly deep pink. Pods longer than the calyx, terete compressed, 10-12 mm long, 4-6 jointed, faintly reticulately veined.

Note: occasional, along stream bank admits grasses.

Flowering and fruiting: September to November

Exsiccata: ASD 959A Alakh, Rajkot, ASD 993 Kalamnuri, Isapur road, Hingoli, SYC 154 Sapli, SYC 154B Sapli, SYC 172 BAMU Campus Aurangabad.

A. longifolius (Rottl.ex Spreng.) Wight. & Arn. var. major Pokle. Reinwardtia 11: 292. 1999.

Erect, woody, branched, herbs, up to 10 feet tall, stem and branches glabrous, terete, striate. Leaves unifoliolate, petiolate, stipulate; petioles ca 5-15 mm long, stipule scarious, obliquely ovate, stipels two, lateral ovate, obtuse, ca 2-3 × 1-2 mm. Leaflets ovate, elongate, tapering, ca 5-15 × 0.5-1.4 cm, obtuse or subacute, cuneate or subcordate at base.

Flowers numerous in pairs on erect, appressed to densely hairy rachis, in spicate terminal racemes, ca 15-30 cm long, pedicels ca 2-4 mm long. Primary bract ovate very acuminate, ca 5-15 × 4-5 mm, silky brownish purple outside, ciliate ouside. Calyx ca 6-14 mm long, gamosepalous, pubescent, calyx tube ca 1-2 mm long. Corolla deep pink or purplish yellow red, standard oblong, cordate at base, emerginate at apex, ca 8-10 × 7-9 mm, wings obovate, ca 6-8 x 3-4 mm, tapering at base, apex round, keel, ca 6-8 × 2-4 mm. Stamens 9+1. Ovary ca 4-6 mm long. Pods 3-5 articled, terete, compressed, apiculate, slightly moniliform, 7-15 mm long.

Note: Stem woody, leaves ovate elongate, leaf apices obtuse or subacute, lower surface subcordate.

Flowering & fruiting: September to December.

Distribution: Occasional in Maharashtra, founds in cultivated fields, in dark cotton soils.

Exsiccata: ASD 651A Devaliya Bodeli, ASD 602, Alakh Rajkot, ASD 678A Mount Abu Road, SYC 044 Vaijapur, Aurangabad, SYC 196 Mirzapur, Deglur.

A. longifolius (Rottl.ex Spreng.) Wight. & Arn. var. pygmaeus Pokle Reinwardtia 11: 290. 1999.

Erect, less branched, herbs, up to 30 cm, stem and branches glabrous. Leaves diamorphic, petiolate, stipulate; petioles ca 7-9 mm long, glabrous; stipule linear, ca 11.2-2.2 mm, striate, glabrous, stipels two, lateral, oblong, obtuse, ca 1.8-0.6 mm, glabrous, striate, clilate hairy at apex. Leaflets ovate- oblong to elliptic-lanceolate, ca 1.7-5.5 × 0.5-1.2 cm.

Flowers in pairs dense hairy, terminal, axillary, racemes, rachis ca 8-15 cm long, pedicels ca 1-2 mm long, pubescent. Primary bract ovate, acuminate, long tailed, ca 7.2 × 3.8-4 mm. Calyx ca 4.8-5.2 × 1.2 mm long, distantly ciliate along margin, gamosepalous, calyx, tube ca 1-2 mm. Corolla pink, standard round shaped, ca 6 × 3.2 mm, emerginate at apex, base cordate shaped, reticulately veined, wings obovate, ca 4.8-1.2 mm, narrow at base, apex broadly acute or obtuse, keel ca 5.4-0.9 mm. Stamens 9+1, ca 5-8 mm long. Ovary ca 4-6 × 0.8-1.2 mm, glabrous. Pods 3-5 jointed, terete, compressed, apiculate, slightly moniliform, few short many trichomes poorly developed, pods 7-12 mm long.

Note: Erect, height up to 25-40 cm, dwarf, woody, leaves short, ovate- small, inflorescence elongate 10-15 cm long, primary bract tip very long, acute. Pod constricted.

Flowering & fruiting: September to November.

Distribution: Infrequent, Aurangabad (Paithan & Vaijapur Talukas).

Exsiccata: ASD 652A Nitella phata, Pawagad road, Vadodara, ASD 660 A Allakh, Rajkot ASD 667, Mount Abu, SYC 084 Bidkin, Aurangabad, SYC 156 on the way of Surgana, Nashik.

A. pubescence Law. var. pubescence. Law in Wight, Ic. T. 250. 1840; Baker in Hook. Fl. Brit. India 2: 160. 1876; Cooke, Fl. Pres. Bombay 1: 372. 1958 (Repr.); Sanj. Legumes of India 80. 1991; Naik. Fl. Osmanabad. 101. 1979; Singh & Karthikeyan. Fl. Maharashtra 605.2000.

Erect or decumbent, annual herb 30-90 cm tall; branches slender, hairy. Leaves 1-foliolate; petioles 1.5-3 mm long, hairy; stipules linear-lanceolate 10-12 mm long, prolonged in to a fine acicular point, clothed with longed hairs. Leaflets oblong lanceolate 1-4.5 x 0.3-1 cm, conspicuously 3 nerved from the rounded or subcordate base, acute, mucronate, subglabrous above, clothed with long white hairs especially on nerves beneath; petiolules very short, stipels minute, caduceus. Flowers sessile, in dense terminal spicate racemes; rachis plumose. Bracts ovate, acuminate, silky villous outside. Calyx 6-8 mm long, divided nearly to the base; teeth narrowly lanceolate subulate, densely plumose. Standard petal yellow colored, keel and wing deep pink. Pods 2-4 jointed, moniliform, included within

the calyx, joints globose, reticulately veined.

Note: Frequent on gravelly soil of hill slopes.

Flowering and fruiting: September to December.

Distribution: Aurangabad, Nanded, Osmanabad and Parbhani district.

Exsiccata: Naik, Osmanabad, 863; Vaidya, Hingoli, 560; W. Khan, Mahadevghat, 246; ASD 960A Kolhapur, BRZ 4295 Kinwat,Nanded,` DSP 625 Chouka, Aurangabad, MAD 2428 Nil, MAD 6072 Kandhar, Nanded, MAW 246 Mahadeo ghat Bhokar, MAW 275 Mahadeo ghat Bhokar, VNN 588 Osmanabad, VNN 797 Udgir,VNN 863 Osmanabad, VNN 2849A Purandhar, SYC 026 Shulibhanjan, Aurangabad, SYC 071 Mahabaleshwar.

A. pubescence Law. var. vasavadeae (Hemadri) Sanjappa. Taxon 32:668. 1983 & Legumes of India. 80. 1991. A. vasavadae Hemadri in Indian Forester 97:65, f. 1-2. 1971; Naik, Fl. Osmanabad. 101.1979 pro parte non law 1840; Fl. Maharashtra. 605. 2000.

Annual, erect, branched rarely unbranched herbs 50-90 cm tall, stem pubescent. Leaves unifoliolate, petiolate, stipulate, petioles ca 1-2.5 mm long, petiolules very short ca 0.5-1.0 mm long, stipules lanceolate, acute, ca 5 × 2.5 mm, striate, pubescent, deciduous, stipels two, lateral, ovate, oblong, subacute, striate, pubescent, caducous, ca 2 × 0.4 mm. Leaflets ca 2.5 × 0.2-0.4 cm, elliptic-lanceolate, prominently three nerved.

Flowers few paired, pedicillate on dense terminal racemes, pedicels ca 1-2 mm long. Primary bract broadly ovate, acuminate, silky villous, outside, striate, ca 7.2 × 3 mm, secondary bracts two, linear acute, lateral ca 1 × 0.1 mm. Calyx ca 8.3 × 1 mm long, gamosepalous, calyx tube ca 1.0-1.5 mm long, sepals narrowly lanceolate, acute, densely plumose, striate, dark golden coloured shade at tip of all sepals. Corolla bicolored, standard deep yellow, wings and keel deep pink or purple pink. Standard bilobed, cordate at base emerginate at apex, ca 5.2 × 3.4 mm, wings broad at base ca 5-5.3 × 1-1.3 mm, keel boat shaped, ca 5-5.5 × 1-1.5 mm. Stamens 9+1. Ovary ca 3 mm long, glabrous. Pods 4-6 mm, compressed, 1 articled, conspicuously reticulately veined, with a beak.

Note: very similar to and only a form of var. pubescens with pedicelled flowers and often only 1 jointed pod which is compressed and conspicuously reticulately veined.

Flowering & fruiting: September to December.

Distribution: Rare in grasslands, Aurangabad only.

Exsiccata: ASD 967 Aurangabad, ASD 698 Aurangabad, ASD 1001 Aurangabad, SYC 024 Sambhaji hill, Aurangabad, ASD 605 Majalgaon, ASD 696A Aurangabad, ASD 935 Satara, ASD 964 Kolhapur, SYC 051 Jaitkheda, Aurangabad, SYC 075 Panchgani, SYC 023 Nashik.

A. scariosus (Rottl. ex Spreng.) Grah. Ex Thw. var. scariosus. Enum. Pl. Zeyl. 88. 1859; Ali in Biologia 12:32. 1966; Sanj. Legumes of India 80. 1991. Hedysarum scariosum Rottl. Ex Spreng. Syst. Veg. 3:319. 1826. Alysicarpus rugosus var. styracifolius (DC.) Baker in Hook. Fl. Brit. India 2:159. 1876; Cooke, Fl. Pres.Bombay 1:371. 1958 (Repr); Naik. Fl. Osmanabad 99.1979; Singh &

Karthikeyan. Fl. Maharashtra. Vol I. 607.2000.

Erect or procumbent herbs, 30-60 cm tall; branches finely pubescent. Leaves unifoliolate; petioles 5-10 mm long, stipules linear -lacnceolate, 6-10 mm long, very acute. Leaflets elliptic, obovate or orbicular, 0.7-3 x 0.5-1.5 cm, rounded at base, obtuse or pubescent, petiolules minute; stipels small, deciduous. Flowers in 1-2.5 cm long, axillary terminal, compact racemes; pedicels very short; bracts broadly ovate, 7-8 x 3-3.5 mm, acuminate, hairy on the back, long ciliate. Calyx divided to the base, sepals lanceolate 8-10 x 1.5-2.5 cm, hairy on back long ciliate. Petals deep pink, often included within the calyx. Pods moniliform 3-5 jointed, rarely exserted from the calyx; joints transversely rugose.

Note: Common, along edges of fields and in open grasslands.

Flowering and fruiting: July to January.

Distribution: In all district.

Exsicatta: Naik 941 Nilanga, Pokle 3851(b) Bhokardan, W. Khan Amdari 2166, Madhukar 5507 Yeldari. - ASD 641 Taloda road Dhule, SYC 038 Sitakhandi, SYC 109 Paithan, Aurangabad, SYC 110 Fulambri,Aurangabad, ASD 472 Parbhani, ASD 661 Rajkot, SYC 096 Badnapur, Jalna, SYC 098 Kedarguda, Nanded, ASD 991 Hivra Hingoli, SYC 081 BAMU Campus Aurangabad, SYC 047 BAMU Campus, Aurangabad, SYC 108 Dhakephal, Aurangabad.

A. tetragonolobous Edgew. J. Asiat. Soc. Bengal 21: 69. 1853; Baker in Hook. Fl. Brit. India 2: 159. 1876; Cooke. Fl. Pres. Bombay 1:372. 1958 (Repr.); Sanja. Legumes of India 81. 1991; Naik. FL. Osmanabad 99.1979; Singh & Karthikeyan 607. 2000.

Erect or procumbent annual herb; branches slender, 10-30 cm long, pubescent. Leaves 1-foliolate; petioles 2-3 mm long; stipules scarious, lanceolate, 4-5 mm long, broad at base, acute, ciliate, striate. Leaflets ovate, elliptic to lanceolate, 1-3 x 0.3-0.5 cm, rounded or subcordate at base, obtuse or sub-acute, glabrous above, pubescent on nerves beneath; petiolules very short; stipels minute, caduceus. Flowers in lax, axillary and terminal racemes 4-15 cm long, in distant pairs; pedicels 0.5-1.5 mm long, filiform, bract ovate-lanceolate, 4-5 mm long, acute, caduceus. Calyx 4-5 mm long, deeply divided, pubescent outside, sepals lanceolate, acute, ciliate with long white hairs, imbricate. Petals uniformly deep pink or standard petals sometimes with yellow spot, included within the calyx or only slightly exserted. Pods 4 gonous, moniliform, 2-6 jointed, 10-12 mm long, joints transversely ribbed, glabrous.

Note: Common in grasslands, barren lands, wet lands, along road side etc.

Flowering & fruiting: June to December.

Distribution: (Aurangabad, Parbhani, Nanded, Beed, Osmanabad, Rajkot, Belgaum District).

Exsiccata: ALV 7278 Parbhani, ASD 628 Sastapur, Basavkalyan, Bidar, ASD 663 Limbadi road Rajkot, ASD 923B Khultabad, Aurangabad, ASD 925 Shulibhanjan, Aurangabad, ASD 967 Belgaum road, Belgaum, BRZ 731 Kharbi range Nanded, BRZ 895 Ambadi forest Nanded, DSP 487 Pitalkhora, Aurangabad, DSP 3105 Wadi fort Aurangabad, DSP 3418 Soygaon, Aurangabad, DSP 3469 Autramghat,

Aurangabad, MAD 5111 Nanded, MAW 341 Sitakhandi, MAW 989 Sitakhandi, MAW 1796 Bhokar, SPR 5303 Sautada, Beed, SPR 5840 Sautada, Beed, SPR 6943 Sautada,Beed, VNN 49 Osmanabad, VNN 264 Papnas Osmanabad, VNN 966 Naldurga, VNN 1085 Vadval Nagnath, Latur, VNP 256 Ajanta, Aurangabad, VNP 3754 Nakshatravadi, Aurangabad, SYC 001 BAMU Campus Aurangabad, SYC 013 Chemtech BAMU Campus Aurangabad, SYC 004 Gautala, SYC 012 Gogababa Hills, Aurangabad, SYC 010 BAMU Campus Aurangabad, SYC 188 Sitakhandi, Nanded, SYC 064 Phonda.

A. luteo-vexillatus Naik et Pokle. Jour. Econ. Tax. Bot. 7:670. F. (1985) 1986; Sanj. Legumes of India 79. 1991; Singh & Karthikeyan. Fl. Maharashtra 603. 2000.

Erect, suberect, branched herbs, 10-20 cm tall, branches slender, terete, pilose. Leaves unifoliolate, petiolate, stipulate, petioles ca 2.5-4 mm long; stipules obliquely deltoid, acute, ca 5.3 × 2 mm; stipels ovate, oblong, subacute, ca 2-2.3 × 0.6-0.8 mm, petiolules very small. Leaflets elliptic-oblong, ca 1.5-3.0 × -0.7-1.2 cm.

Flowers in leaf opposed, lax racemes ca 4-7 cm long. Primary bract broadly, ovate, acuminate at apex, ca 3-4 × 2.4-2.6 mm, secondary bracts two, ovate, ca 2.1-2.3 × 0.6-0.8 mm. Pedicels slender, ca 1-1.2 mm long. Sepals two, ca 5-6.2 × 1-1.4 mm. Corolla slightly exerted beyond the calyx, standard yellow or yellow orange with red narrow margin on either side, ca 5.2 × 3.8-4.2 mm, wings obovate, deep pink, ca 4.2-4.4 × 0.8-1.2 mm, spathulate, keel boat shaped, deep pink, ca 5 × 1.2 mm. Stamens 9+1. Ovary ca 2-3 mm long. Pods 0.9-1.2 cm long, prominently four winged, 2-3 jointed, joints quadrate, faintly rugose, tomentose.

Note: Found in grassland.

Distribution: Infrequent found in Aurangabad, Beed, Osmanabad, Parbhani, Hingoli & Nanded, growing in grasslands on waste lands and in cultivated fields.

Flowering & fruiting: August to November.

Exsiccata: ASD 958 Savkheda, SYC 031 Deglur, Nanded, SYC 136 Mhaismal, Aurangabad,
ASD 940 kagjipura, Aurangabad, SYC 030 Gogababa hills, SYC 142 Maheshmal, SYC 078 Sapli, Hingoli.

A. monilifer (L.) DC. Prod. 2:157. 1825; baker in Hook. F. Fl. Brit. India 2: 157. 1876; Cooke, Fl, Pres. Bombay 1: 368. 1958 (Repr.); Sanj. Legumes of India 79. 1991. Naik Fl. Osmanabad 100. 1979; Sanj. Legumes of India 77. 1991; Naik Fl of Marathwada 243. 1998. Hedysarum moniliferum L. Mant. Pl. 1: 102. 1767.

Prostrate, branched herbs, 30-40 cm long, pubescent with deciduous, long, spreading trichomes terete, striate. Leaves unifoliolate, petiolate, stipulate, petioles ca 3-5 mm long, petiolules very small, ca 4.2 × 1.2 mm long, stipels curved, filiform, obtuse, ca 2 × 0.7 mm. Leaflets obovate to oblong-elliptic, ca 0.4-2 × 0.3-1.5 cm.

Flowers close 3-5 paired, axillary or leaf opposed short racemes, pubescent, pedicels ca 1.5-2 mm long. Primary bract ca 2.4 × 1.2 mm, secondary bracts two, linear, acute ca 1.8-0.2 mm. Calyx ca 3.8 × 0.6 mm long. Corolla pinkish purple Standard ca 4.6 × 2 mm, wings spathulate, ca 4.5 × 0.8 mm, keel boat shaped ca 5.5 × 1.2 mm. Stamens 9+1, ca 5.4 mm long. Ovary ca 2-3 mm long,

style ca 3-4 mm long, bent, stigma, globose trilobed. Pods moniliform, 15-20 mm long.

Note: Typical leaves small, pod small.
Flowering & fruiting: September to December.
Distribution: Common on rocks soils, in grasslands, hill slopes. Aurangabad, Nanded,
Exsiccata:ASD 657 Pawagad,Vadodara, ASD 658 Bagdara, ASD 664 Vetti Rajkot, ASD 670 Gir road Gondal, ASD 673 Samakhari Murbi, ASD 674 Mount Abu, ASD 688 Bagalkot, ASD 907 Sitakhandi, ASD 915 Isapur, Nanded, ASD 945 Aurangabad, ASD 679 Madukarai Coimbtore, ASD 984 Coimbtore, BRZ 435 Ambadi Nanded, DSP 3610 Aurangabad, DSP 4033 Aurangabad, MAD 6011 Mirjapur Nanded, MAW 948 Sitakhandi Nanded, MAW 1967 Sitakhandi Nanded, SYC 039 Mahurgad, Nanded, SYC 165 Chandrapur, SYC 170 Chandrapur.

A. hamosus. Edgew. J. Asiat Soc. Bengal 21:171. 1853; Baker in Hook f. Fl. Brit. India 2: 157. 1876; Cooke, Fl. Pres. Bombay 1: 368. 1958 (Repr.); Sanj. Legumes of India 78. 1991. Hedysarum procumbens Roxb. Fl. Ind. 3:345. 1832 non-Mill. 1768. Alysicarpus procumbens (Roxb.) Schindl. In Feddes Report. 21:11. 1925; Singh & Karthikeyan, Fl. Maharashtra 603. 2000.

Prostrate or procumbent herb; branches numerous, slender, 15-60 cm long, clothed with long spreading hairs. Leaves 1- foliolate; petioles 3-8 mm long, hairy; stipule scarious, linear, 5-8 mm long, acute striate. Leaflets broadly ovate or orbicular, 1-3 x 0.8-2.5 cm cordtate at abse, mucronate at apex, hairy on both surfaces; petiolules very short; stipel subulate. Flowers in pairs along the rachis in axillary, 4-8 flowered racemes, pedicel 2-3 mm long; bracts ovate, acute, ciliate. Calyx 2-3 mm long, much shorter than the first joint of the pod; three inner teeth linear, acute, ciliate. Petals deep pink. Pods oblong, 1-2 cm long, compressed, 3-7 jointed, with raised line between the joints, clothed with straight and hooked hairs.

Note: Frequent on gravelly slopes of hills.
Flowering and fruiting: September to November.
Distribution: In all district.
Exsiccata: ASD 645 Akkalkunwa, ASD 648 Akkalkunwa, ASD 680 Abu road,Mount Abu, ASD 682 Himmat nagar, ASD 913 Bodhadi Nanded, SYC 175 Pune University Campus, Pune, SYC 145 Chandrapur, SYC 093 BAMU Campus, Aurangabad, SYC 107 BAMU Campus Aurangabad, ASD 648B Aurangabad, SYC 005 BAMU Campus, Aurangabad, SYC 017 Chalisgaon Ghat, SYC 184 Chandrapur, ASD 645A Akklakunwa, ASD 655 Halul, ASD 948A Aurangabad, SYC 041 Mahurgad, Nanded, SYC 042 Nanded, SYC 154 Zarighat, Nashik, SYC 183 Chandrapur, SYC 186 BAMU Campus, Aurangabad.

A. ovalifolius (Schumach.) J. Leonard. Bull. Jard. Bot. Stat. Brux. 24:88 1954; Sanj. & Bhatt. In J. Bom. Nat. Hist. Soc. 75. 250. 1978; Sanj. Legumes of India 79. 1991; Naik, Fl. Marathwada 1: 246. 1998.; Singh & Karthikeyan Fl, Maharashtra 603. 2000; Hedysarum ovalifolium Schum. Beskr. Guin Pl. 359. 1827.

Prostrate or procumbent herbs; branches tetrete, striate, minutely pubescent, 15-45 cm long. Leaves 1-foliolate; petioles 2-5 mm long, striate, stipule ovate-lanceolate, 5-10 mm long, striate,

glabrous. Leaflets variable, obovate, elliptic, orbicular, ovate, lanceolate or linear-lanceolate,1-6.5 to 1-2.5 cm, rounded or subcordate at base, rounded, obtuse or acute, glabrous above, pubescent on conspicuous nerves beneath; petiolule minute, stipels obscure. Flowers in distant pairs along terminal, 6-12 flowered, lax, simple or branched racemes 8-15 cm long; pedicel 2-3 mm long, bracts ovate-acuminate, like the stipules, longer than the pedicels. Calyx glabrous, striate, 2 mm long, tube as long as the subulate, acuminate teeth. Petals deep pink. Pods linear, 1.5-2 cm long, compressed, 6-8 jointed, with raised line between the joints, reticulate and longitudinally striate, straw colored.

Note: Occasional but locally abundant.
Flowering and fruiting: September to November.
Distribution: So far known from Nanded district only.
Exsiccata: ASD 649B Ankaleshwar, ASD 650A Ankaleshwar, ASD 655 Halul, ASD 909 Badhadi Nanded, ASD 994 Islapur dam Pusad, SYC 036 Sitakhandi, Aurangabad, SYC 067 Phonda, SYC 129 Sauvarnaghat, Nashik, SYC 169 Chalisgaon ghat, SYC 180 Chandrapur, ASD 654 Nitella phata Vadodara, ASD 686 Modosa Himmatnagar, SYC 174 Ambadi, Nanded, SYC 181 Chandrapur.

A. vaginalis (L.) DC.var. vaginalis
Prodr. 2:353. 1825 Baker in Hook. F. Fl. Brit. India 2:158.1876; Naik, Fl.Osmanabad 100.1979. Hedysarum vaginale L.SP.Pl.746.1753. Alysicarpus nummularifolius DC. Prodr.2.353.1825. A. vaginalis var. nummularifolius (DC.) Baker in Hook.f.Fl.Brit.India 2:157.1876.

Prostrate herbs, stems spreading or ascending, 15-45 cm long, glabrescent. Leaves 1-foliolate; petioles 5-8 mm long; stipules scarious, ovate. 10-15 mm long, acuminate, striate. Leaflets very variable in shape and size on one and same plant, often elliptic, obovate, orbicular or oblong, 1.5-6 x 0.7-2 cm, rounded or cordate at base, rounded, acute or truncate at apex, apiculate, glabrous, petiolules very short, stipels minute, caduceus. Flowers in close pairs in 6-12 flowered, 2-8 cm long racemes; pedicels 2-2.5 mm long. Calyx 3.5-4 mm long, glabrescent, equaling the first joint of pods; sepals linear, acute, striate. Petals deep rose colored, slightly exserted. Pods subterete or compressed, 2-2.5 cm long, apiculate, 3-8 jointed, glabrous; joints longer than broad, reticulately veined, black.

Note: Common on gravelly slopes of hills, roadsides, grasslands etc.
Flowering and fruiting: September to November.
Distribution: In all district.
Exsiccata: ASD 642 Taloda road, Dhulia, ASD 683 Himmatnagar, ASD 689 Bagalkot, ASD 982 Balvelampatti, Coimbatore, SYC 144 Hatkanangale, Kolhapur, ASD 623 khanapur, Bidar, ASD 672 Sir Forest, ASD 6833 Himmatnagar, ASD 911 Sitakhandi Nanded, ASD 924 Khultabad Aurangabad, ASD 986 Coimbatore, SYC 035 Sitakhandi, Nanded, SYC 128 Ambolighat, Kolhapur, SYC 027 BAMU Campus, Aurangabad, ASD 925 Bodhadi Nanded, SYC 028 BAMU Campus Aurangabad, SYC 066 Malvan, Sindhudurga, SYC 065 Vengurle, SYC 028, BAMU Campus, Aurangabad.

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Adsorptive removal of dye from waste water by using activated carbon synthesized from *Leucaena leucocephala*

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Abstract

The large capacity of waste water production due to the rapid growth of industries has resulted in limited water resources. The need to protect and conserve water resources have enforced researchers worldwide to focus on the development of an effective, economical, and environmentally friendly novel materials. In this study we synthesized activated carbon from the flower stem of *Leucaena leucocephala*. Activated carbon was used in the removal of malachite green dye and methyl orange dye.

Keywords: Activated carbon, waste water treatment, green synthesis.

Introduction

Since dyes have a synthetic origin and complex aromatic molecular structures, they are inert and difficult to biodegrade when discharged into waste streams. This aspect has always been overlooked in their discharge The removal of synthetic dyes is of great concern, since some dyes and their degradation products may be carcinogens and toxic and, consequently, their treatment cannot depend on biodegradation alone [1,2]. There are advantages and disadvantages of various methods of dye removal from wastewaters. Many physicochemical methods have been tested, but only that of adsorption is considered to be superior to other techniques. This is attributed to its low cost, easy availability, simplicity of design, high efficiency, easy operation, biodegradability and ability to treat dyes in more concentrated forms. Activated carbon adsorption is one such method which has a great potential for the removal of dyes from wastewater [3-6]. This has led to the search for cheaper substitutes. Hence, low-cost activated carbons based on agricultural solid wastes have been investigated for a long time. Agricultural by products and waste materials used for the production of activated carbons include plum kernels [6], cassava peel [7], bagasse [8], jute fiber [9], palm-tree cobs [10]. Leucaena is a genus of plants in the family Leguminosae, which includes flowering plants. It has been shown that this species has a great deal of promise for Malaysian timber plantation plants

(MTIB 2017). Research has revealed that L. leucocephala's trunks and branches can be utilized as raw materials to make composite goods such oriented strand boards. It is known as a multipurpose tree and is widely used in gum production, furniture, construction timber, poles, etc. [11],[12].

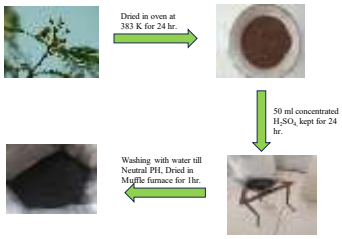
In present study the results of removal of malachite green dye from aqueous solution by adsorption onto activated carbon prepared from flower stem of Leucaena leucocephala.

1. Materials and chemicals

Leucaena leucocephala flower stems were collected from botanical garden of Balwant college, Vita.Conc.H2SO4, Sodium hydroxide (NaOH), Methyl orange dye, Malachite green dye, solvent (usually water) Heating apparatus (like a hot plate) Magnetic stirrer, Centrifuge, UV spectrophotometer.

2. Activated carbon preparation

The adsorbent was prepared from a dry flower stem. The stems were crushed into small pieces, washed with double distilled water, and dried in an oven at 383 K for 24 h. 25 g dried sample was put in a container and 50 ml concentrated H2SO4 was added as an impregnating reagent, then kept for 24 hr.

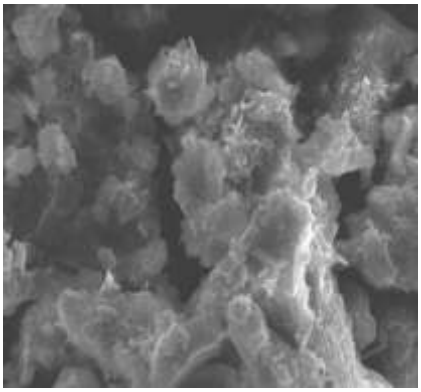


After the acid was leached out the sample was washed with distilled water till neutral pH. For complete formation as carbonaceous material, it was kept in a muffle furnace, for 1 h at 573 K. crushed to a particle size of 125 µm and finally stored in an airtight container for further analysis.

Characterization techniques

SEM Analysis

From SEM analysis a rough surface morphology was observed



Results and Discussion:

PH Study (Parameter)

100 ppm solution of malachite green dye and methyl orange dye solution was taken in three different conical flasks (50ml) and 0.050 gm of the composite was added in each flask and shaken for 2hrs in an orbital shaker (maintained in pH 5, 6, 7, 8 by using solution HCl and NaOH) (Shown in fig. 2)

Table No. 1

Activated carbon for Malachite Green Dye

Sr. No.	PH	Absorbance
1	5	1.522
2	6	0.736
3	7	0.651
4	8	0.358

Table No. 2
Activated carbon for Methyl Orange dye

Sr. No.	PH	Absorbance
1	5	1.375
2	6	0.837
3	7	0.325
4	8	0.401

From above observation it is concluded that Malachite green dye show maximum adsorption at PH 8 and Methyl Orange at pH 7 (**Table No.1 and Table No. 2**)

PH 8 kept constant and the weight of activated carbon was varied from 0.06 gm, 0.07 gm, 0.08 and 0.09 gm for malachite green (**Table No. 3**) and methyl orange (**Table No. 4**)

Table No. 3

Sr. No.	Weight	Absorbance
1	0.06	0.310
2	0.07	0.294
3	0.08	0.056
4	0.09	0.033

Table No. 4

Sr. No.	Weight	Absorbance
1	0.06	0.290
2	0.07	0.254
3	0.08	0.036
4	0.09	0.023

Fig. No. 2 Methylene blue dye after adsorption

Conclusion:

In this study, activated carbon was successfully developed from Leucaena leucocephala. The potential applicability of activated carbon was tested on the uptake of Malachite green dye & Methyl Orange dye respectively. The effect of the pH parameter was tested. From experimental data & UV spectrometer readings, it is concluded that activated shows maximum adsorption of Malachite green dye at pH 8 & Methyl orange dye at pH 7 respectively. Can be effectively used in the removal of dyes.

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Study of rhizosphere fungi and rhizoplane fungi on Mulberry

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Abstract

This study investigates the rhizosphere and rhizoplane of mulberry (Morusspp.) to understand their ecological significance and microbial interactions. The rhizosphere, the zone of soil influenced by root activity, and the rhizoplane, the root surface itself, play crucial roles in nutrient acquisition and plant health. We comprehensively analyzed microbial diversity, soil physicochemical properties, and root exudate composition. Our findings reveal a rich microbial community, with notable differences in diversity between rhizosphere and rhizoplane samples. Essential microorganisms identified include beneficial bacteria and fungi that enhance nutrient cycling and disease resistance. Additionally, root exudates significantly influenced microbial activity and community structure. This research highlights the importance of the rhizosphere and rhizoplane in mulberry cultivation, suggesting that management practices aimed at enhancing these zones could improve plant growth and resilience. These insights contribute to the broader understanding of plant-soil-microbe interactions in agroecosystems.

Keywords: mulberry root exudates, root zone, fungi, bacteria, actinomycetes.

Introduction

A small area of soil surrounded and affected by vascular plant roots is known as the rhizosphere. This zone is characterised by intense biological activity owing to the release of root exudates, which stimulate or inhibit rhizosphere organisms. The interactions between the soil, the plant, and the organisms comprising the rhizosphere characterise this region's complexity and dynamics. Plant/microbe and plant/faunal interactions abound in the rhizosphere. These interactions range from symbiotic relationships such as N2 fixation and mycorrhizal associations to

pathogenic interactions. Management strategies such as bioremediation and biological control may be successful when rhizosphere ecology is considered. A greater understanding of the rhizosphere and its effects on organisms that inhabit this area will allow for manipulations that benefit plant production and the environment.

The rhizosphere is a dynamic area where intricate interactions occur between plants and creatures closely linked to the root. The composition and pattern of root exudates influence microbial activity and population, affecting nematodes and microarthropods in the same habitat. Rhizosphere organisms and plants have beneficial or adverse interactions, eventually affecting plant development and root function. Furthermore, organisms that affect plant development and production but do not directly injure or benefit plants may also be found in the rhizosphere. A better understanding of the soil–root and soil–seed interface is needed to manage microorganisms, increase plant growth, and reduce the impact of plant production and agriculture on the environment. The benefits of studying the rhizosphere include using plant growth-promoting organisms and suppressing plant diseases and weeds using biocontrol agents. Rhizosphere organisms can also enhance the formation of stable soil aggregates and act as bioremediation agents for contaminated soils. With a greater understanding of the ecology and biota in the rhizosphere, this zone of increased nutrients, biotic activity, and interactions can be manipulated to improve plant productivity and environmental quality.

Material and Methods

This was studied by soil dilution plate count method as suggested by Hiltner (1904). Soil samples were collected from mulberry field to analyze rhizosphere and rhizoplane microflora. Samples then were brought to the laboratory in polythene bags. The dried soil samples were finally powdered, sieved and used to isolate microorganisms. Martins Rose Bengal agar medium was used to isolate the microflora, or bacteria, fungi, and actinomycetes, from the soil samples that were obtained using the serial dilution plate technique (Waksman 1922).

The composition of the MRB medium was

Dextrose - 10 gms,
Peptone - 5 gms,
KH_2PO_4 - 1 gms,
$MgSO_4$ - 0.5 gms,
Rose Bengal - Trace,
Streptomycin – 0.03 gms,
Agar-Agar – 20 gms
Distill water -1000 ml

Experiments and Results

Fungi, bacteria and actinomycetes are known to colonise diverse habitats and substrates, and they are known to play a substantial role in plant health and productivity besides producing diseases. The specialised ecological niches where the microbial association and activity are amply evidenced are soil, rhizosphere, rhizoplane and phyllo plane. These microbes may interact with the same plant simultaneously, independently, synergistically, and antagonistically, sometimes resulting in beneficial effects and, at other times, harmful consequences. The microbes living in the complex region of the rhizosphere

influence crop health and yield (Manoharachary & Mukarji, 2006).

The colonies of microbes like fungi, bacteria and actinomycetes were identified based on their appearance on solid media through microscopic examination. The solid puffy growth on the medium indicated the presence of fungi, while watery growth signals the presence of bacteria. However, the actinomycetes appeared on a medium like a shiny colony in the form of pustule (pearl-like) in different colours.

Altogether, 23 microflora forms (Tables 1 &2) were isolated from rhizosphere soils of healthy and diseased mulberry fields. Among them, 14 were observed from fungi, seven were observed from bacteria, and two were observed from actinomycetes. However, out of 20 isolated forms in rhizosphere soils, 11 belong to fungi, and the rest belong to bacteria and actinomycetes, as in the case of rhizosphere soil. Among the population of fungi, T. harzianum and A. niger were found to be the highest; however, V.chlamydosporium, P. oxalicum was noted least in the rhizosphere. When a similar population was assessed in root rot infection, it was found that the population of Fusarium spp. was increased. However, the antagonistic population of fungi was decreased. Similar observations were noted in the bacterial and actinomycetes population. In the rhizoplane profile, the pathogenic fungal population was also increased in root rot. The bacterial and actinomycetes antagonists were decreased when the crop was infected with root rot.

About the distribution of soil microflora, the data presented in Table .3 revealed that, in general, the total population in terms of colony-forming units (CFU/g) of microflora such as fungi, bacteria and actinomycetes were significantly higher in rhizosphere (average CFU/g). The microbial population was 166.3 x 106 and 160.1 x 106; however, it was 191.7 x 106 in root rot, root complex and healthy, respectively. In rhizoplane, it was noted as 134.1 x 106, 126.9 x 106 and 157.1 x 106. It was noted that the microbial population was less in the rhizoplane than in the rhizosphere. The bacterial population was slightly higher than the fungal population. Actinomycetes rank third in the population. Of the total microflora population, bacteria occupied the highest population compared to fungi and actinomycetes. In the case of the rhizosphere soils, the bacteria occupied the population by 47.9%, followed by fungi at 45.6%, while 48.3 and 45.4% were recorded in rhizoplane soils, respectively. However, the actinomycetes occupied the most minor population percentages, 6.5% and 6.3% in rhizosphere and rhizoplane soils, respectively. Compared with healthy and diseased mulberry fields, a significantly higher population (CFU/g) of total microflora was recorded in healthy fields compared to diseased fields in both habitats. There was a significant difference among the population occupied by fungi, bacteria and actinomycetes in healthy and diseased fields. However, a minor population of different microflora was noticed in fields infested with root rot disease. In both the habitats of mulberry, the number population (CFU/g) of fungi, bacteria and actinomycetes was recorded to the extent of 74.3, 78.8 and 7.0 x 106 in the case of rhizosphere soils. In contrast, it

was 58.4, 61.5 and 7.0 x 106, respectively, in the case of rhizoplane soil.

Further, this microflora was categorized into three groups based on their behavior: beneficial, harmful, and saprophytic. In the case of rhizosphere soil, the 23 forms of microflora were categorized. Results about the prevalence of beneficial/harmful/saprophytic microflora in the rhizosphere and rhizoplane habitat of healthy and diseased mulberry fields are revealed in Tables 4 and 5.

On comparison of healthy and diseased fields, it was interestingly noted that the population (CFU /g) of beneficial microflora (99.2 x 106) was significantly higher than that of saprophytic (56.8 x 106) and harmful (35.7 x 106) microflora in rhizosphere habitat of healthy mulberry fields and similar trends were also observed in case of rhizoplane habitat. It was noted that microflora was beneficial (84.3 x 106), saprophytic (39.9 x 106), and harmful (32.9 x 106) in the rhizoplane habitat. However, the population of beneficial microflora in rhizosphere and rhizoplane soils was strongly affected in diseased mulberry fields. A decreased population was recorded in rhizosphere and rhizoplane soils over the control.

Similarly, the prevalence of saprophytic microflora was also affected in rhizosphere and rhizoplane habitats of diseased mulberry fields but was significantly less than that of beneficial microflora over the control. In diseased fields, the saprophytic forms 56.8 and 39.9, respectively. Among the soil-borne diseases, the saprophytic forms were reduced to the maximum number in fields infested with root disease complex.

Table 1. Microbial profile in rhizosphere habitat of healthy and diseased mulberry field.

Microflora	**Colony forming units (CFU)/g ×10^6**	
	Control	**Infested with root rot**
Fungi		
Aspergillus flavus	10.70	04.50
A.fumigans	09.90	03.70
A.niger	13.90	05.70
Botrydiplodiatheobromae	00.00	17.00
*Chaetomium*spp.	04.80	01.90
Fusariumoxysporium	00.00	04.50
F. solani	00.00	16.60
Macrophominatheobromae	00.00	06.50
Penicilliumoxalicum	00.90	02.50
Penicillium spp.	12.70	06.80
Rhizopus spp.	03.90	04.20
Trichodermaviride	04.60	00.00
T. harzianum	19.40	02.00
V. chlamydosporium	02.80	00.00
Total	83.60	75.90
Bacteria		
Agrobacterium spp.	12.70	20.20
*Azatobacter*spp.	15.80	04.50
*Azospirillum*spp	06.00	00.00
Bacillus sutilis	22.30	05.00
Pseudomonas flourescens	08.50	04.30
Pseudomonas spp.	11.10	24.00
*Xanthomonas*spp.	11.90	21.70
Total	88.30	79.70
Actinomycetes		
*Nocardia*spp.	08.20	04.80
Streptomyces spp.	11.60	05.90
Total	19.80	10.70
Grand Total	191.7	166.3

Table 2. Microbial profile in rhizoplane habitat of healthy and diseased mulberry field.

Microflora	Colony forming units (CFU)/g x 10^6	
	Control	Infested with root rot
Fungi		
Aspergillus flavus	08.30	03.60
A.fumigans	00.00	00.00
A. niger	12.70	04.80
Botrydiplodiatheobromae	00.00	13.60
*Chaetomium*spp.	05.20	03.50
Fusarium oxysporum	00.00	05.00
F. solani	00.00	13.50
Macrophominatheobromae	00.00	05.60
Penicilliumoxalicum	00.00	00.00
Penicillium spp.	09.70	04.90
Rhizopus spp.	04.00	02.50
Trichodermaviride	14.10	01.20
T. harzianum	15.90	02.60
V. chlamydosporium	00.00	00.00
Total	69.90	60.80
Bacteria		
Agrobacterium spp.	07.20	13.50
Azatobacter spp.	05.70	01.80
Azospirillumspp	04.00	00.00
Bacillus sutilis	15.80	08.70
Pseudomonas flourescens	15.90	10.00
Pseudomonas spp.	09.70	15.00
Xanthomonas spp.	16.00	15.80
Total	74.30	64.80
Actinomycetes		
Nocardia spp.	05.20	03.10
Streptomyces spp.	07.70	05.40
Total	12.90	08.50
Grand Total	157.1	134.1

Table 3. Distribution of rhizosphere and rhizoplane microflora in healthy and Diseased mulberry field.

Mulberry field	Colony forming units (CFU)/g x 10^6							
	Habitat							
	Rhizosphere				Rhizoplane			
	Fungi	Bacteria	Actino-mycetes	Total	Fungi	Bacteria	Actino-mycetes	Total
Infested with root rot	75.9 (45.6%)	79.7 (47.9%)	10.7 (6.5%)	166.3	60.8 (45.4%)	64.8 (48.3%)	8.5 (6.3%)	134.1

Infested with root disease complex	74.3 (46.4%)	78.8 (49.2%)	7.0 (4.4%)	160.1	58.4 (46.0%)	61.5 (48.5%)	7.0 (5.5%)	126.9
Control (Healthy)	83.6 (43.6%)	88.3 (46.1%)	19.8 (10.1%)	191.7	69.9 (44.5%)	74.3 (47.3%)	12.9 (8.2%)	157.1
Total	233.8 (45.1%)	246.8 (47.6%)	133.8 (25.8%)	518.1	189.1 (45.2%)	200.6 (47.9%)	28.4 (6.7%)	418.1

Figures in parentheses represent the CFU percentage out of total microflora.

Table 4. Population of beneficial, harmful and saprophytic microflora inrhizosphere habitat of healthy and diseases mulberry field.

Microflora Group	**Colony forming units (CFU) /g×10^6**	
	Control	**Infested with root rot**
Beneficial	99.2	26.5 (-73.3%)
Harmful	35.7	110.5 (+209.5%)
Saprophytic	56.8	29.3 (-48.4%)
Total	191.7	166.3 -

Figures in parentheses are the percentage of increase (+) or decrease (-) Over the control.

Table 5. Population of beneficial, harmful and saprophytic microflora in Rhizoplane habitat of healthy and diseases mulberry fields.

Microflora Group	**Colony forming units (CFU)/g× 10^6**	
	Control	**Infested with root rot**
Beneficial	84.3	32.8 (-61.1%)
Harmful	32.9	82.0 (+149.2%)
Saprophytic	39.9	29.3 (-51.6%)
Total	157.1	144.1

Figures in parentheses are the percentage of increase (+) or decrease (-) Over the control.

Discussion

Mulberry (Morus indica L.) is one of the most important commercial crops grown extensively as a food plant for silkworm Bombyx mori L. Twenty diseases caused by fungi, bacteria, viruses, mycoplasma and nematodes have been reported so far in mulberry. The diseases cause a 5 to 10% loss in leaf yield by defoliation and an additional 20 to 25% loss by deterioration in leaf quality (Sukumar and Padma, 1996). Soil-borne diseases are widely prevalent; mulberry, a perennial crop, has severe constraints due to soil-borne diseases' effects on producing quality leaves for feeding silkworms (Philip et al., 1995). Among the diseases, root rot is caused by soil-borne fungi like Fusarium oxysporum Schlecht and inadequate control measures against this disease.

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Plant Ecology

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Abstract

Plant ecology is a critical field of study that examines the interactions between plants and their environment, encompassing both biotic and abiotic factors. This introduction to plant ecology provides an overview of key concepts such as plant distribution, community structure, ecosystem dynamics, and the adaptive strategies plants use to survive and thrive in diverse habitats. The study also explores the role of plants in ecosystem services, their response to environmental changes, and the importance of conservation efforts. By understanding plant ecology, we can better appreciate the complexity of ecosystems and the essential functions plants perform within them.

Keywords: Plant ecology, plant distribution, community structure, ecosystem dynamics, adaptive strategies, ecosystem services, environmental changes, conservation, habitat diversity, biotic and abiotic interactions.

Introduction

In any habitable area many kinds of plants and animals live together and interact with or influence one another. The entire assemblage gather of living organisms forms a community. Organisms live in a surrounding which is non-living and is called the environment. The living community in any area influences the non-living environment and is itself controlled by the environment.

Definition: Ecology is defined as the "science which deals with relationship between organism and their environments". OR

The living organisms and the environment interact with and are dependent upon one another and together constitute an integrated unit called ecological system or ecosystem.

The science which deals with the study of ecosystem is called ecology, a term first coined by the German biologist Ernst Haeckel (1869).

The word ecology is derived from Oikos (Gr) meaning house or living place and logos (Gr) meaning study.

Therefore, ecology literally means study of house or environment in which organisms live.

Organisms of one kind belong to one species often live together to form a small or large assemblage called Population.

A Community is made of several populations belonging to different plant and animal species of interacting and interdependent populations.

The largest ecosystem in the entire habitable part of the earth and the entire environment. This is called the biosphere or ecosphere in which the living part plants and animals of the community interact with the non-living part the environment to maintain stable and steady system.

Any large disturbance in one component of the system affects the other component with the result that the balance between the two is upset and the stability of the whole system is affected.

Branches:

The ecological studies are often made with reference to plants or animals alone and hence a broad division as plant ecology and animal ecology are made. However, in nature plants and animals are so intimately associated that such division cannot be justified.

1. **Autecology** is concerned with the stud of individual plants or the population of individuals plant species in relation to environment.
2. **Synecology** is the study of plant communities and the relationship with the environment.
3. **Habitat ecology** the nature or type of habitat e.g. Fresh water ecology, marine ecology, forest ecology.
4. **Population ecology** the number of individuals of a species in a locality constitute population. The size of populations, their distribution, inter relation of different populations to one another etc. are included under population ecology.
5. **Conservation ecology** management of natural resources like land, water, forest etc. constitute conservation ecology.
6. **Ecosystem ecology** the interrelationship of biotic and abiotic factors, food relations and energy flow constitute the study of ecosystem ecology.
7. **Radiation ecology** with the growing use of nuclear energy and radioactive substances, the radiations spread out in the environment have become extremely dangerous and harmful to life. This branch is concerned with the study of radiations in relations to ecosystems.
8. **Palaeoecology** the study of past organisms helps us to trace evolution of various groups of plants and animals through space and time.
9. **Gene ecology** the study of genetic set up of species or populations helps us to understand the origin and inheritance of adaptations in plants and animals.
10. **Applied ecology** Applications of ecological concepts to human welfare.
11. **Systems ecology** concerns with interpreting ecological concepts and processes in terms of mathematical formula and models so that predictions can be made about future events resulting from manipulations of nature.

Scope and importance of ecology

Ecology is not confined to the premises

of biology but wanders into the domain of almost all other sciences gathering bits of information to build its own fort.

An analysis of the environmental factors requires sufficient knowledge of physics, chemistry geology and meteorology. The study of distribution of organisms over the globe, today and in the past, demands knowledge of geography's, palaeontology and paleoclimatology. The soil science pedology gives the relationships between soil and organisms. A science can be perfected only on the basis of quantified data collected and analysed in a systematic manner. So, mathematics and statistics are of great value to ecology as well. The effects of variations in some environmental components can be predicted by the application of statistical methods to ecological data. The study of man as an organism brings into the fold of ecology several other fields such as anthropology, sociology and economics. The human society is as complex as any other ecological system. The study of religious, legal and political organizations adds new dimensions to the human society. Thus, ecology is an interdisciplinary synthetic science. It is difficult to set limits to its scope. It is a fact that ecology is a biological science – concerned with the living organisms.

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Fundamentals of Genetics

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Abstract

The word genetics comes from the Greek word 'gen' meaning 'to become' or 'to grow.' It is a biological discipline that focuses on the principles of heredity and variation in plants and animals. Heredity includes traits that parents pass to their offspring, creating similarities between generations. However, offspring also show differences from their parents, known as variation, which is crucial for evolution.

The word genetics was first given by "William Bateson" in 1906. It has been derived from the Greek word gene - meaning "to become" or "to grow ". so, genetics can be defined as "the science of coming into being" or the study of heredity is called Genetics. Genetics is the science of inheritance and variation. So, genetics can be redefined as the science that deals with the structure, organization, transmission and function of genes, and the origin of variation in them.

Heredity can be defined as "characteristics passed down from one generation to the next.". It is the tendency on the part of the offspring to reproduce to the characteristics of the parents.

The resemblance between individuals related by descent can be close, but it is never complete. An offspring is never the same copy of his parents. Genetic variation in heredity is observed in sexually produced offspring but not in asexually produced clones unless a mutation occurs. It is become to variations that each individual is unique and can be readily distinguished from another.

Heredity and variation occur simultaneously and form the basis of evolution. Genetics, the branch of science that studies these concepts, tries to explain why organisms resemble their parents while also exhibiting differences.

Keywards: Genetics, Fundamentals, Terminology, Historical developments and Significance of Genetics

Introduction

Definition of Genetics:

Genetics is the scientific study of heredity and variation of inherited traits. Genetics includes the study of genes, themselves, how they function, interact, and produce the visible and measurable traits we see in individuals and

populations of species as they change from one generation to the next generation over time, and in different environments.

History of Genetics:

The history of most scientific disciplines including genetics are generally characterized by relatively long periods of stagnation punctuated by bursts of rapid progess.

Many of these waves of research are spurred by advancements in technology. Genetics is a relatively young field compared to other branches of biology, with its roots traceable to Mendel's work in the nineteenth century. However, even before Mendel's groundbreaking research, people throughout history had some rudimentary understanding of genetics and often attempted to elucidate the mechanisms behind heredity.

About six thousand years ago men kept records of pedigrees of domestic animals such as horse and food plants as rice. The concepts or hypotheses that have been proposed from time to time are often referred to as theories of blending inheritance. Proponents of these theories believed that parental traits blend or mix during transmission to the offspring. These attempts to elucidate the phenomenon of inheritance can be classified under the following categories.

1. According to the Moist Vapour Theory by Pythagoras (580-500 B.C.), organs of the body produced vapours during coitus which formed the body parts of the embryo.
2. Empedocles (504-433 B.C.) proposed the Fluid Theory, suggesting that each body part produced a fluid. The mixing of fluids from the two parents was used in the formation of the embryo. Any issues in this process could result in missing characteristics from one or both parents.
3. Aristotle (384-322 B.C.) put forth the Reproductive Blood Theory, which proposed that males produce purified reproductive blood containing nutrients from all body parts, while females produce impure reproductive blood. The coagulation of this blood in the female body forms the embryo, with the male's contribution being more significant due to the purity of their reproductive blood.
4. The Preformation Theory, put forward by Swammerdam (1679) and advocated by Malpighi (1673), suggested that the organism is already present in miniature form in the sperm or egg, known as a homunculus. Fertilization stimulates its growth. However, this theory was later discarded by Wolff, who proposed the Theory of Epigenesis.
5. Wolff's Theory of Epigenesis (1738-1794) stated that differentiation into various organs/parts occurs after fertilization, leading to the development of adult tissues and organs. This concept is widely accepted.
6. Lamarck's Theory of Acquired Characters (1744-1829) suggested that acquired characters in an individual can be passed on to their offspring. However, this concept was rejected by Weismann based on experiments on rats over 22 generations.
7. Charles Darwin's Theory of Pangenesis (1809-1882) proposed that small, invisible copies of each body organ and component

(gemmules) are transported in the bloodstream to the sex organs. These gemmules, when assembled in the gametes, lead to the development of respective organs. However, this theory was also rejected due to the lack of scientific basis.

8. The Germplasm Theory, proposed by German biologist August Weismann in 1889, states that body tissues are categorized as germplasm and somatoplasm. Germplasm refers to the reproductive tissues or cells that produce gametes, while somatoplasm includes all other body tissues not related to sexual reproduction. According to this theory, the transmission of characteristics from one generation to another occurs exclusively through germplasm, and any alterations in the germplasm will lead to changes in the subsequent generation. This theory is broadly accepted.

Objections to Blending Inheritance:

1. In unisexual organisms, the trait of sex does not blend. Such organisms are either male or female.
2. If blending inheritance were true, children of dark and fair-coloured parents would be of an intermediate colour. However, this is not the case, as the children often have different colours, including fair, dark, and intermediate shades.
3. Many individuals exhibit ancestral characteristics not present in their immediate parents. This phenomenon is known as atavism, reversion, or throwback. For example, some babies may have a short tail, and some people can move their external ears.
4. Several traits appearing in children are not found in their immediate parents but are similar to those of their grandparents, indicating that characteristics may remain hidden in one generation and appear in the next.
5. In 1760, German botanist Kolreuter obtained fertile interspecific hybrids in tobacco, and the hybrids did not resemble either parent. After self-pollination, some offspring resembled the hybrids, while others resembled one grandparent or the other in different traits. This demonstrated that traits have a particulate nature and remain discrete.
6. John Goss, in 1822, crossed yellow and green-seeded pea varieties. The resulting hybrids were all yellow-seeded. Upon self-pollination, three types of offspring were produced: yellow-seeded, green-seeded, and with both yellow and green seeds.
7. In 1862, Naudin concluded that through repeated crossings of hybrids, the parental types appear in the offspring, showing that hybrids contain traits from both parents, even if these traits may not be externally visible.

Historical developments in genetic

The science of genetics founded by Mendel reached the present status by the contribution of many scientists which are tabulated as follows.

1590. Z. Janssen and H. Janssen Produced the first operational microscope.

1665. R. Hooke Introduced the term "cell" and described cork cells.

1668 F. Redi disproved the theory of spontaneous generation by demonstrating that maggots do not spontaneously arise from decaying meat.

1672 Malphigi Classified the tissues.

1674 A. van Leeuwenhoek Improved the lens system of the microscope by grinding.

1682 N. Crew Described bladders and pores in wood and pith.

1694 J.R. Camerarius conducted pioneering experiments on pollination and reported the existence of sexual reproduction in plants.

1700 R. Linnaeus Classified the biological organisms.

1761 J.C. Kolreuter Hybridized various species of tobacco and concluded that they contributed equally to the characteristics of the progeny.

1779 C. F Wolff Founder of embryology.

1809 J.B. Lamarck Coined the word "biology" and stressed the importance of cells in living organisms. He proposed the theory of the inheritance of acquired characteristics.

1837 R. Brown Discovered the nucleus in cells of flowering plants.

1838 M.J. Schleiden and T. Schwann Formulated the cell theory in plants and animals.

1840 Purkinj Gave the term "protoplasm".

1824 Dutrochet Showed that all plants and animals are composed of cells.

1825 F.V. Raspail Developed the frozen-section technique and used iodine for the detection of starch.

1835 Hugo von Mohle emphasized the importance of protoplasm and described the process of cell division.

1845 A. Donne Used photomicroscopy for the first time.

1846 K. Nageli Showed that plant cells arise from the division of preexisting cells.

1846 G.B. Amici Showed that an egg in the ovary is stimulated to develop into an embryo by the entrance of a pollen tube.

1858 Rudolf Virchow demonstrated that animal cells originate from the division of preexisting cells.

1859 C. Darwin proposed the theory of natural selection.

1862, Kolliker used the term "cytoplasm" to refer to the living material surrounding the nucleus.

1865 G. Mendel Developed the fundamental principles of heredity.

1869 Friedrich Miescher identified DNA

1870 W. His Invented the microtome.

1871 F. Meischer Isolated nucleic acids from pus cells.

1873 H. Fol Described spindle and astral rays.

1875 O. Hertwig Studied reproduction in sea urchins and concluded that fertilization involves the union of sperm and egg nuclei.

1875 Eduard Adolf Strasburger discovered cell division in plants and introduced the terms "cytoplasm" and "nucleoplasm."

(1843-1905) Walther Flemming coined the term "chromatin" in 1878 to describe the thread-like structure found in the nucleus of a cell:

1879 H. Fol Showed that only one sperm enters the egg during fertilization.

1881 E.G. Balbiani Discovered giant chromosomes in the salivary glands of Drosophila.

1882 W. Flemming Coined the term “mitosis”.

1883 W. Rouse proposed that chromosomes contain genes, which are the fundamental units of heredity.

1885 A.F.W. Schimper introduced the term "plastids."

1888 Th. Boveri C coined the term “centrosomes”.

1888 W. Waldeyer Coined the term “chromosomes”.

1892 O. Hertwig Proposed the protoplasm theory of inheritance.

1892, J. Ruckert observed lampbrush chromosomes (LBCs) in shark egg cells.

1892 W. Weisman stated that chromosomes are the most crucial components of the nucleus.

1892 Th. Boveri Described meiosis in Ascaris.

1898 Camillo Golgi first described the Golgi apparatus in nerve cells.

1898 The name mitochondrion was introduced by Benda.

1899 S. Altman Introduced the term “nucleic acid”.

1900 C.E. Correns, H. de Vries and E. Tschermak Rediscovered Mendel’s laws of inheritance.

1901 The term plasmodesmata was first used by Strasburger.

1901 Hugo de Vries first used the term Mutation means sudden change.

1902 C.E. McClung Identified sex chromosomes in bugs.

1902 H. de Vries Coined the term “mutation”.

1902 Walter Sutton and Theodor Boveri give the theory posits that chromosomes serve as the physical carriers of heredity, containing genetic material in the form of genes.

1903 W. Waldeyer demonstrated that centromeres are the chromosomal regions that spindle fibers attach to during mitosis.

1905 L. Cuenot Discovered lethal genes affecting coat colour in mice

1906 Bateson coined the term “genetics”

1909 Johannsen coined the term “gene”.Archibald Garrod published the book “Inborn Errors of metabolism”

1910 T.H. Morgan studied linkage and crossing over in Drosophila, coining the term "crossing over," for which he was awarded the Nobel Prize in 1933.

1911 Sturtevant constructed the first linkage map in Drosophila.1917 -1923 Bridges gave genic balance theory and non-disjunction theory. He described the different chromosomal abnormalities and aberrations.

1925 Bernestein proposed multiple allelic inheritance of ABO blood group

1928 H.J. Muller reported the use of the CIB technique to demonstrate that X-rays are mutagenic, an achievement for which he was awarded the Nobel Prize in 1946.

1928 Griffith discovered transformation in Diplococcus pneumoniae.

1930 R.A. Fisher, J.B.S. Haldane and Sewell Wright laid the foundation for population genetics.

1941 Beadle and Tatum proposed the "one gene-one enzyme" hypothesis in their studies on Neurospora, for which they were awarded the Nobel Prize in 1958.

1944 Avery, MacLeod and McCarty demonstrated the transforming principle as DNA, the genetic material

1950 Chargaff demonstrated that in DNA, the amount of adenine is equal to the amount of thymine, the amount of guanine is equal to the amount of

cytosine, and the content of purines is equal to the content of pyrimidines.

1952 Hershey (Nobel prize, 1969) and Chase revealed DNA as the genetic material of bacteriophage.

1953 Watson and Crick proposed DNA double helix model and won the Nobel Prize; their model of DNA

1955 Benzer described fine structure of the phage T4rII locus

1956 Tjio and Levan resolved the normal diploid chromosome number of humans as 46

1957 Frankel Conrat and Singer established RNA as the genetic material of tobacco mosaic virus

1958 Meselson and Stahl identified semi-conservative replication of DNA

1961 Nirenberg and Mathaei cracked the genetic code present on mRNA Jacob and Monod proposed the "Operon model" for gene regulation (Nobel prize, 1978)

1965 Harris Watkins produced hybrid cell fusing somatic cells of mouse and man.

1970 Nathan and Smith isolated first restriction endonucleases (Nobel prize, 1968).

1972 Berg produces first recombinant in vitro (Nobel prize, 1980).

1977 Maxim, Gilbert and Singer published DNA sequencing techniques (Nobel prize, 1980)

1981 The first transgenic mammals were made.

1983 Kary Mullis and others developed the polymerase chain reaction (PCR) for quick amplification of DNA. Nobel prize for Barbera McClintock for her jumping genes concept.

1986 Nirenberg and Har Gobind Khorana deciphered the entire genetic code.

1990 Gene therapy is used to treat human genetic diseases in the USA.

1995 DNA of the bacterium Haemophilus influenzae was fully sequenced.

1997 Ian Wilmut cloned a sheep "Dolly"

1998 Rough draft of human genome map showing more than 30,000 genes was released. Development of Terminator gene technology by Delta and Pine Co and Bollguard cotton by Monsanto

2001 Craig Venter and Francis Collins announced the first complete draft of human genome.

2003 The Human Genome Project was successfully completed.

Branches of genetics

Modern genetics is traditionally classified into three branches transmission genetics, molecular genetics and population genetics.

1. Transmission genetics:

Transmission genetics deals with the study of the passage of characters from one generation to the next. It is studied mainly through breeding experiments in individual organisms. It also encompasses the basic principles of genetics such as the relationship between chromosomes and heredity, the arrangement of genes on chromosomes, and gene mapping. It has important practical applications in the development of new varieties in plants and animals. Since Mendel pioneered this approach to genetics, it is often referred to as Mendelian genetics or classical genetics.

2. Molecular genetics:

Molecular genetics involves the study of the chemical nature of the gene, its structure, organization, and function at molecular level. It includes the cellular

processes of replication, transcription, and translation and also gene regulation which is the processes of control of expression of the genetic information. The developments in molecular genetics have led to breakthroughs in cloning and genetic engineering.

3. Population genetics:

Population genetics is the study of the variation of genes between and within populations of a species and its changes over time and space. It is important in evolutionary studies, as evolution is just the change in the genetic makeup of population over time. However, these fields may overlap each other and each organism for example Drosophila or maize may be studied at the level of transmission, molecular and population genetics.

4. Classic Genetics:

Classic genetics, as its name implies, represents the earliest branch of genetic science, heavily grounded in Mendel's principles of inheritance and independent assortment. It primarily utilizes Mendelian inheritance patterns, which assert that genes are passed from parents to their offspring. The core concepts of classical genetics were applied in research and experimentation with various plant species. In essence, Mendel's laws form the fundamental basis of classic genetics.

5. Cytogenetics:

Cytogenetics is a traditional, well-established, and thoroughly studied branch of genetics. This interdisciplinary field primarily focuses on the study of chromosomes through various techniques. Its main objectives are to examine the structure and number of chromosomes and to identify any abnormalities.

6. Microbial Genetics:

Microbial genetics is an interdisciplinary field that explores the genetics of microorganisms such as bacteria, viruses, fungi, protozoa, and archaea. In other words, it represents a highly advanced branch of microbiology.

7. Human Genetics:

Genetics and genetic tools are increasingly utilized in human genetic research. This field involves examining human DNA, genes, chromosomes, and the alterations within the genome. Inherited disorders such as thalassemia, sickle cell anemia, and Huntington's disease are now detected using genetic techniques. These studies focus on understanding inheritance patterns, disease severity, and the likelihood of passing conditions to future generations.

8. Clinical Genetics:

In simpler terms, clinical genetics focuses on patient care, making it somewhat similar to human and medical genetics, but with some technical differences. It is primarily used in the diagnostic field, where clinicians conduct tests to identify gene mutations, genomic changes, cancer-related loci, chromosomal alterations, inheritance patterns, and genetic diseases that can lead to significant health issues.

9. Medical Genetics:

The field of medical genetics is closely related to clinical genetics, but there are some distinctions. While clinical genetics primarily focuses on disease and its diagnosis, medical genetics goes further by identifying the causes of diseases and working on their management. Additionally, medical genetics encompasses the study of infectious pathogens, their transmission, and their role in disease development.

For instance, pathogens responsible for malaria and tuberculosis are now analyzed using techniques such as RT-PCR.

10. Epigenetics:

Epigenetics focuses on gene expression rather than gene alteration. This interdisciplinary field combines genetics with the study of gene expression across various tissues and organisms.

11. Plant Genetics:

Genetic technologies play a crucial role in plant research, with many landmark studies in genetics having focused on plants. The molecular and cytogenetic methods used in plant research often yield unique and valuable results. Scientists develop a range of genetically modified organisms (GMOs) for various purposes, including:

Creating economically valuable plants

Enhancing existing important traits

Boosting the nutritional content of plants

Protecting plants from pathogens and environmental stresses

Advancing plant evolutionary studies

12. Evolutionary Genetics:

Genetic alteration is one of the evolutionary forces which is separately studied in evolutionary genetics. Genetic changes at the DNA, gene or chromosome level leads to changes in the genomic composition of organisms, timely.

Such changes produce new traits which are helpful for organisms to survive. Evolutionary geneticists study those forces and how they occurred over a course of time. It also allows them to draw an evolutionary relationship between organisms.

13. Quantitative genetics:

Quantitative genetics focuses on traits that can be measured on a continuous scale, such as height and weight, and examines the underlying mechanisms. It extends the principles of Mendelian inheritance by considering how the combined effects of multiple genes and environmental factors produce a range of phenotypic outcomes.

14. Biochemical genetics:

Biochemical genetics the study of the fundamental relationships between genes, protein, and metabolism. This involves examining the causes of various specific hereditary diseases.

15. Behavioural genetics:

Behavioural genetics is the study of how genetics influences behaviour in animals, including humans.

16. Developmental genetics:

Developmental genetics is the study of the process by which organisms grow and develop

17. Conservation genetics:

Conservation genetics is a field that integrates various disciplines and employs genetic methods to aid in the conservation and restoration of biodiversity.

18. Ecological genetics:

Ecological genetics is the study of genetics in natural populations.

Terminology:

1. **Alleles or Allelomorphs:** A pair of contrasting characters or related factors controlling a single trait. Exa. – Height – Tall (T) and Dwarf (t), Colour – Red (R) and White (r).and sperm cells of animals and in the egg and pollen cells of plants. Human beings have 23

2. Autosomal: refers to genes located on chromosomes that are not sex chromosomes. Autosomal chromosomes do not include the XX or XY sex chromosomes.

3. Carrier: a person who has a defective gene and a dominant normal gene and therefore, is chromosomes in their reproductive cells.

4. Centromeres: A specialized, constricted region of a chromatid that contains the kinetochore; during cell division, sister chromatids are joined at the centromere.

5. Chromatids: one of the two halves of a duplicated chromosome.

6. Chromatin: the complex of DNA, RNA and proteins that makes up uncondensed eukaryotic chromosomes.

7. Chromosome: structures within the nucleus of eukaryotic cells composed of chromatin and visible at cell division (condensed chromatin).

8. Clones: A group of cells derived from a single ancestor.

9. Crossover: the breaking and rejoining of homologous (non-sister) chromatids during early prophase I of meiosis, resulting in recombination

10. Diploid: the condition of having two sets of chromosomes per cell (2n)

11. Dominant: The character or allele that expressed in F-1 generation is called as Dominant.

12. Dominant: an allele that overpowers another is dominant.

13. F-1generation or first filial generation: It is the first generation of hybrid individuals obtained by crossing parents with contrasting characters.

14. F-2 generation or second filial generation: It is the generation resulting by selfing or self-crossing of F-1 hybrids.

15. Factor or Determiner: It is a functional unit of heredity present in the gametes (gene) which determines the character of the organism.

16. Gametes: Haploid sex cells formed by segregation of the organisms.

17. Gene: Every trait is controlled by a gene. A human has 20,000 genes. Genes are controlled by 2

18. Genome: All the genetic material in the chromosomes of a particular organism; size generally given as its total number of base pairs.

19. Genotype: Genetic or internal constitution of an organism. Exa. – TT (Pure tall), Tt (Hybrid tall), tt (Pure white).

20. Genotype: All the genes of a beastie equal the genotype of the beastie. (Genes an organism possesses)

21. Haploid: A single set of chromosomes (half the full set of genetic material), present in the egg

22. Haemophilia: sex-linked recessive. Males get it most often.

23. Heterozygosity: Heterozygosity refers to the presence of different alleles at one or more loci on homologous chromosomes.

24. Heterozygous: An organism with dissimilar determiners or genes. Exa. – Tt, Rr.

25. Heterozygous: alleles of a gene are "different"

26. Homologous chromosomes: A pair of chromosomes containing the same linear gene sequences, each derived from one parent

27. Homozygous: An organism with identical (similar) determiners or genes. Exa. - TT, rr.

28. Homozygous: alleles of a gene are "the same"normal. (Nn)

29. Hybrid: A heterozygous individual formed by the parents having contrasting characters. Exa. - Tt – Hybrid Tall, Rr - Hybrid Red.

30. Inbreeding: It is crossing between closely related individuals.

31. Offsprings: These are individuals produced by the parents.

32. Parents: A diploid individual formed by the fusion of two gametes. Exa – TT, Tt, tt.

33. Phenotype: External appearance of an individual. Ex.- Tall, Dwarf, Red, White.

34. Pure breed: A homozygous individual formed by the parents and with identical characters and breed true to the species at least three consecutive generation. Ex. – TT- Pure Tall, RR- Pure Red, tt- Pure Dwarf, rr- Pure White.

35. Recessive: The character or allele that suppressed in F-1 generation is called as Recessive. Exa. – tt, rr

36. Recombination: exchange of genetic material between chromosomes

37. Zygote: diploid (2n) cell resulting from the union of two gametes in sexual reproduction.

Scope and Importance of Genetics

Genetics, the study of heredity and variation in living organisms, is a cornerstone of modern biology and medicine. It encompasses the understanding of how traits are passed from parents to offspring and the molecular mechanisms that underlie these processes. The scope of genetics is vast, influencing various fields including agriculture, medicine, biotechnology, and anthropology.

In agriculture, genetics plays a crucial role in crop improvement and livestock breeding. Through genetic engineering, scientists can create genetically modified organisms (GMOs) that are resistant to pests, diseases, and environmental conditions, leading to higher yields and food security. Additionally, understanding the genetic makeup of plants and animals helps in the conservation of endangered species by enabling the development of strategies to maintain genetic diversity.

In medicine, genetics has revolutionized our approach to disease diagnosis, treatment, and prevention. Genetic research has led to the identification of genes responsible for various hereditary diseases, enabling early diagnosis and personalized medicine. For instance, knowledge of the BRCA1 and BRCA2 genes allows for early detection and preventive measures in individuals at high risk for breast and ovarian cancers. Moreover, advancements in gene therapy hold promise for treating genetic disorders by correcting defective genes.

Biotechnology, another field profoundly impacted by genetics, has seen significant advancements due to genetic research. Techniques such as CRISPR-Cas9 allow for precise editing of the genome, opening new possibilities in developing therapies for genetic diseases, improving crop traits, and even in synthetic biology, where new biological parts and systems are designed.

Anthropology also benefits from genetics by providing insights into human evolution and migration patterns. Genetic analysis of ancient DNA helps in reconstructing the history of human populations, understanding their interactions, and uncovering the genetic basis of adaptations to different environments.

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Formulation And Evaluation of Herbal Crack Healing Cream: A Research

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Abstract

Skin diseases are numerous and a frequently occurring health problem affecting all ages from the neonates to the elderly and cause harm in number of ways. If the cracks in the heels are deep, they can be painful, hurting when a person stands up, and they may sometimes bleed. Some wild plants and their parts are frequently used to treat these diseases.

An anti-cracked heels cream formulation consisting of extraction of *Aloe barbadensis*, *Mimusops elengi linn*.

Microbiological studies were performed for safety of materials used in the formulation. It can be concluded that herbal creams without side effects having antibacterial, anesthetic, anti-inflammatory property can be used as the provision of a barrier to protect the skin.

Keywords: *Mimusops elengi*, bakul, anesthetic, anti-inflammatory

Introduction

The skin is the largest organ of the body, with a total area of about 20 square feet. Skin has three layers: The epidermis, the outermost layer of skin, provides a waterproof barrier and creates our skin tone. The cosmetics are the utility product used extensively throughout the world for maintaining and improving general appearance of face and other part of body e.g. skin, eye, hair, hand, etc. herbal cosmetics are the preparation which represent cosmetics associated with active bio- ingredients, nutraceuticals and pharmaceuticals. Cosmetics are products that are used to cleanse and beautify the skin. The first recorded use of cosmetics is attributed to Egyptians in 4000 B.C. Pharmaceuticals are essentially drug products and are defined as products that prevent, mitigate, treat or cure disease and affect the structure or function of the body. The skin underneath your feet is often dry, rough and chapped. Disorders - Athlete's foot, psoriasis, eczema, thyroid disease, diabetes and some other skin conditions can be the cause of cracked heels. Maintaining healthy skin is important for a healthy body. Natural treatment is

cheap and claimed to be safe. A review of some plants for the treatment of skin diseases is provided that summarizes the recent technical advancements that have taken place in this area during the past 17 years. It is also suitable raw material for production of new synthetic agents. The literature in ayurveda, especially charksamhita stated numerous medicinal plants in varnyakashaya. The herb like chandun, haldi, khas, nagkheshara, manjistha, yastimadhu are used to obtained glowing complexion and
arusa, amla, bavchi, guduchi, chakmard are mentioned as kustaharan. Herbs like amalaki, haridra, khadira, vidyanga, jati saptaparna, karavira of various potential from khshthagna and mahakashiya are mentioned effective in skin disorder. Herbs used in cosmetics preparation have varieties of properties like Antioxidant, Anti-inflammatory, Antiseptics and Antibacterial etc.

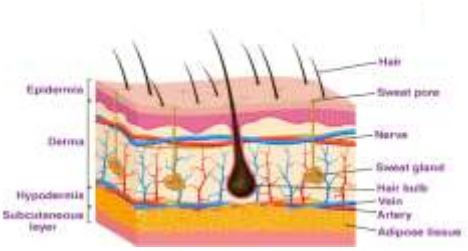


Fig no.1.skin structure

Herbal Cream:

Definition: Creams are semisolid emulsion system with opaque appearance as contrasted with translucent ointments. Cream is used for external purpose. Creams are intended for application to the skin and mucous membrane. Their consistence depends on whether the Emulsion is water in oil or oil in water

1. Nature of solids in internal phase.

Skin care creams can be classified on different basis:

- According to function: E.g. cleansing, foundation, massage etc.
- According to characteristic properties: - e.g. cold creams vanishing creams etc.
- According to nature or type of emulsion

Skin nourishment is important and required to preserve the normal characters of the skin or as a treatment for dry skin.

Herbal Cream: The herbal cream is basically water in oil type of emulsion. The natural ingredients chosen for preparation of herbal cream are turmeric, papaya, aloe-vera, tulsi, and neem. The choice of these ingredients is based on their individual properties.

In general, herbal creams are used to shield the skin from various obstacles & provide calming effect (Mohiuddin, 2019). Additionally, herbal creams are frequently utilized for various cosmetic applications such as skin cleaning, beautification, and nourishment.

Fig no.2.Herbal Cream

What are Cracks:

Heel Cracks associated with hyperkeratotic and anhidrotic skin are a common problem faced by many health

professionals. Moreover, such lesions can act as a portal of entry for secondary infection and further complications. Challenges include creating optimal conditions for achieving wound healing in conjunction with reducing detrimental impact forces, removal of hyperkeratosis (callus) and ultimately deterrence of further episodes by hydrating anhidrotic tissue. Thus, the successful treatment and prevention of dry heel fissures is dependent on addressing these multiple factors.

Heel fissures are splits or cracks in the epidermis, which can manifest as a consequence of anhidrosis and may or may not present with hyperkeratosis. Epidermal fissures are superficial and not considered to be a wound at this early stage. However, with increased pressure these splits become deeper, involving the dermis so that they begin to bleed and result in pain on weight-bearing activities. These fissures are regarded as partial-thickness skin wounds and are at increased risk of developing infection. Full-thickness ulcer formation can occur if the fissure progresses further, resulting in an open wound that has the potential to lead to deeper infection and cellulitis, especially in patients with diabetes and peripheral vascular disease.

Fissure formation often develops at sites where the epidermis is under direct physical stress, such as the heel margin. The heel pad plays an important role as a shock absorber by reducing and transmitting impact forces. This transmission of load was investigated by Ahanchian et all who produced a finite model that also demonstrated propagation of tissue stress with increased contact load. These areas of high tissue stress are often associated with fissures, despite the apparent lack of direct pressure, particularly when combined with anhidrosis. Furthermore, the authors noted that impact forces increase tensile deformation of soft tissue and can create short-term vascular changes in the heel pad.

Management Manipulation of detrimental impact forces, as described earlier, with orthoses or heel cups, plays an important role in both short- and long-term treatment,

in addition to prevention of dry heel fissures by deflecting pressure3. However, successful management also requires removal of any localised cause of hyperkeratosis, if possible. Topical, or in some instances oral, treatment of bacterial, fungal and viral infections, with appropriate medication can eliminate or reduce the underlying cause.

Heels can crack when the skin around the rim of your heel becomes dry and thick, and increased pressure on the fat pad under the heel causes the skin to split. A number of factors can raise the risk of developing cracked heels, including obesity, wearing open-heel footwear such as sandals, and having cold, dry skin.

Cracks in the feet, often called heel fissures, can be caused by various factors including dry skin, standing for long periods, wearing open-back shoes, or certain medical conditions like diabetes. Regular moisturizing, wearing supportive shoes, and using a pumice stone to gently exfoliate can help prevent and treat them. Severe cases may require medical attention.in such cases crack healing creams can be used.

The Crack Heels treated by using various herbal creams, herbal products.

The ingredients used in formulation of crack heeling cream.

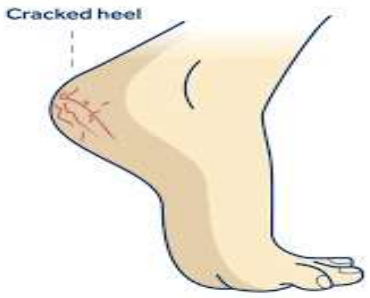


Fig.no.3. Crack heel

The Bases & Ingredients use in Crack Heel Cream are *Aloe barbadensis*, Polysorbate60, White soft paraffin, Cetosteryl alcohol, Glycerin, Methyl paraben, Propyl paraben, Purified water.

Aloe barbadense:

Antibacterial properties:

Many researchers mentioned that Aloe vera inhibits the growth of some microorganisms like Str. pyogenes, Shigella flexneri, Klebsiella sp., especially against Gram-positive bacteria causing food poisoning or diseases in humans and animals,

Antifungal activity:

Antifungal activity has received less attention, although inhibitory activity against Candida has been reported.

Aloe vera has healing and hydrating properties, and works as an ideal choice for dry skin. Mixing it with glycerine acts as an excellent moisturizer for dry and cracked skin on your feet.

White soft paraffin: Paraffin is mainly used in topical pharmaceutical formulations as a component of creams and ointments. In ointments, it may be used to increase the melting point of a formulation or to add stiffness. Paraffin is additionally used as a coating agent for capsules and tablets, and is used in some food applications. Paraffin coatings can also be used to affect the release of drug from ion-exchange resin beads. Paraffin is an odorless and tasteless, translucent, colorless, or white solid. It feels slightly greasy to the touch and may show a brittle fracture. Microscopically, it is a mixture of bundles of micro crystals. Paraffin burns with a luminous, sooty flame. When melted, paraffin essentially without fluorescence in daylight; a slight odor may be apparent.

Cetosteryl alcohol: Cetostearyl alcohol is used in cosmetics and topical pharmaceutical preparations. In topical pharmaceutical formulations, cetosteary alcohol will increase the viscosity and act as an emulsifier in both water- in-oil and oil-in-water emulsions. Cetostearyl alcohol will stabilize an emulsion and also act as a co-emulsifier, thus decreasing the total amount of surfactant required to form a stable emulsion. Cetostearyl alcohol is also used in the preparation of non-aqueous creams and sticks, and in nonlathering shaving creams. Research articles have been published in which cetostearyl alcohol has been used to control or slow the dissolution rate of tablets or microspheres containing water-soluble drugs, or poorly water-soluble drugs, as well as to stabilize amorphous systems. In combination with other surfactants, cetostearyl alcohol forms emulsions with very complex microstructures. These microstructures can include liquid crystals, lamellar structures, and gelphases. Cetostearyl alcohol occurs as white or cream- colored unctuous

masses, flakes, pellets or granules. It has a faint, characteristic sweet odor. On heating, cetostearyl alcohol melts to a clear, colorless or pale yellow-coloured liquid free of suspended matter.

Glycerin: Glycerin is used in a wide variety of pharmaceutical formulations including oral, otic, ophthalmic, topical, and parenteral preparations. In topical pharmaceutical formulations and cosmetics, glycerine is used primarily for its humectant and emollient properties. Glycerinis used as a solvent or co solvent in creams and emulsions. Glycerin is additionally used in aqueous and non-aqueous gels and also as an additive in patch applications. In parenteral formulations, glycerine is used mainly as a solvent and co solvent. In oral solutions, glycerine is used as a solvent, sweetening agent, antimicrobial preservative, and viscosity- increasing agent. It is also used as a plasticizer and in film coatings. Glycerin is used as a plasticizer of gelatine in the production of soft-gelatine capsules and gelatine suppositories. Glycerin is employed as a therapeutic agent in a variety of clinical applications, and is also used as a food additive.

Methyl paraben: Methylparaben is widely used as an antimicrobial preservative in cosmetics, food products, and pharmaceutical formulations. It may be used either alone or in combination with other parabens or with other antimicrobial agents. In cosmetics, methyl paraben is the most frequently used antimicrobial preservative. The parabens are effective over a wide pH range and have a broad spectrum of antimicrobial activity, although they are most effective against yeasts and molds. Antimicrobial activity increases as the chain length of the alkyl moiety is increased, but aqueous solubility decreases; therefore, a mixture of parabens is frequently used to provide effective preservation. Preservative efficacy is also improved by the addition of propylene glycol or by using parabens in combination with other antimicrobial agents such as Imidurea Owing to the poor solubility of the parabens, paraben salts (particularly the sodium salt) are more frequently used in formulations. However, this raises the pH of poorly buffered formulations. Methylparaben (0.18%) together with propylparaben (0.02%) has been used for the preservation of various parenteral pharmaceutical formulations. Methyl paraben occurs as colorless crystals or a white crystalline powder. It is odorless or almost odorless and has a slight burning taste.

Propyl paraben: Propylparaben is widely used as an antimicrobial preservative in cosmetics, food products, and pharmaceutical formulations. It may be used alone, in combination with other paraben esters or with other antimicrobial agents. It is one of the most frequently used preservatives in cosmetics. The parabens are effective over a wide pH range and have a broad spectrum of antimicrobial activity, although they are most effective against yeasts and Molds Owing to the poor solubility of the parabens, the paraben salts, particularly the sodium salt, are frequently used in formulations. This may cause the pH of poorly buffered formulations to become more alkaline. Propylparaben (0.02% w/v) together with methylparaben (0.18% w/v) has

been used for the preservation of various parenteral pharmaceutical formulations.

Water: Water is widely used as a raw material, ingredient and solvent in the processing, formulation and manufacture of pharmaceutical products, active pharmaceutical ingredients (API) and intermediates, and analytical reagents. Specific grades of water are used for particular applications in concentrations up to 100%.

The term 'water' is used to describe potable water that is freshly drawn direct from the public supply and is suitable for drinking. Water used in the pharmaceutical industry and related disciplines is classified as either drinking (potable) water, purified water, sterile purified water, water for injection (WFI), sterile water for injection, bacteriostatic water for injection, sterile water for irrigation, or sterile water for inhalation. Validation is required for all systems producing the water indicated, with the exception of potable water. The chemical composition of potable water is variable, and the nature and concentrations of the impurities in it depend upon the source from which it is drawn. Water classified as potable water for applications such as some initial rinsing and API manufacturing operations, must meet the US Environmental Protection Agency's National Primary Drinking Water Regulations, or comparable regulations of the EU or Japan. For most pharmaceutical applications, potable water is purified by distillation, ion exchange treatment, reverse osmosis (RO), or some other suitable process to produce 'purified water'. For certain applications, water with pharmacopeial specifications differing from those of purified water should be used, Water is a clear, colorless, odorless, and tasteless liquid.

Objective

1. Formulation Development- Identify suitable ingredients known for their skin healing properties, such as moisturizers, emollients, and natural extracts
2. Optimization of Formulation- Fine-tune the formulation based on feedback from efficacy and safety evaluations. Adjust ingredient ratios and processing methods to enhance the cream's performance
3. Documentation and Regulatory Compliance- Document the formulation process, test results, and any modifications made. Ensure compliance with regulatory requirements for skincare products.

By achieving these objectives, the aim is to develop a crack healing cream that effectively promotes skin repair, meets regulatory standards, and satisfies the needs and expectations of users.

Materials And Method

A. Drug Profile:

Medicinal plants are the richest bio-resource of drugs of traditional systems of medicine, modern medicines, nutraceuticals, food supplements, folk medicines, pharmaceutical intermediates and chemical entities for the synthetic drugs. In recent years, there has been a surge of interest in herbal remedies for a number of ailments. Use of herbal drugs has been an inseparable part of human civilization as many food materials like ginger, garlic, turmeric etc. have long been used as medicines. The world health organization (WHO) estimates that about 80% of the population is still

depends upon these herbal medicines for their treatment of diseases due to easy availability, economic and less side effects when compared to allopathic system of medicines. Plants have been used in a number of systems of medicines in our country as well as in other countries. India is well known as the 'Emporium of Medicinal Plants'. The use of plants to treat various diseases in India dates back to the times of Rig-Veda (3500 to 1800 B.C.). Later, the monumental Ayurvedic works like Charksamhita and Sushrut Samhita followed by other Ayurveda and Siddha treatises have incorporated nearly 700 plant derived drugs entering into several medicinal preparations used in the health care system. 1 The main aim of this review is to give recent information along with the traditional uses of Mimusops elengi that might be an important plant due to its invaluable pharmacological properties by which students and researchers will get the overall information about its published phytochemical and pharmacological properties for their further research.

Fig.no.4. Bakul plant

1. **Morphology:** Mimusops elengi, commonly called Bakul, is a medicinal plant belonging to the family Sapotaceae. It is a small to large glabrous evergreen tree with a compact leafy head and short erect trunk, bark smooth, scaly and gray. Leaves are 6-10cm long and 3-6cm broad pointed with serpentile ends, glabrous, base acute or rounded, petioles 1.3-2.5cm long. Flowers are white in colour with a sweet fragrance, nearly 2.5cm across solitary and bud's ovoid, acute; pedicels 6.20 mm long. Calyx 1cm long, stamens 8, opposite to the inner circle of lobes. Ovary appressedly silky-pubescent. The fruit is a berry, containing usually one, rarely two seeds about 1.7-1.9cm in length and 1.2-1.5cm in breadth. It is compressed, obliquely ovoid and yellow when ripe. The seeds are light brown to blackish in colour. All parts of the tree have medicinal properties.

The different parts of the plant are given: Vernacular names Taxonomy and nomenclature (common names) is as following
Kingdom: Plantae
Order: Ericales
Family: Sapotaceae
Genus: *Mimusops*,
Species: *Mimusops elengi Linn*. (Bakul)
Binomial name: *Mimusops elengi* (L).

2. Botanical Description:
The plant is also known as varieties of name as mention bellow: Sanskrit:Anangaka, Bakula, Chirapushpa, Dhanvi, Gudhpushpa, Kantha, Karuka, Kesha, Mukula, Padyamoda, Sharadika, Sindhugandha, Simhakeshaa, Sthirmukhgandha, Surabhi, T ailanga, Varalahdha, Visharada Gujarati: Babhuli, Bolsari, Varsoli, Vovoli Hindi: Bakul, Bolsari, Maulsarau, Maulser, Ma ulsari Marathi: Bakhor, Bakula, Barsoli, Ovalli, Owli, Vavoli, Wovali, Wowli Malayalam: Bakulam, Elengi, Ilanni, Iranni, Makuram Tamil: Alagu, Ilangi,

Kesaram, Kosaram, Magil, Magilam, Vagulam Punjabi: Maulsari, Maulsiri Bengali: Bakal, Bakul, Bohl, Bukal English: Bullet wood

3. General Properties of the plant and their traditional uses:

The bark is acrid and sweet; cooling, cardiotonic, alexipharmic, stomachic, anthelmintic, astringent; cures biliousness and diseases of the gum and teeth. The flowers are sweet, acrid, oleagenous; cooling, astringent to the bowels; good for the teeth, causes flatulence. They are used as expectorant; cures biliousness, liver complaints, diseases of the nose, headache and their smoke are good in asthma. The seeds fix loose teeth; as an errhine cures nasal congestion and headache. The root is sweet and sour; aphrodisiac, diuretic, cardiotonic, stomachic, astringent to the bowels; good for gonorrhoea; as a gargle, strengthens the gums.

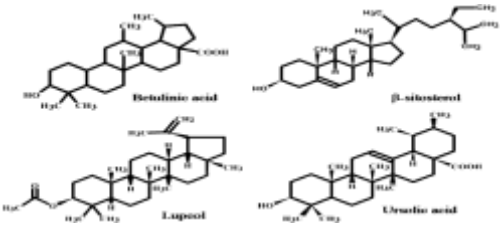
The fruits are sweet and sour, aphrodisiac, diuretic, astringent to the bowels, good in gonorrhoea. The pulp of the ripe fruit is sweetish and astringent and has been successfully used in curing chronic dysentery. The leaves are traditionally used in fever, postural eruptions of skin, ulcer, headache, dental diseases, bacterial diseases wound along with antioxidant, cytotoxic, analgesic and antipyretic activities. Chemical constituents the important constituents of the bark are alkaloids, starch, tannin and sapponins. Among this taraxerol, taraxerone, ursolic acid, betulinic acid, V-spinosterol, W-sitosterol, lupeol,10,11,12 isoretronecyl tiglate,13 tau- muurolol, alpha-cadinol, penta-decanoic acid, di-isobutyl phthalate, hexa-decanoic acid, eicosane, oleic acid, octadecadienoic acid are major one.6 The bark contains the amino acids such as Tryptophan, Lysine, Methionine, Proline, Glysine and Alanine.

The volatile oil constituents of the bark are Linalol, Copaene, Isosafrol, β-caryophyllin, Safrol, cadinene, Phenol, 2,5-bis(1-methylethyl) -(Thymol), γ-cadinene.15 The lipid concentration of the bark was ranging from 13.5 to 16.8 mg/gm. In summer (16.8 mg/gm) showed highest content over other season i.e. monsoon (13.5mg/gm) and winter (14.7 mg/gm). Dibutyl phthalate is the important secondary metabolite present in the bark of Mimusops elengi. The flower of Mimusops elengi contains volatile oil, querictol, teraxerol and lupeol. The most abundant volatile constituents of the flowers of Mumusops elengi are phenylethanol (29.8%), (E)-2-hexenal (11.8%), benzyl alcohol (10.4%), 3-Phenyl-

2-propene-1-ol, 4- Panda et. al., Am. J. Pharm Tech Res. 2012; 2(6) ISSN: 2249-

3387 217 www.ajptr.com Hydroxybenzene methanol, Methyl-4-hydroxybenzoate, 2-Butyl phenol, Hexadecenoic acid, Long chain carboxylic acid, (Z)-9- Octadecanoic acid.16,17 The major constituents of seeds of Mimusops elengi are Quercitol, Dihydroqurecitin, Qurecitin, Ursolic acid.8 Leaves of Mimusops -D□-sitosterol-□-sitosterol, □-carotene, D-mannitol, □elengi contains Qurecitol, Hentriacontane, glucoside and Qurecetin.18 The lipid concentration of leaves was higher in summer (32.7 mg/gm) over that of monsoon (29.75 mg/gm) and winter (30.7 mg/gm). The alkaloids contents of leaves ranging from 0.8 to 2.0 mg/gm, higher amount of

alkaloid observed at summer (2.6 mg/gm) over than monsoon (0.8 mg/gm)
*Chemical constituents present in Bakul plan*t
and winter (1.8 mg/gm) respectively. The bark contains lower amount of alkaloids than the leaves. Tdian Medlar Nepalese: Bakulapuspa Sinhalese:



Munemal

4. Pharmacological Properties:

Medicinally all parts of *M. elengi* are used to cure various human ailments. However, the bark has been studied extensively for its pharmacological properties. *M. elengi* exhibits various biological and pharmacological activities such as antiviral, antibacterial, antifungal, anthelmintic, anticariogenic, antihyperlipidemic, antihyperglycemic, diuretic effects, free radical scavenging, antioxidant, cognitive enhancing, cytotoxic activities etc. due to presence of a variety of active phytochemicals.

- **Antiviral Activity:**

The crude aqueous and methanol extracts of M. elengi inhibited HIV type 1 protease (PR) by more than 70 % at a concentration of 0.2 mg/ml as determined by HPLC

- **Antibacterial Activity:**

There are several studies reporting antibacterial potential of extracts prepared from different parts of *M. elengi.*

Dried and powdered bark of *M. elengi* was extracted with various solvents for evaluation of antibacterial activity against Gram-positive and Gram-negative bacteria and other microorganisms isolated from tooth-tartar of dental patients.

- **Antimicrobial agent:**

In vitro evaluation of antibacterial activity of aqueous, petroleum ether, toluene, chloroform, methanol and ethanol extracts from leaves of *M. elengi* was investigated against five pathogenic bacteria viz., *Escherichia coli, Pseudomonas aeruginosa, Salmonella typhi, Vibrio cholera and Streptococcus pneumonia* at concentrations of 10,20,30,40 and 50 µl. Among the five pathogens tested, S. pneumonia and *E. coli* showed a maximum inhibition of 26.9 mm and 24.4 mm with aqueous extract at 50 µl compared to standard antibiotics Gentamicin, Tetracycline and Streptomycin. The methanol and ethanol extracts at 10 to 50 µl showed a maximum inhibition against all the pathogens. However, further in a study, aqueous and acetone bark extracts of *M. elengi* and *Juglans regia* (Walnut) were evaluated and compared for antibacterial activity against salivary microflora collected from children of 6-12 years of age with moderate caries (DMFT = 3-4) using paper disc diffusion method. The acetone extract of J. regia showed highest zones of inhibition indicating its use as a potent antibacterial agent. Comparatively, the aqueous and acetone extracts of M. elengi did not show any significant zones of inhibition.

- **Antifungal Activity:**

Different extracts (petroleum ether, ethyl acetate and methanol) from bark, fruits and leaves of *M. elengi* were tested for antifungal activities against some pathogenic fungi. Fruit extracts were less potent against most of the tested

organisms compared to those prepared from bark and leaves of *M. elengi* and were inactive against the fungus *Trichoderma viride*. However, leaf extracts displayed good activity against Trichoderma viride extracts of leaf and bark of *M. elengi* on the radial growth and sclerotial development (number and size) of the polyphagous fungus *Sclerotinia sclerotiorum* (Lib.) de Bary affecting 400 crop species was investigated. The unsterilized aqueous bark extract showed significantly higher inhibition of radial growth and number and size of sclerotia compared to the sterilized and unsterilized aqueous leaf extract. Further, unsterilized aqueous bark extract at 30 % concentration showed highest sensitivity reducing radial growth by 56.54 %, sclerotia number by 65.15 % and sclerotial size by 68.90-73.11 %. Hexane, ethyl acetate, ethanol and methanol extracts of *M. elengi* and other medicinal plants were tested against the dental caries causing bacteria.

- **Anthelmintic Activity:**

The anthelmintic potential of crude methanolic extract and its fractions from the leaves of *M. elengi* was studied in adult earthworms *Pheretima posthuma*. The methanolic extract and ethyl acetate fraction of the leaves caused paralysis and death of the worms at high doses compared to Albendazole as standard and distilled water as control In a similar study in viro anthelmintic activity of *M. elengi* using methanolic bark extract (25, 50 and 100 mg/ml) was reported against earthworms (*Pheretima posthuman*) Dhamija et al., (2011) reported anthelmintic activity of ethanolic and aqueous extracts of *M. elengi* against adult earthworm *Eisenia foetida* (redworm) at 4 mg/ml or more

- **Anticarciogenic Activity:**

The effects of oral administration of 50 % alcoholic extract of *M. elengi* and its different fractions namely ethyl acetate, n-butanol, methanol and aqueous were studied against ethanol-induced gastric damage and it was observed that ethyl acetate fraction possessed anti-ulcer activity against experimental gastric ulcers. Further in a study, the effect of alcoholic and petroleum ether extracts of bark (200 mg/kg body weight) of *M. elen*gi was evaluated in rats. The alcoholic extract showed significant antiulcer activity compare to petroleum ether extracts of bark.

- **Antihyperlipidemic Activity:**

In an experiment, hyperlipidemia in Hyperlipidemic group (HG), Fenofibrate group (FG) and *M. elengi* treated groups (100, 300, 600 mg/kg body weight, p.o.) was induced by single i.p. injection of Triton WR-1339 at 200 mg/kg except normal control (NC). The groups treated with *M. elengi* showed significant reduction in levels of triglyceride and total cholesterol as compared to HG after 7 and 24 h of induction. Even after 48 h the groups treated with *M. elengi* at 300 and 600 mg/kg showed significant decrease in level of triglyceride and decrease in level of total cholesterol compared to HG.

- **Wound Healing Activity:**

A methanolic extract from bark of *M. elengi* was examined for wound healing activity in the form of ointment in three types of wound models on mice: the excision, the incision and dead space wound model. The extract ointments showed considerable response in all the wound models compared to standard

drug Betadine ointment in terms of wound contracting ability, wound closure time, tensile strength and dry granuloma weight. Histological analysis was also consistent with the proposal that *M. elengi* bark extract exhibits significant wound healing.

- **Diuretic Activity:**

The diuretic and electrolyte excretion activities of petroleum ether, chloroform and alcoholic extracts (200 mg/kg body weight, p.o.) of bark of *M. elengi* were investigated. The highest diuretic and electrolyte excretion activities were presented by the alcoholic extract. Further in another study, the ethyl acetate, ethanol and aqueous extracts (250 mg/kg body weight, p.o.) of *M. elengi* were evaluated for diuretic activity. The aqueous extract showed a significant diuretic activity compared to other extracts.

B. Excipient Profile:

The excipient use for formulation of crack healing cream are: White soft paraffin, Polysorbate60, Cetosteryl alcohol, Glycerin, Methyl paraben, Propyl paraben, Purified water.

1. White paraffin wax:

- Non-proprietary Names: BP: White Beeswax JP: White Beeswax PhEur: Beeswax, White USP-NF: White Wax
- Synonyms: Bleached wax; cera alba; E901.
- Chemical Name and CAS Registry Number: White beeswax [8012-89-3]
- Empirical Formula and Molecular Weight White wax is the chemically bleached form of natural beeswax; see Section 13. Beeswax consists of 70–75% of a mixture of various esters of straight-chain monohydric alcohols with even-numbered carbon chains from C24 to C36 esterified with straight-chain acids. These straight- chain acids also have even numbers of carbon atoms up to C36 together with some C18 hydroxy acids. The chief ester is myricyl palmitate. Also present are free acids (about 14%) and carbohydrates (about 12%) as well as approximately 1% free wax alcohols and stearic esters of fatty acids.
- Structural Formula: Functional Category Controlled-release agent; stabilizing agent; stiffening agent.
- Applications in Pharmaceutical Formulation or Technology: White wax is a chemically bleached form of yellow wax and is used in similar applications: for example, to increase the consistency of creams and ointments, and to stabilize water-in-oil emulsions. White wax is used to polish sugar-coated tablets and to adjust the melting point of suppositories. White wax is also used as a film coating in sustained-release tablets. White beeswax microspheres may be used in oral dosage forms to retard the absorption of an active ingredient from the stomach, allowing the majority of absorption to occur in the intestinal tract. Wax coatings can also be used to affect the release of drug from ion-exchange resin beads. (2–4) See also Wax, Yellow.
- Description: -White wax consists of tasteless, white or slightly yellow-colored sheets or fine granules with some translucence. Its odor is similar to that of yellow wax but is less intense.

Typical Properties:

Arsenic 43 ppm, Density 0.95–0.96 g/cm3, Flash point 245– 2588C, Heavy metals 40.004%, Iodine number 8–11 Lead 410 ppm, Melting point 61–658C, value 48 Solubility Soluble in chloroform, ether, fixed oils, volatile oils, and warm carbon disulfide; sparingly soluble in ethanol (95%); practically insoluble in water. Unsaponified matter 52–55%.

Method of Manufacture:

Yellow wax (beeswax) is obtained from the honeycomb of the bee (Apis mellifera Linne´ (Fam. Apidae)); see Wax, Yellow. Subsequent treatment with oxidizing agents bleaches the wax to yield white.

2. Cetosteryl alcohol:

- Nonproprietary Names: BP: Cetostearyl Alcohol PhEur: Cetostearyl Alcohol USP-NF: Cetostearyl Alcohol
- Synonyms: Alcohol cetylicus et stearylicus; cetearyl alcohol; cetyl stearyl alcohol; Crodacol CS90; Lanette O; Speziol C16-18 Pharma; Tego Alkanol 1618; Tego Alkanol 6855.
- Chemical Name: and CAS Registry Number Cetostearyl alcohol.
- Empirical Formula and Molecular: Weight Cetostearyl alcohol is a mixture of solid aliphatic alcohols consisting mainly of stearyl ($C_{18}H_{38}O$) and cetyl ($C_{16}H_{34}O$) alcohols. The proportion of stearyl to cetyl alcohol varies considerably, but the material usually consists of about 50–70% stearyl alcohol and 20–35% cetyl alcohol, with limits specified in pharmacopeias. The combined stearyl alcohol and cetyl alcohol comprise at least 90% of the material. Small quantities of other alcohols, chiefly myristyl alcohol, make up the remainder of the material.
- Functional Category Emollient; emulsifying agent; viscosity-increasing agent.
- Applications in Pharmaceutical Formulation or Technology: Cetostearyl alcohol is used in cosmetics and topical pharmaceutical preparations. In topical pharmaceutical formulations, cetostearyl alcohol will increase the viscosity and act as an emulsifier in both water-in-oil and oil-in-water emulsions. Cetostearyl alcohol will stablize an emulsion and also act as a co-emulsifier, thus decreasing the total amount of surfactant required to form a stable emulsion. Cetostearyl alcohol is also used in the preparation of nonaqueous creams and sticks, and in nonlathering shaving creams.(1) Research articles have been published in which cetostearyl alcohol has been used to control or slow the dissolution rate of tablets or microspheres containing water-soluble drugs,(2–5) or poorly water-soluble drugs,(6–8) as well as to stabilize amorphous systems.(9) In combination with other surfactants, cetostearyl alcohol forms emulsions with very complex microstructures. These microstructures can include liquid crystals, lamellar structures, and gel phases. (10–21)
- Description: Cetostearyl alcohol occurs as white or cream-colored unctuous masses, flakes, pellets or granules. It has a faint, characteristic sweet odor. On heating, cetostearyl

alcohol melts to a clear, colourless or pale yellow-coloured liquid free of suspended matter.

3.Glycerin:

Non-proprietary Names BP: Glycerol JP: Concentrated Glycerin PhEur: Glycerol USP: Glycerin

- Synonyms Croderol; E422; glicerol; glycerine; glycerolum; Glycon G-100; Kemstrene; Optim; Pricerine; 1,2,3-propanetriol; trihydroxy propane glycerol.
- Chemical Name and CAS Registry Number Propane-1,2,3-triol
- Empirical Formula and Molecular Weight C3H8O3 92.09
- Structural Formula 6 Functional Category Antimicrobial preservative; cosolvent; emollient; humectant; plasticizer; solvent; sweetening agent; tonicity agent.
- Applications in Pharmaceutical Formulation or Technology Glycerin is used in a wide variety of pharmaceutical formulations including oral, otic, ophthalmic, topical, and parenteral preparations. In topical pharmaceutical formulations and cosmetics, glycerine is used primarily for its humectant and emollient properties. Glycerin is used as a solvent or cosolvent in creams and emulsions. (1–3) Glycerine is additionally used in aqueous and nonaqueous gels and also as an additive in patch applications. (4–6) In parenteral formulations, glycerine is used mainly as a solvent and cosolvent. (7–10) In oral solutions, glycerine is used as a solvent, (10) sweetening agent, antimicrobial preservative, and viscosity-increasing agent. It is also used as a plasticizer and in film coatings. (11–14) Glycerin is used as a plasticizer of gelatin in the production of soft-gelatin capsules and gelatin suppositories. Glycerin is employed as a therapeutic agent in a variety of clinical applications, (15) and is also used as a food additive. Table I: Uses of glycerin. Use Concentration (%) Antimicrobial preservative.

Methods And Experimental Work

1. Drug Extraction
2. Preparation of Crack Healing Cream
3. Evaluation of Cream

Drug extraction:

Bakul (*Mimusops elengi Linn*) plant leaves were taken from campus of Delonix society's Baramati College of Pharmacy which is located in Baramati. These leaves where washed by tapped water. After cleaning the leaves, they were grinded in the grinder by adding some water followed by filtration. The filtered material was kept on heating for evaporating the water. For complete removal of water, it was kept in the oven for 15 minutes at 121 degrees Celsius. The extracted material was Triturated to obtain fine particles and was passed by a sieve. Now the extracted drug is ready to add in the cream.

Preparation of crack healing cream:

Cream preparations are emulsion type. Cream is prepared by taking ingredients of oil phase and aqueous phase separately. Heating to liquefy or dissolve all ingredients and then mixing them together with continuous stirring till the cream is produced and cool down.

Preparation of Phase A and Phase B

Phase A:

oil phase is prepared my mixing and dissolving by heating ingredients 2ml Polysorbate60, 6gm White soft paraffin, 2gm Cetosteryl alcohol,0.05gm Methyl paraben and 0.05gm Propyl paraben.

Phase B:

Aqueous phase was prepared by mixing Purified water, and Glycerine.

Oil phase was added to aqueous phase by adding slowly and continuously stirring. Allow the cream to cool and transfer it in to the container.

Ingredients	Quantity
Bakul extract	0.5gm
Polysorbate 60	2ml
Cetosteryl alcohol	2gm
Glycerin	q.s
Methyl paraben	0.05gm
White paraffin wax	6gm
Purified water	q.s

Evaluation of Extracted Drug:

A. Anti-microbial Test:

Testing the antimicrobial activity of a Harbel drug, typically involves several steps to evaluate its effectiveness against specific microorganisms. Here's a general outline of the process:

1. Preparation of the Drug Sample

- Formulation: Ensure the Harbel drug is in a suitable form for testing (e.g., dissolved in a solvent if necessary). 1gm of extract was dissolved in 5ml of water
- Sterilization: Sterilize the drug solution to avoid contamination, typically by filtration.

2. Selection of Microorganisms

- Choose a range of microorganisms to test against, including bacteria (both Gram- positive and Gram-negative), fungi, and possibly viruses.
- Common test organisms include Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, and Candida albicans. Microorganisms used for project work are: Gram positive- Bacillus cereus Gram negative- E. Coli

3. Culture Media Preparation

- Preprepared appropriate culture media plates where taken (e.g., Mueller-Hinton agar for bacteria, Sabouraud dextrose agar for fungi).
- Sterilize the media and pour into petri dishes.

Fig no.5. Culture Media Preparation

4. Inoculation of Media

- Use sterile techniques to inoculate the media with 0.1ml test microorganisms.
- A standardized inoculum, often 0.5 McFarland standard, is used to ensure consistency.

5. Application of the Drug

- Agar Well Diffusion Method: Create wells in the agar and fill them with the 0.1ml drug solution.

6. Incubation

- Incubate the plates at 37°C for 24 hours for bacteria.

Fig.no.6 Incubated plates

7. Evaluation of Results

- Zone of Inhibition: Measure the clear zones around the discs or wells where microorganisms did not grow. Zone of inhibition for bacillus cereus is -21 mm diameter Zone of inhibition for *E. Coli* is - 14mm diameter

8. Data Analysis

- Compare the results with standard references to assess the antimicrobial potency of the Harbel drug.
- Interpret the results to determine the drug's efficacy and potential therapeutic uses.

This procedure will help you assess the antimicrobial activity of the Harbel drug and determine its potential as a therapeutic agent.

The zone of inhibition of standard drug (Neem) – 25mm diameter & the zone of inhibition of Bakul is 21 mm diameter for Bacillus cereus.

The zone of inhibition of standard drug (Neem) – 20 mm diameter & the zone of inhibition of Bakul is 15 mm diameter for *E. coli.*

B. Anti-fungal test

Testing the antifungal activity of a herbal drug involves a series of laboratory procedures designed to determine its effectiveness against fungal organisms. Here's a detailed protocol for conducting an antifungal test:

1. Preparation of drug sample

- Formulation: Ensure the Harbel drug is in a suitable form for testing (e.g., dissolved in a solvent if necessary). 1gm of extract was dissolved in 5ml of water
- Sterilization: Sterilize the drug solution to avoid contamination, typically by filtration

2. Selection of Fungal Strains

- Choose relevant fungal strains for the test, such as:
- *Candida albicans* (common yeast infection)
- *Aspergillus niger* (common mold)
- *Trichophyton rubrum* (causes athlete's foot)
- Obtain these strains from a reputable microbiological culture collection.

3. Preparation of Fungal Inoculum

- Culture: Grow the fungal strains on suitable media (e.g., Sabouraud Dextrose Agar) until sufficient growth is observed.
- Standardization: Prepare a fungal suspension in saline or broth, adjusting the concentration to match a standard (e.g., 1 x 10^6 CFU/mL).

4. Antifungal Assay Methods

Agar Well Diffusion Method

- Media Preparation: Pre prepared agar plates were used.
- Well Preparation: Use a sterile cork borer to create wells in the agar.
- Filling Wells: Fill the wells with the 0.1 drug sample
- Evaluation: Measure the zones of inhibition around the wells.

Fig no.7.incubated image

5. Data Analysis

❖ Zone of Inhibition: For diffusion methods, larger zones indicate higher antifungal activity. Zone of inhibition for Candida albicans is 25mm diameter.

6. Incubation

❖ Incubate plates at 37°C for 24 hours.

7. Evaluation

❖ Measure and record the diameter of inhibition zones. The zone of inhibition for candida albicans was found to be 25mm diameter.

By following these steps, you can effectively evaluate the antifungal properties of a herbal drug, providing valuable data for its potential therapeutic use.

Evaluation Tests for Crack Healing Cream

1. Spread ability

Small amount of cream was spread on hand.

2. Wash ability

A small amount of cream applied available and washed under running water.

3. PH

The PH was measured by weighing 1gm of the sample and dissolving it in the 100ml of distilled water at room temperature. Dip PH paper into it.

4. Appearance

The appearance of the gel was determined by its colour, its texture and its odour.

5. Test for Stability

The cream was observed for 3 months for its stability.

6. Test for consistency

Consistency of the cream should be medium.

Result & Discussion

We prepared crack healing cream of Mimusops elengi and following evaluation results were observed.

1. Spread ability:

The cream was spread on the hand. The cream was easily spread so it has easy spread ability.

2. Wash ability:

It is a crucial parameter for evaluating crack healing creams, as it indicates how easily the product can be removed from the skin. This property affects user experience and satisfaction, particularly in terms of cleanliness and ease of reapplication.

The formulated cream has good washability.

3. PH:

The pH of crack healing creams is an important factor as it can influence the cream's compatibility with the skin, its stability, and its overall effectiveness. Ideally, the pH of such creams should be close to the natural pH of the skin, which

is slightly acidic, typically around 4.5 to 5.5.

The pH of the formulated cream was found to be 5.

4. Appearance:

- ❖ Colour- Green
- ❖ Texture- Smooth
- ❖ Odor- Odorless

5. Test for Stability:

The cream was observed for 3 months, the stability of the cream was same for 3 months.

1st month *2nd month* *3rd month*

6. Consistency:

Consistency of cream refers to its texture and thickness, which can vary depending on factors such as fat content, processing methods, and temperature.

Consistency of the formulated cream is medium.

Result Table

Spread ability	Easy spreadable
Wash ability	Good wash ability
PH	**5** PH
Appearance Color Texture odor	Green Smooth Odorless
Stability	Stable for 3 Months
Consistency	Medium

Conclusion:

This project aims to produce crack heal cream by extracting valuable bioactive.

This provides an eco-friendly solution for skin infections.

The concept of above formulation was to incorporate the oil of the cream, as creams are widely accepted & better absorbed by skin with its moisturizing & emollient effect.

Hence in the present investigation we prepared cream by using conveniently excipients.

Results of evaluation demonstrated the pH of the creams were in normal range of the skin with good stability, spread ability & Wash ability which indicated creams were capable to remain in the site of application for prolonged time.

Thus, we concluded that cream would provide safe & effective for healing cracks.

The crack healing cream offers an effective and reliable solution for those suffering from dry, cracked skin.

Formulated with a blend of natural ingredient and advanced exipients it provides deep moisturization, rapid relief, and promotes the regeneration of healthy skin.

Regular use not only heals existing cracks but also strengthens the skin's barrier to prevent future damage.

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Natural Resources and Sustainable Development

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Abstract

This document delves into the crucial connection between natural resources and the concept of sustainable development. It highlights the pivotal role that natural resources play in human survival and economic progress, while also acknowledging the environmental consequences that often follow their exploitation. The paper scrutinizes the foundations of sustainable development, the obstacles encountered in managing resources, and the approaches to strike a balance between their use and preservation. By adopting a human-centered viewpoint, it underscores the necessity for worldwide collaboration, innovation, and ethical accountability to secure a sustainable future for future generations.

Introduction

Natural resources have been the cornerstone of human civilization, providing the essential materials for survival, economic growth, and technological advancement. Yet, the unsustainable exploitation of these resources has resulted in significant environmental issues, including deforestation, pollution, and climate change. Sustainable development presents a solution that aims to harmonize the needs of the present with the capacity to fulfil the requirements of future generations. This document explores the complex interplay between natural resources and sustainable development, emphasizing the importance of responsible management and creative solutions.

The Significance of Natural Resources

Natural resources, encompassing water, minerals, forests, and fossil fuels, are indispensable for human existence and economic activities. They supply raw materials for various industries, energy for transportation and heating, and vital nutrients for agriculture. The availability and accessibility of these resources have historically been pivotal in determining the prosperity of civilizations.

Obstacles in Resource Management

Despite their critical role, natural resources are finite and frequently face overexploitation. The primary challenges in managing these resources include:

Resource Depletion: The overuse of non-renewable resources like oil and coal can lead to their depletion.

Environmental Damage:
Activities such as deforestation, mining, and industrial operations contribute to pollution, loss of biodiversity, and climate change.

Unequal Distribution:
Access to natural resources is often uneven, resulting in conflicts and disparities among regions and nations.

Principles of Sustainable Development

Sustainable development aims to tackle these challenges by advocating for practices that ensure the long-term availability of resources and the health of the environment. The fundamental principles include:

Equity Across Generations:
Ensuring that the use of resources today does not compromise the ability of future generations to meet their needs.

Balancing Economic and Environmental Goals:
Striking a balance between economic growth and the protection of the environment.

Inclusion and Participation:
Engaging communities, businesses, and governments in the decision-making processes.

Strategies for Sustainable Resource Management

To achieve sustainable development, it is crucial to adopt innovative and inclusive strategies. Some of these strategies include:

Investment in Renewable energy: Pouring resources into solar, wind, and hydroelectric power to diminish reliance on fossil fuels.

Implementation of Sustainable Practices:
Adopting sustainable agricultural and forestry methods to safeguard ecosystems.

Development of Technological Innovations:
Creating new technologies for efficient resource utilization and waste reduction.

Enforcement of Environmental Regulations:
Implementing and enforcing environmental laws and policies that encourage sustainable practices.

Raising Awareness and Education: Educating the public about the importance of sustainability and promoting responsible consumption.

Germany's Shift to Green Energy: Germany's move towards green energy, known as the Energy wind, has greatly lowered its carbon footprint and reliance on non-renewable fuels. The nation's investment in wind and solar power stands as an example for environmentally friendly energy solutions.

Protecting Forests in Costa Rica: Costa Rica's work in reforestation and forest preservation has brought back vast areas of damaged land, increased wildlife diversity, and boosted eco-friendly tourism, showing the advantages of sustainable forest management.

The Role of People

At the core of sustainable growth is the understanding that the health of individuals and the environment are linked. Sustainable actions not only safeguard the natural world but also improve life standards, decrease poverty, and support social fairness. It's crucial for communities that rely on natural

resources for their living to be engaged in efforts to protect these resources. By encouraging a sense of care and accountability, we can build a fairer and more sustainable world.

Conclusion

Natural resources are essential for human existence and progress, yet their improper use threatens the environment and the well-being of future generations. Sustainable development provides a holistic approach to managing resources while preserving them. Through creative approaches, worldwide collaboration, and a dedication to moral duty, we can secure a sustainable future that satisfies the needs of both humanity and the environment.

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Inbreeding Depression and Heterosis

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Introduction

The assessments of heterosis and inbreeding depression together provide information about the gene action involved in the expression of different polygynous traits, hence for plant breeders. Knowledge of hybrid vigour and inbreeding decline is essential. It is important to get the understand the principles of inbreeding and outbreeding before cross-breeding and breeding decline. To this pattern, marriage with direct relations was restricted in many civilizations around the world. In certain civilizations marriage was prevalent in close relations like brother-sister, cousin sister in order to avoid mixing of noble blood.

Cross-pollinated and asexually reproducing crops are highly heterozygous. Therefore, on inbreeding, there is a lot of loss in their vigour. In addition, the progeny obtained by hybridization in their unrelated strains is quite vigorous. As a result, varieties of such crops are heterozygous, and every effort is made to avoid inbreeding in their breeding.

History

People had the information of inbreeding depression for a long time. Marriage between close relatives is for bidden in many societies; In Hindus, marriage is prohibited even among individuals of the equivalent same gotra. But systematic observation on inbreeding decline began during the breeding of cows around 1700 AD.

In 1876, Darwin described the impacts of inbreeding on his book "Cross- and Self-Fertilization in Vegetable Kingdom". He concluded that self-fertilization the offspring produced by fertilization are weaker than the progeny produced by cross-fertilization.

Darwin (1877) concluded that nature hates self-fertilization, that is, self-fertilization decreases vigour.

East in 1908 and Shull in 1909 Impacts of inbreeding on maize described in detail. Later inbreeding depression in other crops was considered by numerous researchers.

Inbreeding Depression

The mating or crossbreeding between two organisms delivered from a similar ancestor is called inbreeding. Self-fertilization is the nearest type of inbreeding. So, there are types of breeding as well as sib mating and half-sib mating. Different morphological characteristics of plants, for example,

homogamy, cleistogamy, and bisexuality which promote self-fertilization also encourage inbreeding.

A few examples of inbreeding are brother-sister mating, cousin-sister mating, selfing, back cross, etc. The decrease in vigour due to inbreeding is called inbreeding depression

Some of the main characteristics of (inbreeders) are as per the following.

1. Regular self-pollination happens place in interbreeders.
2. Generally, inbreeders have restricted adaptations and low Adaptability.
3. Recessive deleterious genes are not found in the genotypes.
4. Homozygous balance is found in the inter breeders, because of which there is no unfavorable impact of inbreeding on them.
5. Homozygosity and pure breeding are found in individuals.
6. Inbreeding involves numerous pure lines.

Effects of Inbreeding:

Inbreeding has effects on different parameters for example, homozygosity, population mean, hereditary relationship and variation. But a brief description of the impacts of inbreeding on the cross-fertilized crop is as per the following.

1. Decrease in yield: Yield is greatly reduced because of inbreeding. The interspecies yield of most crops is a quarter or less that of open-pollinated varieties. Inbreeding just in certain crops results in little or no reduction in vigour and yield.

2. Reduction in vigour: Inbreeding reduces the vigour of the plants, and the plants become relatively weak, small and Appearance of dwarf plants.

3. Decrease in reproductive capacity: Many plants deliver so few seeds that it is difficult to maintain them. Only a few inbred lines of most crops produce number of seeds to utilized for breeding.

4. Increase in homozygosity: Inbreeding increases homozygosity. Overall, more than 99% homozygosity occurs in plants by selfing for 7-8 generations. Therefore, after 7-8 generations of self-pollination, very little variation is found in any line. These lines are called inbred lines.

5. Appearance of lethal and sub lethal alleles: Chlorophyll deficiency, rootless seedlings and other deformities.

6. Segregation of population in distinct lines.

Degrees of inbreeding depression: The degree of inbreeding loss varies greatly from species to species. The depression may be from exceptionally high to nil. Based on degree of depression, the plant species can be divided into the following four categories:

(1) High (2) Moderate
(3) Low (4) Negligible or absent

1. High inbreeding depression: High inbreeding depression is found in many harvests like lucern, carrot and so on. Lethal and sub lethal impacts are found in many plants resulting from inbreeding of these species. Self-fertilization of just 3-4 generations reduces vigour and fertility to such an extent that very few lines can be maintained. The lines that survive have almost no yield.

2. Moderate inbreeding depression: Many plants, which includes Moderate inbreeding decline is located in maize, jowar, bajra and etc. Lethal and lethal trends are discovered in lots of plants in inbred generations. But it is possible to maintain most of the lines or sequences. The yield of many inbreds is one-1/3 or extra that of open-pollinated types.

3. Low inbreeding depression: Very little depression melancholy is found in lots of plants like cucurbit, onion & sunflower etc. In inbred generations, deadly or sub lethal trends are located in very few plants. There is noticeably little loss in vigour and fertility, and it is not viable to hold only a few traces. There is little discount within the yield of inbred lines, and the yield of many interspecies may be similar to that of free-pollinated varieties.

4. No inbreeding depression: Hybrid vigour is found in self-pollinated crops, but they lack inbreeding depression. A few examples of such crops are paddy, wheat, barley, pulses and so on.

Heterosis or Hybrid Vigour

Introduction

When the F1 generation is better than its parents in a trait (generally, yield), this condition is called heterosis or hybrid vigour, but the term is rarely used. When the performance of a generation is intermediate or close to that of one parent, these conditions are called lack of dominance and partial dominance, respectively Average to partial or incomplete dominance (heterosis), however it is of no significance in plant reproducing. For a cross breed to be helpful in heterosis, it is necessary that the yield of the (F1) generation or its performance is superior to the existing improved variety, whether it is the parent of this hybrid (F1) or not. Excellence from the popular improved variety of the F1 generation is called economic or usable heterosis. In fact, economic hybrids are useful only in plant breeding. In other words, hybridization of the increase in the health and vigour of F1 over the parents. Some of the salient features of Heterosis as follows.

1. Heterosis is related to F1 generation only.
2. The heterosis is genetically controlled.
3. In all F1 hybrids, heterosis is not found.
4. Specific combining ability is from.
5. The relation of heterosis is found with heterozygosity that is why more heterosis is found in cross-pollinated crops than in self-pollinated crops.
6. True heterosis and pseudo heleterosis: - Normal vigour in real hybrid Vigour; yield and in adaptation, superiority is found in comparison to the parents. Whereas in the false Hybrid Vigour, only vegetative growth increased.
7. A significant amount of dominance variance needs to be present in order to start a hybrid vigour breeding program.

History

The first examine of hybrid Vigour in plants was done by Colreuter (1763) utilizing handling on tobacco species. Later various researchers discovered hybrid vigour in other plants as properly.

Darwin concluded in 1876 that hybrids obtained by crossing unrelated strains are quite vigorous.

Beal studied heterosis in open-pollinated varieties of maize from 1877 to 1882. He found that hybrids of a few varieties give up to 40 percent better yield than the parent.

Knight (1928) described vigour as the result of the hybridization of species and from which he gave the rule of against inbreeding. The second reproduction, Hubert, Gartner, Noudine (1825–1855) also extended this method.

Mendel (1865) noticed the hybrid vigour in his pea hybrids.

Charles Darwin, (1876) in his trial of inbreeding and cross breeding reached the resolution that cross fertilization is normally useful and self-fertilization is harmful.

Beale (1880) used controlled processing to improve maize.

East and Hage (1912) and different researchers gave the term heterozygosis for the extra vigor of the hybrid.

Shull (1914) coined the term "heterosis" for the greater vigor of the hybrid rather than heterozygosis. The term hybrid vigour for heterosis is also used.

Whaley (1944) was of the assessment that it would be more suitable to term the developed superiority of the hybrids as hybrid vigour and to refer to the mechanism by which the superiority is developed as heterosis.

Smith (1955) opined that the use of heterosis and hybrid vigour as synonyms is highly desirable on the basis of their long usage.

Effects of Heterosis: Heterosis can affect any one or more of the plant's characters. Generally, hybrids that affect the economic characters of plants are beneficial in plant breeding. It is basically the result of the expanded metabolic activity of the heterozygote its effects are well established in the following three ways:

A. Quantitative Effects B. Physiological Effects C. Biological Effects

A. Quantitative Effects:

(a) Increase in size and genetic vigour: Hybrids are generally more vigorous i;e bigger, better and more quickly developing than the parents e.g., head size in cabbage, cob size in maize, fruit size in tomato etc.

(b) Increase in yield: Yield may be estimated as far as grain, fruit, seed, leaf tuber or the entire plant. Hybrids usually have increased yield.

(c) Better quality: Hybrids show improved quality e.g., hybrids in onion show better keeping quality.

B. Physiological Effects:

(a) Greater resistance to diseases and pests: Some hybrids show more resistance to insects or diseases than parents.

(b) Greater flowering and maturity: Earliness is highly desirable in vegetables. In many cases, hybrids are earlier in flowering and maturity than the parents, for example tomato hybrids are earlier than their parents.

(c) Greater Adaptability: Hybrids are usually less susceptible to unfavourable ecological conditions.

C. Biological Effects

Hybrids exhibiting heterosis show an expansion in biological productivity efficiency i.e., an increase in fertility and survival capacity.

Heterosis in animals:

(i) Mule is a hybrid from a cross between Jack and Mare which has been known since ancient times for its notable characteristics of solidarity and determination.

(ii) Cross between red Sindhi breed of Indian Cattle and Jersey breed of America contemns 30% more butter fat in milk.

(iii) Increased pork yield in pigs, more egg laying hens, silk creation in silk worms etc

Factors Affecting Heterosis: The magnitude of the hybrid is influenced by four main genetic factors i.e.

(1) the mode of pollination,

(2) the genetic diversity of the parents, (3) the genetic basis of the parents and (4) the adaptability.

Their brief description is as follows.

1. Genetic Diversity of Parents:

The diversity of parents has a profound effect on the expression of a hybrid. For example, in wheat, more hybrid energy is found in crosses between distantly related parents. In cotton, more hybrid vigour was found to be associated with parental diversity. In Maize the level of hybrids increased to some extent with parental diversity. Thereafter, due to increase in parental diversity, there was a decline in hybrid power. Thus, maximum hybrid energy is found at the optimum or intermediate level of parental diversity.

2. Mode of Pollination:

Depending on the method of pollination of crops, the difference in the quantity of hybrid vigour is found. Generally, more hybrids are found in cross pollinated crops than in self-pollinated crops.

3. Genetic Base of Parents:

The genetic basis of the parents also has an effect on the magnitude of the hybrid. For example, in cotton, more hybrid energy has been found to be related to the broader genetic base of the parents.

4. Adaptability:

The adaptability of the parents also has an effect on the amount of hybrid power. In cotton and numerous different crops, crossbreeds were found to be associated with broader adaptability of the parents as there is a close relationship among flexibility and hereditary base.

Methods for Estimation of Heterosis:

Several different formulas can be used to estimate hybrid heterosis. Heterosis is estimated in three different ways, a brief description of these sources is given below.

1) Mid parent heterosis
2) Better parent heterosis
3) Standard heterosis

1) Mid Parent Heterosis: When the heterosis is estimated over the mid parent i.e. mean value or average of the two parents is known as mid parent heterosis. It is also known as average heterosis or relative heterosis and calculated by using formula.

$$\text{Mid Parent Heterosis} = \frac{\text{F1} - \text{MP}}{\text{MP}} X100$$

Where,
F1 is mean of F1
MP is mean of two parents

2) Better Parent Heterosis: When the heterosis is estimated over the better parent is known as better parent heterosis. It is also known as heterobeltiosis, the term heterobeltiosis was used by Bitzer et al (1968) to describe the improvement of heterozygote over the better parent of the cross. It was calculated with the help of the following formula.

$$\text{Better parent heterosis} = \frac{(\text{F1} - \text{BP})}{\text{BP}} \text{x } 100$$

Where F1 = the mean value of F1
BP = the mean value of the better parent

3) Standard Heterosis: It refers to the superiority of F1 over the standard commercial check variety. It is also called as economic heterosis or useful heterosis and calculated by using formula.

$$\text{Standard Heterosis} = \frac{\text{F1} - \text{Check}}{\text{Check}} \text{x} 100$$

Theories of Heterosis: There are two main principle which have been utilized to clarify the mechanism of heterosis.

The epistasis is additionally viewed as related with heterosis. Thus, there are three possible genetic causes of heterosis viz Dominance, Over dominance & Epistasis. These are briefly discussed below:

1. Dominance Hypothesis:

This hypothesis was proposed by Davenport (1908), Bruce (1910), Keeble and Pellew (1910). This is the most broadly accepted hypothesis of heterosis. As per this hypothesis, heterosis results from the masking of harmful effects of recessive alleles by their dominant alleles. When recessive alleles are deleterious; here the deterious recessive genes of one parent are hidden by the dominant genes of another parent and the hybrid exhibits heterosis. Both the parents differ for dominant genes. Therefore, according to the dominance hypotheses, heterosis is not the result of heterozygosity; it is the result of prevention of expression of harmful recessives by their dominant alleles. Heterosis is directly proportional to the number of dominant genes contributed by each parent.

With the help of following example heterosis can be explained:

In a cross between Inbred A (RR yy XX zz) with Inbred B (RR yy XX zz), there will be no heterosis in F1 hybrid, there is no masking of recessive gene in hybrid. But in another cross, Inbred A (RR yy XX zz) is crossed with Inbred D (rr YY xx ZZ), where the F1 hybrid is (Rr Yy Xx Zz) with all the genes having dominant allele.

As a result, the harmful effects of r, y, x and z are hidden by the dominant alleles R, Y, X and Z. Thus, some parents produce heterotic progeny while others do not. Generally, parents of diverse or different origin are more likely to produce heterotic progeny than those of similar origin.

Inbrid A RR yy XX zz (Parent 1) X Inbrid B RR yy XX zz (Parent 2)

↓

RR yy XX zz
Hybrid
No heterosis

Inbrid B RR yy XX zz X Inbrid D rr YY xx ZZ

↓

Rr Yy Xx Zz
Hybrid heterosis

2. Over dominance Hypothesis:

This hypothesis was given by Shull (1903) and East (1908) independently. The over dominance was coined by Hull in 1945 working on maize. This is sometimes known as single gene heterosis, super-dominance, and cumulative action of divergent alleles and stimulation of divergent alleles. As per this theory, heterozygotes are superior to both the homozygotes.

So, the heterozygote Aa would be superior to both the homozygotes AA and aa. Consequently, heterozygosity is fundamental for the cause of heterosis. In the case of maize, the quality mama influences development. The heterozygote Ma/mama is more

energetic with late development than the homozygotes Ma/Ma or mama/mama.

Different names have been given to this idea e.g., super predominance (Fisher 1930), cooperation of alleles at a solitary locus (East, 1930) over-strength (Hull, 1945) etc., but the term over-dominance is widely accepted

3. Epistasis Hypothesis:

In 1952, Gowen had proposed that impact of one locus on the expression of another may be involved in heterosis. Theoretically, epistatic interactions will lead to the most extreme heterosis when the following two conditions are met with.

(A) First, the epistasis should be predominantly of complementary type, i.e., the estimates of (dominance effects) and / (dominance x dominance interaction effects) have a similar sign so that they do not cancel each other out.

(B)Second, the interacting sets of genes should be dispersed in both the parents.

It has been proposed that without any over dominance, dispersion (between the two parents of hybrids) of genes showing complementary epistasis seems to be the major cause of heterosis.

Differences between inbreeding and heterosis are following:

1. Inbreeding results from matings between closely related individuals, whereas heterosis results from crossing between unrelated strains.
2. Inbreeding depression is the decrease in fitness and vigour with decreased heterozygosity, while heterosis is the increase in fitness and vigour with increased heterozygosity.
3. Inbreeding depression results due to fixation of unfavourable recessive genes in F2, while in the event of heterosis the unfavourable recessive genes of one parent are covered by favourable dominant genes of another parent. The fixation of all favourable dominant genes in one homozygous line is impossible due to linkage between some unfavourable recessive and favourable dominant genes.
4. The heterosis will be the highest when a few alleles are fixed in one parent and different alleles in the other parent.
5. The genes with absence of dominance will not exhibit heterosis in F1 yet may show increase in performance in F2, due to fixation of genes, for example additive action.
6. If some genes have dominance in one direction and some in other direction there will be no heterosis due to mutual cancellation effects of such genes.

Utilization of heterosis in crop improvement program

1. Gains in yield and yield stability offered by heterosis have prompted use of hybrids in several crops.
2. Genetic yielding ability has been increased greatly, and thus total production has been increased, with minimal dependence on chemical inputs and maximum use of biological power.
3. Enthusiasm and funds have been directed to hybrid breeding, in part because of the proven efficiency of the inbred/hybrid method for producing products that farmers need and want, and in part because private capital was attracted to the profit potential of hybrid breeding and sales.

4. The hybrid method has given breeders greater precision in developing, identifying, and multiplying the best hybrid genotypes in cross-pollinated crops

Summary

This chapter is concluded that, inbreeding and heterosis is important for to understanding the inbreeding -hybrid vigour system for hybrid seed, hybrid crop varieties, to improve quality and quantity of yield etc.

Mating between close relatives or inbreeding in cross-pollinated plants results in loss of vigour and fertility; this is called inbreeding depression. Self-fertilization in plants is a good example of inbreeding. Various morphological traits such as homogamy, pollination of closed flowers (cleistogamy) and bisexuality encourage inbreeding in plants. Inbreeding affects various parameters such as: Homozygosity, population mean, relationship variation and hereditary.

Levels of inbreeding depression can be: high (eg carrots, alfalfa), moderate (eg jawar, bajra, etc.), low (e.g. onions and sunflowers, etc.) and insignificant or absent (eg wheat, barley, legumes & self-pollinating plants).

The superiority of F1 over its parent in one or more traits is referred to as heterosis or hybrid vigour. Some of the characteristics of heterosis are as follows, Heterosis is only associated with the F1 generation, Heterosis is genetically controlled, Heterosis is not found in all F1 hybrids. The special ability to combine is from. Hybrid vigour effects are known in the following ways, quantitative effects, physiological effects, and biological effects.

Heterosis is influenced by four main genetic factors, namely pollination patterns, genetic diversity of parents, genetic basis of parents and adaptability. Heterosis is estimated in three different ways, Mid parent heterosis, better parent heterosis & Standard heterosis. There are two main principles used to explain the mechanism of heterosis. It is further believed that epistasis is related to heterosis. Thus, there are three possible genetic causes of heterosis, namely Dominance, Over dominance & Epistasis

According to the dominant hypothesis, cross breeding is caused by dominant alleles of different genes masking the adverse effects of their recessive alleles, and the loss of inbreeding due to the homozygous recessive variants and their side effects. Caused by the opposite expression, according to the over dominance hypothesis, hybrid vigour is the result of gene heterozygosity, while the loss of inbreeding is due to homozygosity.

In crop improvement, the use of heterosis occurs through the use of hybrid, synthetic and composite cultivars. Hybrid varieties are widely used in most cross-pollinated crops such as corn, sorghum, millet, sunflower, castor, cotton, onion, cabbage and others. In addition, hybrid varieties are widely used in self-pollinating plants, such as tomatoes, brinjal and others.

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Vulnerability and Adaptation to Climate Change

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Abstract

This document examines the ideas of susceptibility and adjustment within the framework of climate change. As the Earth heats up and weather patterns become increasingly erratic, communities around the globe are facing growing dangers. The level of vulnerability differs among regions and groups of people, with those on the fringes of society often experiencing the most severe impacts of climate change. Strategies for adaptation are essential for enhancing resilience and promoting sustainable growth. This document sheds light on the human aspect of climate change, emphasizing the importance of inclusive and fair adaptation strategies to safeguard the most at-risk and secure a sustainable future.

Introduction

Climate change transcends the boundaries of environmental concerns; it represents a significant challenge for humanity that touches every facet of our existence. From catastrophic weather events to the encroachment of rising sea levels, the consequences of a changing climate are felt most intensely by those least prepared to deal with them. The vulnerability to climate change is a multifaceted combination of physical, social, economic, and environmental elements, and comprehending this complexity is crucial for formulating effective adaptation plans. This document explores the human narratives behind the data, looking into how individuals and communities are adjusting to the new circumstances brought about by climate change.

Exploring Vulnerability

Vulnerability to climate change is determined by how susceptible a system or population is to and their ability to cope with adverse effects. It is shaped by three primary factors:

Exposure:

The degree to which individuals and assets are in danger.

Sensitivity:

The impact severity when exposed.

Adaptive Capacity:

The capability to adjust, lessen damage, and seize opportunities.

Case Studies of Vulnerability

Coastal Communities

For communities living along the coast, climate change often means the threat of rising sea levels, more intense storms, and erosion. For instance, in Bangladesh, entire villages are being forced to relocate as saltwater intrusion renders agriculture unfeasible and homes are destroyed by floods. The loss of livelihoods and cultural heritage renders these communities deeply vulnerable.

Urban Inequality

In urban settings, the economically disadvantaged face heightened risks. In cities such as Mumbai and Manila, informal settlements are typically situated in areas prone to flooding, lacking proper infrastructure. When heavy rains cause flooding, these communities are exposed to significant health hazards, property loss, and displacement. The urban poor often lack the means to recover from such events, perpetuating a cycle of poverty and vulnerability.

Adaptation Strategies

Adaptation involves making adjustments in natural or human systems in response to actual or anticipated climatic conditions. Successful adaptation can diminish vulnerability and foster resilience. Key strategies include:

Community-Led Adaptation

The empowerment of local communities to develop and implement their own adaptation solutions is crucial. For example, in certain regions of Africa, farmers are adopting crops that are resistant to drought and altering their planting schedules to adapt to changing rainfall patterns. These community-driven initiatives ensure that adaptation measures are tailored to the context and culturally appropriate.

Enhancing Infrastructure

Pouring resources into robust infrastructure is crucial for minimizing susceptibility. In the Netherlands, forward-thinking flood defenses such as the "Room for the River" initiative have revolutionized flood control, permitting rivers to safely spill over into designated zones. This strategy not only safeguards individuals and assets but also rejuvenates natural habitats.

Policy and Leadership

Effective policies and leadership structures are essential for unified adaptation strategies. Nations like Rwanda have woven climate resilience into their national development strategies, making certain that every sector takes into account the risks posed by climate change. Open and participatory decision-making processes foster trust and guarantee that adaptation efforts are fair.

Funding Sources

Obtaining financial resources is a significant obstacle to adaptation, especially for developing nations. Global efforts such as the Green Climate Fund seek to offer financial backing for adaptation projects. Additionally, microfinance initiatives and insurance solutions designed for the benefit of vulnerable groups can significantly contribute to increasing adaptive capabilities.

Making Climate Change Personal

Climate change can often seem distant and intangible, yet its effects are deeply personal. Narratives of individuals and communities adapting to these shifts

bring a human element to the issue. Think of Maria, a farmer in Guatemala who has adapted her farming techniques to grow crops that are more resistant to unpredictable weather, or Ahmed, a fisherman in the Maldives who is dealing with the issues of coral bleaching and dwindling fish populations. Their tales of resilience and creativity inspire optimism and highlight the significance of adaptation.

Conclusion

The link between vulnerability and adaptation to climate change is inextricably connected to human welfare and progress. As the impacts of climate change grow stronger, it's critical to concentrate on the most at-risk populations and ensure that adaptation strategies are inclusive and just. By paying attention to the experiences of those at the forefront and supporting solutions driven by communities, we can forge a more robust and sustainable future for everyone. The personal stories behind the statistics remind us that climate change is not merely a scientific issue but a deeply human one.

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The influence of *Chromolena odorata* leaf extract and leachate on the food intake of coastal species.

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Abstract

Allelopathy, a natural phenomenon happens when biosynthetic compounds or metabolites created by one living being affect the development, maturation, and reproduction of different species. Such organisms that develop toxins are called invading species. One of the invasive species from the Asteraceae family, *Chromolena odorata* (L.) R. M. King & H. Rob, was chosen for study because of its allelopathic effect on the nutritional uptake potential (N, P, K, Ca, Mg, S, Zn, Fe, Mn and…) of some costal species. It is evident from this study that the invasive weed's leaf leachate and leaf extract have a significant impact on the micro and macronutrient contents of the studied plant species, and that this species either directly or indirectly inhibits the growth and development of other plants. Hence it is required to eliminate the *Chromolaena odorata* an invasive plant from coastal line vegetation. This will help to rebuild the mangrove vegetation over the coastal line and also aid to protect them in their natural habitat. *Chromolena odorata* is a plant that may therefore be used to make weedicide or herbicide.

Keywords: Allelopathy, Chromolena odorata, mineral uptake, invasive species, mangrove associate

Introduction

Chromolaena odorata, or Siam weed, is a fast-growing Asteraceae perennial shrub. It is native to Central and Southern America but has become an invasive weed in tropical Asia, Africa, and the Pacific. Shrubs spread and scramble. In open areas, the plant can grow 3–7 meters. Devil weed, French weed, communist weed, hagonoy, and co-hoy are other names. (Ngozi et al., 2009; Chandrasekaran and Swamy, 2010; Vaisakh and Pandey, 2012). In Sawantwadi taluka, District Sindhudurg, Maharashtra, it is known by commom name Ranmodi. Due to its invasive and

allelopathic nature, this weed has been categorized as one of the most hazardous weeds worldwide. It was introduced to numerous locations either on purpose or by error as an ornamental plant (Vaisakh and Pandey, 2012; Otarigho and Morenikeji, 2013). The younger leaves of *C. odorata* are toxic due to high levels of nitrate (Orapa et al., 2002).

In a preliminary survey, it was marked that a vast area of land, especially in the roadside of coastal area of Sawantwadi, Maharashtra are infested with the weed. But now days, it grows along estuarine region and sea shores. The research on the effects of Siam weed or its extracts on the growth of other coastal plants is limited. Keeping the above background in mind, the current study aimed to assess the allelopathic effects of Siam weed aqueous leaf extract and leaf litter leachate on mineral nutrient metabolism in selected coastal plant species.

Material and method:

Acid digestion method of Toth et al., (1948) has been followed for the analysis of inorganic constituents. Leaves were collected and washed with water blotted to dry and then kept in oven at 600C till a constant weight was obtained. The oven dried plant material was randomly combined and pulverized. The sulphur content was determined according to the method of Blanchar et al., (1965). Sodium and potassium were estimated flame photometrically using standard procedure on flame photometer. The remaining inorganic elements viz. calcium, potassium, magnesium, iron, manganese, zinc and copper were estimated using atomic absorption spectrophotometer (P-E, 3030 A).

Result discussion:

Every organism on earth requires a continual nutrition supply to live and to complete its life cycle. These nutrient substances they obtain from external sources rely on habitat of that organism. In plants nutrients necessary must be in their inorganic type.

According to Mengel and Kirkby (1982) mineral absorption capability of plants is always specific, genetically programmed for the different mineral nutrients. There are distinct 16 most important mineral elements required by plant in more or less amount for their typical optimal growth. As per requirement or essentiality of these element, they are classed as macronutrients (N, P, K, Ca, Mg, S, and Na) which are found and needed by plants in comparatively higher levels and micronutrients (Fe, Mn, Cu, Zn, Mo, B and Cl) that are found and needed by plants in relatively fewer amounts. Both these mineral elements are crucial for physiological and biochemical activities.

According to Marschner (1986) these micro and macronutrients requirement directly or indirectly related with various metabolic processes in their life of organism. Therefore, both are essential to govern entire productivity of that organism (plant). The mineral absorption potential values are largely depending on plant type, plant age and concentration of other mineral components. This figure may alter based on several things including pH, composition and constituents of soil, climate, significant rain fall. Which may lead to develop shortage of mineral elements in plants (Gauch, 1972). The poor environmental conditions also impede the uptake, transport and distribution of plant nutrients throughout the plant body.

Epstein (1972) and Rain (1976) revealed nutritional deficiencies and accompanying effects on plant metabolism. Mineral deficient plant presents different indications like chlorosis, malformation, dwarfism (restricted growth), dieback and eventually death of plant. In present investigation, it was thought that the status of these mineral nutrients may give an idea about adaptability and luxuriant growth of the costal plant species also. Following account is regarding the status of mineral elements under different treatments of *Chromolaena odorata.*

Nitrogen

The influence of leaf extracts and leaf leachate of *Chromolaena odorata* on nitrogen contents of few coastal species have depicted in Fig. 1. It is evident from results that under controlled condition 5.62% nitrogen content is highest level observed in Ipomoea pes-cprae and that 3.28% lowest found in Acanthus ilicifolius, among all studied plant species. In other studied plants nitrogen accumulation found as 3.52% in Sonneratia alba, 3.97% in Derris trifoliata, and that 3.84% in Salvadora persica under same control condition.

One quite observant macronutrient found in plants is nitrogen. In an organism, it serves as the building block of nitrate, nitrite, amino acids, amide, urea, ammonia, hexacosamines, quaternary ammonium compounds, proteins and many other metabolites. Most of the metabolic activities occur in cells similar to photosynthesis, protein metabolism, chlorophyll synthesis, in transport and signaling activity, enzyme component (RUBISCO), respiration, in cell division, synthesis of alkaloids, glucosides, contribute to the structure of nucleotide bases, nucleic acids (RNA and DNA), phytohormones IAA, Cytokinins, Polyamines Co-enzyme NAD and NADP (Murata, 1969; Penning de vries, 1975; Chapin,1980; Delgado et al., 1994; Gastal and Lemaire, 2001; Leigh, 2003).

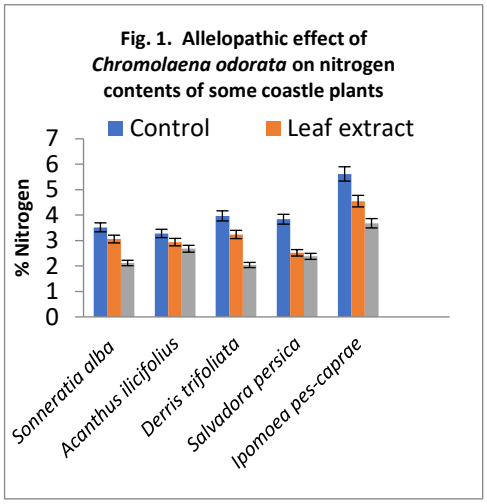


Fig. 1. Allelopathic effect of *Chromolaena odorata* on nitrogen contents of some coastle plants

As per mentioned by Marschner (1986), the nitrogen content range between 2 to 5 % is essential for optimal growth of plant and it depends on the plant species, developmental stage and organ of the plant. According to Parsa and Bagheri (2008) the minimum amount 1to 2% requirement of nitrogen in plants and 4 to 6% is highest amount ranges of it.

In current study, Leaf leachate and leaf extract treatment of *Chromolaena odorata* both found adversely affecting nitrogen contents of all studied coastal plants. In leaf extract treatment highest loss (34.38%) in nitrogen content observed in Salvadra persica (From 3.84 to 2.52% nitrogen) and that lowest 10.37% of total nitrogen found in *Acanthus ilicifolius* (It fall down from 3.28 to2.94% nitrogen). Under this treatment other studied plants found

same kind of decrease in nitrogen content viz. In *Sonneratia alba* 13.07% loss of total nitrogen, in Derris trifoliata 18.39% loss and that 19.04% decline of total nitrogen observed in *Ipomoea pes-caprae* as compare to same.

In case of leaf leachate treatment of *Chromolaena odorata* higher decrease /decline in total nitrogen content observed than that of leaf extract treatment of same and control condition. Under this leaf leachate treatment highest decline in nitrogen content observed in *Derris trifoliata* (48.61% loss) and lowest loss under same treatment observed in *Acanthus ilicifolius* (18.29% of total nitrogen) as compare to control of same. In *Sonneratia alba* 39.77% loss in total nitrogen, in *Salvadora persica* 38.02% loss and that 34.52% decrease in total nitrogen content observed in *Ipomoea pes-caprae* as compare to nitrogen level observed at control condition in same.

Nitrogen act as fundamental element in various structures of cell, tissue, organ and even entire organism therefore alteration in this element highly impact on total growth of organism. Hence from result it can be concluded that *Chromolaena odorata* compete other plants by attacking directly or indirectly on their nitrogen metabolism. From overall observation of current study, it is apparent that nitrogen uptake and distribution is markedly disturbed due to influence of allelochemicals of *Chromolaena odorata* in all studied plants. This may lead to further alterations in the overall metabolism in influenced plants. As per earlier mentioned by Gallacher and Sprent (1978) total nitrogen reflects the total plant growth. Thus, the studies of nitrogen uptake and its partitioning give a very good idea about essential measure to improve the overall crop productivity. Hence it can also conclude that allelochemicals of Chromolaena odorata hampers the net productivity of other plants. In general, it appears that the nitrogen metabolism seems to be rather sensitive to allelochemicals of *Chromolaena odorata* in all studied plant species.

Phosphorus

One of the macroelement necessary for plant development via several metabolic processes is phosphorus. Usually, a decrease in its contents causes a decrease in the rate of several metabolic activities. Inside all living cells, it is found as inorganic phosphorous, phosphate ester, and as energy-rich phosphate bonds.

Fig. 2 shows in present work allelopathic influence of leaf extract and leaf leachate of *Chromolaena odorata* on phosphorous content of coastal plant species. Results clearly show that phosphorous contents drop under both these *Chromolaena odorata* treatments as compared to control. In control condition among investigated coastal plant greatest phosphorous absorption potential observed in Ipomoea pes-caprae and that lowest 0.19% observed in *Sonneratia alba* as well as in *Salvadora persica.* In *Acanthus ilicifolius* this potential is observed as 0.237%; in Derris trifoliata as 0.24. These levels fall within the range of ideal need for it from 0.1 to 0.5 % of the dry weight as stated for other plants or agricultural crops by Marschner (1986).

Phosphorus exists in phosphor lipids as well as in the nucleic acid (DNA and RNA both). As ATP, in all living entities it serves as building block of biological

energy. < Phosphorus hence is essential for many different kinds of biological activities.

According to Grattan and Grieve (1992) phosphorus accumulation in plant tissues depends on experimental conditions and a type of plant cultivar. In present study, under leaf extract treatment *Chomolaena odorata* phosphorus contents found decline in all studied plants. Highest decline 47.37% of total phosphorus observed in *Sonneratia alba* and that lowest decline 12.50% of total phosphorus observed in *Ipomoea pes-caprae* under this treatment of *Chromolaena odorata*. In this leaf extract treatment 24.89% decline observed in *Acanthus ilicifolius*, that 20.83% decrease in Derris trifoliate and 15.79% total phosphorus content decline in Salvadora persica as compare to control one of same.

While in leaf leachate treatment of same Chromolaena odorata plant highest decrease in total phosphorus uptake potential recorded than that of leaf extract treatment and control. Under this leaf leachate treatment lowest fall down 21.05% loss reported in Salvadora persica as compared with control among all investigated plants. In *sonneratia alba* 31.58% decline of total phosphorus level observed which is less that under leaf extract treatment 47.37% of same plant. Except *Sonneratia alba*, in all other studied plant higher decline in total phosphorus level under this leaf leachate treatment observed. Viz. 39.2% loss observed in *Salvadora persica* as compared with control among all studied plants. In sonneratia alba 31.58% decline of total phosphorus level observed which is less that under leaf extract treatment 47.37% of same plant. Except *Sonneratia alba*, in all other studied plant higher decline in total phosphorus level under this leaf leachate treatment observed. Viz.39.2% decline in *Acanthus ilicifolius*, that 37.50% in *Derris trifoliate* and that 32.81% decrease in total phosphorus content observed in *Ipomoea pes-caprae.*

It may be concluded from finding that allelochemical treatment of *Chromolaena odorata* adversely affect phosphorus absorption capability of other plants. Which ultimately results into impairment of all metabolic activities of other plants due to scaricity development in phosphorus contents. Therefore, it can also mention allelochemical created by *Chromolaena odorata* are useful for itself to reduce plant natural rivalry for nutrition acquirement. Phosphorus regulates the photosynthesis and glucose metabolism and via which it limits reproductive growth and finally decides the yield. Hence it can say that allelochemicals emit from *Chromolaena odorata* responsible to fall production of other plants.

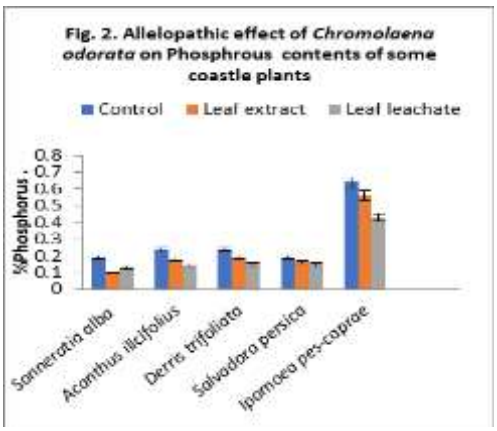


Fig. 2. Allelopathic effect of *Chromolaena odorata* on Phosphrous contents of some coastle plants

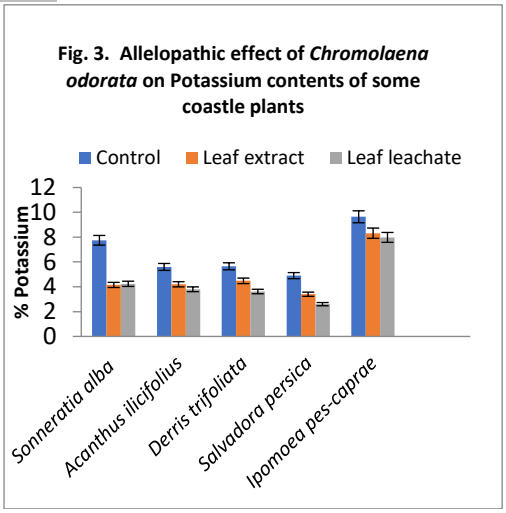


Fig. 3. Allelopathic effect of *Chromolaena odorata* on Potassium contents of some coastle plants

Potassium

Effect of leaf extract and leaf leachate treatment of *Chromolaena odorata* on potassium uptake potential of certain coastal plant (*Sonneratia alba, Acanthus ilicifolius, Derris trifoliata, Salvadora persica and Ipomoea pes-caprae*) have been depicted in Fig.3. It is obvious from finding that with both treatment potassium contents detected decreased in all tested coastal plants.

Potassium is a primary micronutrient that contributes to plant growth and development in a variety of ways, including photosynthesis, protein and carbohydrate translocation, ribosome stability, protein synthesis, nitrogen metabolism, carbohydrate metabolism, glycolysis, phosphorylation, and adenine biosynthesis, as enzyme catalysts, stomatal behavior, and plant osmoregulation, among others. (Suelter, 1970; Humble and Raschke, 1971; Ben-Zioni et al., 1971; Peoples and Koch, 1979; Marschner, 1997).

Epstein (1972) reported 1% potassium plants require for their optimal growth. In extant investigation at control condition highest potassium contents 9.64% observed in *Ipomoea pes-caprae* and that lowest 4.9% potassium observed in *Salvadora persica* among all studied plants. Potassium content in other studied plants under same condition observed as *Sonneratia alba* 7.75%, in *Acanthus ilicifolius* 5.6% and in *Derris trifoliata* 5.65%. These values observed are much higher than that of optimal requirement for normal growth as described by Epstein (1972). But these results can be supported by Leigh et al. (1984) noted that potassium which is the most abundant inorganic constituent in higher plants attaining the concentration as high as 10 % of plant dry weight. That elevation in potassium may be due to impact of coastal ecological condition (halophytic condition) and adjustment of plants with that. According to Golldack et al., (2002) plant adaptations to salt stress (halophytic condition) involves marked reprogramming of potassium channel gene expression in the leaves. Similar kind of results i.e. accumulation of potassium higher than optimal requirement have been noted by Karmarkar (1965) in *Bryophyllum pinnatum* 1.85 % potassium, that 1.89% (dry wt.) in Portulaca oleracea (Karadge, 1981), 2.04 % in *Cassia* species on dry wt. basis (Patil, 2009). and by Naik (2009) upto 2.4 to 2.6 % potassium in grape.

According to Mengel and Krikby (1982), potassium deprivation in plants causes a decrease in nitrate reductase activity, disruption of protein metabolism, and the buildup of amino acids and soluble organic nitrogenous substances.

Under leaf extract treatment of *Chromolaena odorata* decrease in total potassium content observed in all studied

coastal plants. In this treatment, highest 46.45% decrease in total potassium content of same observed in *Sonneratia alba* and that lowest 13.69% in *Ipomoea pes-caprae*. In *Sonneratia alba* this decrease in potassium content is highest than that of leaf leachate treatment 45.29%. In leaf extract treatment 25% loss in total potassium content observed in *Acanthus ilicifolius*, that 20.71% loss in total potassium in *Derris trifoliata*, 30.61% decrease in *Salvadora persica* and that 13.69% loss in total potassium content observed in *Ipomoea pes-caprae* as compare with control of same.

In case of leaf leachate treatment maximum decline in potassium content observed than that of leaf extract treatment of *Chromolaena odorata* (except in *Sonneratia alba*) in all studied plants. Under this treatment highest decrease of total potassium 46.94% observed in *salvadora persica* and that lowest decline 17.22% in *Ipomoea pes-caprae*. In other studied plants decrease in total potassium content observed as 45.29% loss in *Sonneratia alba*, 32.14% in *Acanthus ilicifolius* and 35.93% in *Derris trifoliata*.

As a result of the findings, it is feasible to conclude that *Chromolaena odorata* allelochemicals have a deleterious influence via changing potassium-related metabolism such as osmoregulation and reducing important enzyme systems such as reduction nitrate reductase activity. *Chromolaena odorata* produces toxic allelochemicals that inhibit the growth and development of other plants by interfering with their potassium uptake potential, resulting in failures in a variety of mechanisms such as photosynthesis, protein and carbohydrate translocation, ribosome stability, protein synthesis, nitrogen turnover, and so on.

Sodium:

Effect of leaf extract and leaf leachate of *Chromolaena odorata* on sodium concentrations of certain coastal plant species (viz. *Sonneratia alba, Acanthus ilicifolius, Derris trifoliata, Salvadora persica and Ipomoea pes-caprae*) have been presented in Fig. 4. It is obvious from data that under both these allelochemical treatments of *Chromolaena odorata* discovered accountable for reduction in salt levels in all tested plants.

The range of sodium for healthy growth of normal plants as glycophytes as stated by Chirputkar (1969) and Gauch (1972) is 0.1 to 1.4% dry wt. Na concentration reported greater in the vacuoles than in cytoplasm halophytes (Greenway and Munns, 1980). From present study it is observed that in controlled state highest sodium accumulation 9.5% found in Crotalaria retusa and that lowest 2.69% sodium found in *Acanthus ilicifolius* among all studied plant. Sodium level pattern in studied plants found as *Ipomoea pes-caprae* > *Salvadora persica* > *Sonneratia alba* > *Derris trifoliata* > *Acanthus ilicifolius* at control condition. In *Sonneratia alba* 4.35% sodium, in *Derris trifoliata* 3.79% sodium, in *Salvadora persica* 6.9%, in Crotalaria verrucosa 7.65% and that 8.4% sodium contents observed in *Ipomoea pes-caprae* under control. The range of sodium here found much higher than adequate level given by Chirputkar (1969) and Gauch (1972). Which may play key part of luxuriant growth of these coastal plants. But results support theory of Flowers et al., (1977) which have revealed that halophytes require

sodium for growth, notably in C4 and CAM plants and some halophytes require very high concentration of Na for their maximal growth.

Sodium is macronutrient which is most necessary because of its role in plant growth, development and metabolism. Which have been reported by several researches as it accountable for stimulation of growth with non-modifying C4 photosynthetic activity, during nitrate uptake NO3- reduction and its subsequent incorporation into proteins resulting in growth improvement, in some monocots plants Na increased the NR activity, Na caused to stimulate the growth through cytokinin mediated functions and high levels of alanine, in few succulent halophyte Na contributes to the internal osmotic potential, it contributes in osmotic prospective of cell, sodium maintain the functional integrity of mesophyll cell chloroplasts (Rains, 1972; Mengel and Kirkby, 1982; Nable and Brownell, 1984; Matoh et al.,1986; Ohta, et al, 1987, 1988; Brownell and Bieling, 1996 and Pujol et al. 2001). Enzymatic role of sodium has been reported by several contributors as activator for some enzymes like ATPase, Nitrate reductase, pyruvate phosphate kinase, PEP-case (Evans and Sorger ,1966; Kylin, 1973, Shomer-Ilan and Waisel, 1973).

From current study it can be revealed that all studied coastal plants shown same kind of response to leaf extract treatment of Chromolaena odorata i.e decline in sodium contents. Under this treatment maximum prominent 22.16% % decline and minimum 5.52% decrease in total sodium observed in Derris trifoliate and Sonneratia alba respectively. In same treatment sodium contents found 6.332%decrease of total in *Acanthus ilicifolius*, that 11.59% in Salvadora persica, and that 9.52% decrease in sodium content of *Ipomoea pes-caprae* as compare with control one of them.

As compare with leaf extract treatment and leaf leachate treatment of *Chromolaena odorata* found responsible for more decline in sodium level of all plant studied. Highest decline 34.83% and lowest decline 15.94% in sodium content observed under this leaf leachate treatment in Derris trifoliata and Salvadora persica respectively. Due to this treatment pattern of sodium level (accumulation) found changed as *Salvadora persica* > *Ipomoea pes-caprae* > *Sonneratia alba* > *Derris trifoliata* > *Acanthus ilicifolius*. In this treatment of leaf leachate of *Chromoleana odorata* change in sodium content found as 16.78% loss of total sodium in *Sonneratia alba*, 27.51% decrease in *Acanthus ilicifolius*, and that 32.14% decrease in sodium content of *Ipomoea pes-caprae* as compare with control one of them.

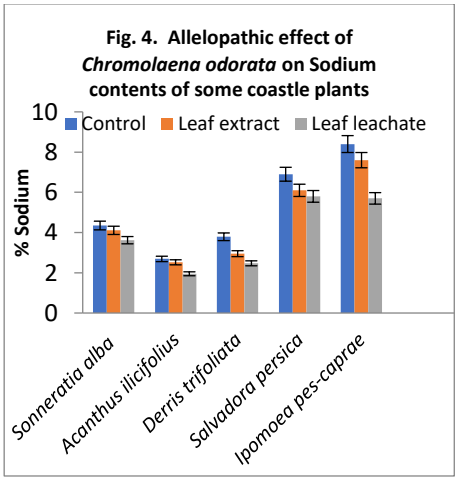


Fig. 4. Allelopathic effect of *Chromolaena odorata* on Sodium contents of some coastle plants

From the outcome it may be stated that allelochemicals of *Chromolaena odorata* influences sodium contents / uptake potential of other plants. It reveals their harmful impact on growth, development and metabolism of predicted plants. That may cause imbalancement in osmotic potential, reduction in enzymatic activity and directly or indirectly slowing growth and development in treated plants.

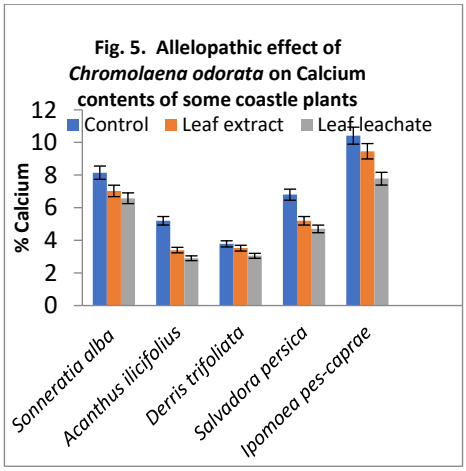


Fig. 5. Allelopathic effect of *Chromolaena odorata* on Calcium contents of some coastle plants

Calcium

The effect of leaf extract and leaf leachate (allelochemicals) of *Cromolaena odorata* on calcium contents of few coastal plant species have been depicted in Fig. 5. It is evident from results that highest calcium content 10.42% observed in *Ipomoea pes-caprae* and lowest 3.78% in *Derris trifoliata* under control condition. Under leaf extract and leaf leachate both treatments found responsible to decline total calcium contents of all studied coastal plants.

Calcium is one of the most critical plant macronutrients. Calcium is a non-hazardous mineral element, at high concentration also and is particularly efficient in detoxifying larger concentrations of other elements in plants (Clarkson and Hanson, 1980). The principal job carried out by calcium in plants is to bond with proteins, nucleic acids and lipids to impact cell adhesion, membrane chromatin arrangement and enzyme conformation (WynJones and Lunt, 1967; Burstrom, 1968; Mengel and Kirkby,1982; Renzel, 1992 and ….so on).

There are multiple findings relating various enzymes were catalysed by calcium such as ATPase, Protein kinase, Pyruvate kinase, nuclease, α- amylase, esterase, pectin esterase, lipoxygenase, polygalacturonase, transaminase and glucose 6-phosphate dehydrogenase. Many researchers have found that calcium regulates activity of enzymes such as phospholypase, ATPase, nitrogenase, nitrate reductase, esterases, pectin esterases, lipoxygenases, nucleases, protein kinase, pyruvate kinase, polygalacturonictransminase and glucose -6- phosphate dehydrogenase (Davidson and Long, 1958; Dodds and Ellis, 1966; Wyn Jones and Lunt, 1967; Clarkson and Hanson, 1980; Clark, 1984; Poovaiah and Reddy, 1987 and Jones et al., 1993).

Salisbury and Ross (1995) revealed that the 0.2 % dry weight is critical concentration of Ca for dicots and that less than 1% for monocots. It is evident from current result that calcium contents under controlled condition found as 8.15% found in *Sonneratia alba*, 5.2% in *Acanthus ilicifolius*, 3.78% in Derris trifoliate and 6.8% in Salvadora persica. This level of calcium found much higher than optimal requirement of normal plants. Similarly high level of calcium reported in *Portulaca oleracea* leaves 4.4 % (dry wt.) calcium was recorded by Karadge (1981) and 2.57 to 3.37 % (dry

wt.) calcium in the leaves of Cassia species was recorded by Patil (2009).

In case of leaf extract treatment of *Chromolaena odorata* decrease in calcium content observed in all studied plants. Highest decline 34.62% of total calcium content observed in *Acanthus ilicifolius* (i.e. calcium content falls down from 5.2% to 3.4% calcium) and that lowest 6.88% of total calcium content observed in *Derris trifoliata* (i.e. from 3.78 to 3.52% calcium) as compare with control one of same among all studied plants. In other studied plants under this treatment calcium content found as 7.03% in *Sonneratia alba* (13.74% decrease)5.2% in *Salvadora persica* (23.53% decline) and 9.46% calcium in *Ipomoea pes-cprae* (9.21%) loss.

In leaf leachate treatment more decrease in calcium content were observed than leaf extract treatment of *Chromolaena odorata* in all studied plants. Under this leaf leachate treatment highest decline 44.23% observed in *Acanthus illicifolius* (i.e. calcium content decreased from 5.2% to 2.9% calcium) and that lowest decrease 19.31% observed in *Derris trifoliata* (i.e. calcium 3.78% to 3.05%) as compare to control of same. In *Sonneratia alba* 19.26% loss in total calcium contents, in *Salvadora persica* 30.88% and that in *Ipomoea pes-cprae* 25.34% decline in total calcium contents observed under this leaf leachate treatment of *Chomolaena odorata*. According to Miller and Claude (1983) calcium deficiency responsible to decline the activities of enzymes nitrogenase and nitrate reductase.

Hence from overall observation it can be conclude that *Chromolaena odorata* impacts calcium uptake potential adversely which may lead to drop in activation of numerous enzymes. Which directly or indirectly affects metabolic processes in those plants. And it may also be concluded that drop in calcium under examined treatment demonstrates decline in productivity of those plants via decline in catalyzing rate of nitrate reductase, nitrogenase and other key enzymes. All tested plant displays greater calcium content which may useful to them to nullify toxicity of other minerals.

Magnesium

Change in Magnesium content under allelopathic treatment of *Chromolaana odorat* in some coastal plants have been depicted in Fig. 6. It is clear from result that like other macronutrient magnesium also found decline under all these studied treatment in all plant studied as compare to control of them. Among all studied coastal plant magnesium content found highest 0.98% in Ipomoea pes-caprae and that lowest 0.12% in *Sonneratia alba* under control condition. Although, the magnesium concentration in the leaves of most studied plants is lower than that of critical value, no any plant species show any deficiency syndrome observed in them.

Magnesium is a tiny, mobile, and strongly electropositive divalent cation found in plants. According to Kirkby and Mengel (1967), magnesium is an important macronutrient that plays an important role in various metabolic processes in plants. It interacts with organic ions such as citrate, oxalate, malate, and pectate, as well as inorganic anions, and it also contributes to the electrical neutrality of organic compounds such as sugar phosphates, sugar nucleotides, organic acids, and

amino acids. Magnesium, according to several researchers, functions as a catalyst for numerous enzyme systems involved, activating enzymes carboxylases, RuBP carboxylase, oxygenase, ATPase, RNA polymerase, nitrate reductase, catalase, glutamate dehydrogenase, peroxidase, and RNAase. (Clark, 1984; Marschner and Cakmak, 1989; Khurana et al., 2005). Magnesium plays vital role of joining the ribosomal subunits (Cammarano et al., 1972).

Medicinal importance of magnesium reported by different workers as it is essential in muscle relaxation after contraction, Mg deficiency may causes neuromuscular symptoms such as tetany, an extreme and prolonged contraction of the muscles, along with various medicinal drugs it helps to control hypertension and heart diseases, diabetes, osteoporosis, migraine headaches and asthma (Liao and Seinfeld, 1998; Paolissoet al.,1992; Sojka and Weaver, 1995; Whitney and Rolfes, 1997; Mauskop and Altura, 1998 and Cydulka, 1996). As per Food and Nutrition Board of the Institute of Medicine (2004) mentioned daily requirement of Mg is 420 mg/ day fulfill diet.

According to Epstein (1972) up to 2% Mg cations as critical value in the plants on a dry weight basis. In current investigation under control condition this level found much less than its critical level in all studied plants as 0.64% Mg cations observed in *Acanthus ilicifolius*, that 0.46% in *Derris trifoliate* and that 0.92% in *Salvadora persica*. These values are supported by similarities with earlier reports of various researchers as in Portulaca leaves, 0.3 % (dry wt.) Mg (Karadge,1981), in mulberry varieties ranges 0.2%– 0.8% (dry wt.) Mg (Duke, 1983 and Khade, 2007), in *Cassia* species, 0.28 % to 0.37 % (dry wt.) Mg (Patil, 2009), in *Morinda* species range from 0.3 to 0.5 % (dry wt.) Mg (Desai, 2011).

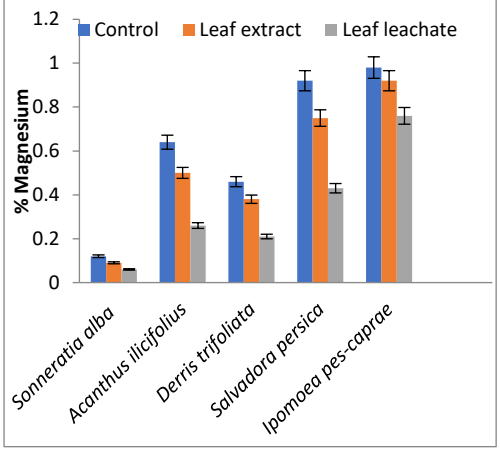
Under allelopathic treatment of leaf extract of *Chomolaena odorata* there is decreased magnesium level observed in all studied plants. Maximum prominent decline 25% observed in *Sonneratia alba* and lowest or less prominent decline observed in total magnesium content of Ipomoea pes-caprae as compare with control one of same and among all studied plants. There is 21.88 % loss in total magnesium content of *Acanthus ilicifolius*, 17.39% decline of Derris trifoliata, 18.48% of *Salvadora persica*, and 6.12% decrease in total magnesium content of *Ipomoea pes-caprae* observed under this leaf extract treatment as compare to control one of same.

In case of leaf leachate treatment higher loss in magnesium level observed than that of leaf extract treatment among all studied plants. Under this treatment highest decrease 59.38% observed in *Acanthus ilicifolius* as compared with control of same. Under this treatment of leaf leachate *Sonneratia alba* shown 50% decline in total Magnesium content (declines from 0.12% upto 0.06% Magnesium), that 54.35% decrease in Derris trifoliata, 53.26% decline in *Salvadora persica*, and that 22.45% fall down in total magnesium of *Ipomoea pes-caprae* (i.e. from 0.98 to 0.76% Magnesium) as compared with control one of them.

Consequently, the results of this study imply that the allelopathic impact of *Chromolaena odorata* therapy lowers

magnesium concentration, which in turn prevents the activation of numerous enzymes. Hence, it was determined that the metabolism of the plant under study was abnormal. It has the potential to reduce enzyme activity such as catalase, acid phosphatase, and ATPase as well as protein synthesis, chlorophyll a and b levels, and biomass. In the end, it was determined that other plants' photosynthetic efficiency was lowered by *Chromolaena odorata*.

Fig. 6. Allelopathic effect of *Chromolaena odorata* on Magnesium contents of some coastle plants



Sulphur (S)

It is clear Fig.7 shows how *Chromlaena odorata* allelochemicals affect coastal species' sulphur levels. The results show that these treatments reduce sulphur in all plants except *Sonneratia alba*.

Sulphur is one of the key macro nutrients for healthy growth and development of plants. Marschner (1995) described various role of sulfur as a component of amino acids viz. cysteine, and methionine. That is, it plays key function in synthesizing proteins and nitrogen metabolism. It aids in stability of protein structures by generating disulfide bonds and sulfydryl (Saito, 2000). It plays crucial role of control of numerous enzymes involve in redox reaction (Nazar et al., 2011). It operates as component of many secondary metabolites and useful for manufacture of gaseous hormone ethylene (Koprivova et al., 2008) in plants. i. e., it has important status in ripening or maturation of plants. It involves in electron transport chain as component of Iron–Sulfur protein and also important for formation of Ferredoxin and Photosystem-I in chloroplast (Yabe et al., 2008).

For optimum for plant growth 30 m mol kg-1 sulphur is sufficient (Bahboudian et al., 2003) and as per suggested by Durenkamp and De Kok (2004) it is sulfur requirement 0.03 to 2 m mol Kg-1 dry weight of plant. According to Munson (1998) optimum value of sulphur in plant species is in the range 0.08 to 1.56 %. In current study under control condition highest 0.74% sulphur contents found in *Acanthus ilicifolius* and that lowest 0.12% sulphur found in *Sonneratia alba* among all studied plants. The pattern of sulphur level found in all studied plants is as *Acanthus ilicifolius* > *Ipomoea pes-caprae* > *Salvadora persica* > *Derris trifoliata* > *Sonneratia alba*. In *Derris trifoliata* 0.19% sulphur, and *Salvadora persica* 0.28% sulphur, and that 0.64% sulphur contents found in *Ipomoea pes-caprae* under controlled condition.

The decrease or maximum use of sulfur mostly takes in the chloroplast in aerial region of plants. As per Crawford et al. (2000) leaf is the principal location of sulfur assimilation and it is transferred to other plant parts through phloem with the help of plasma membrane sulfate transporters.

In extract treatment of *Chromolaena odorata* sulphur contents found reduced in all studied plants except *Sonneratia alba* as compare to control one of same. After this treatment sulphur level pattern found changed as *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Derris trifoliata* > *Salvadora persica* = *Sonneratia alba*. Under this leaf extract treatment highest decrease 46.43% observed in Salvadora persica and that lowest 9.38% decrease in total sulphur level in *Ipomoea pes-caprae* as compare with control. Except in *Sonneratia alba* there is increase in sulphur contents found by 25% of total. While in other studied plants sulphur level found as 35.14% decline in *Acanthus ilicifolius* and that 15.79% decline in *Derris trifoliate* as compare with control of them.

In other treatment i.e. leaf leachate treatment of *Chromolaena odorata* same kind of behaviour 0f decline sulphur level observed. In *Sonneratia alba* only 58.33% elevation in total sulphur observed under this treatment. While in all other studied plants decrease in sulphur content observed as compare with control one of them. Under this treatment pattern of sulphur accumulation in all studied plant again found changed as *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Sonneratia alba* > *Salvadora persica* > *Derris trifoliata*. Under this leaf leachate treatment of *Chromolaena odorata* highest 64.86% decline in sulphur level or accumulation observed in *Acanthus ilicifolius* and that lowest 31.25% decrease in total sulphur contents found in *Ipomoea pes-caprae*. In *Derris trifoliata* 42.11% loss of total sulphur, that 57.14% loss in *Salvadora persica* under this leaf leachate treatment of *Chromolaena odorata* as compare with control one of them. Same kind of reduction in sulphur under salinity impact in leaves of soybean and of Sorghum have been reported by Nukaya et al. (1982) and Clark et al. (1999). Similarly in Hibiscus reduction of the sulfur content under saline impact noticed by Sonar (2013).

It may be concluded from result all researched plants were collected and experimented in coastal region consequently they may be under halophytic affect. Under impact of allelopathic compounds of Chromolaena odorata, all plants suffer from oxidative stress which may be managed by utilizing or reducing sulphur available to bear stress. Loss in sulphur also suggests its negative impact on net productivity of plant due to loss in the chlorophyll production process (Tandon, 1991). From impact of present treatment of *Chromolaena odorata* on sulphur contents, furthermore it can be concluded that it causes inhibition of protein synthesis and ultimately leads in reduction of biomass output in influenced plant.

Copper

Allelopathic effect of *Chromolaena odorata* on copper contents of some coastal plant species have been depicted in Fig. 8. It is evident from result that except *Sonneratia alba* copper content found decreases under both leaf extract and leaf leachate treatment among all studied plants. Copper content pattern among all studied plants found as *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Sonneratia alba* > *Derris trifoliata* under control condition.

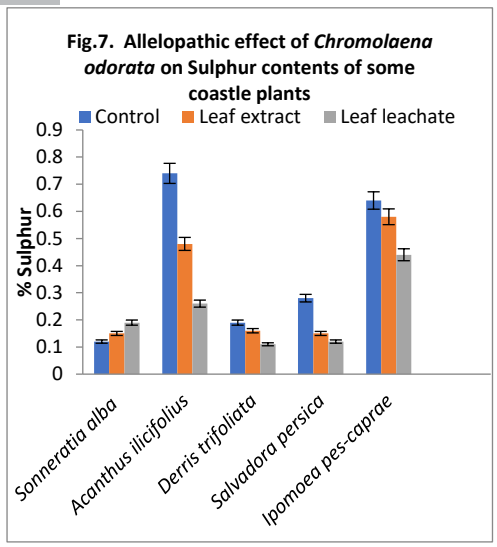


Fig.7. Allelopathic effect of *Chromolaena odorata* on Sulphur contents of some coastle plants

Photosynthesis and respiration are two major processes in plants, which influences the plant production and copper plays vital part in both these processes. Copper is crucial micronutrients is involved in many metabolic redox reactions as a component of various metalloenzymes and it also appears to perform as an intermediate electron acceptor in the direct oxidation of substrate by molecular oxygen (Gupta, 1979). Copper is a constituent of number of enzymes such as, ascorbic acid oxidase, cytochrome oxidase, monoamino oxidase, phenolase, tyrosinase, urease and laccase. Copper has a crucial part in oxidative stress responses since as cofactor in Cu/Zn superoxide dismutase. Various workers reported role of copper in various metabolic processes as in signaling of transcription and protein trafficking machinery, oxidative phosphorylation and iron mobilization(Yruela, 2005), involve in cytocrome oxidase complex of mitochondrial electron transport chain (Kaim and Schwederski, 1995), also act as constituent of plastocyanin which forms part of the electron transport chain (Taiz and Zeiger, 2006), cu has vital role in complex-IV of respiratory system, in maintaining membrane structure of thylakoids (Henriques, 1989) and also act as a stabilizer of the lipid environment close to electron carriers of PSII complex (Baron et al., 1995 and Maksymiec, 1997).According to Sandman and Boger (1983) copper is present in three different forms in proteins such as blue protein, non-blue proteins and mutlicopper proteins. This element is able to exist in multiple oxidative states in vivo. Under the cellular conditions Cu can exist both as Cu2+ and Cu+.

The deficiency symptoms of copper reported by several workers as production of dark green leaves containing necrotic patches(Taiz and Zeiger, 2006), plant appear twisted or malformed and they may abscise prematurely, deficiency may leads to decline soluble carbohydrates considerably (Mizuno et al., 1982), deficiency affect photosystem-I due to decreased level of plastocyanin (Baszynski et al., 1978, Shikanai et al., 2003), this deficiency may induces the activity of ferric reductase enzyme, (Kochian, 2000).

Strain and Cashman (2003) reported the copper deficiency symptoms in human infants as prematurity, low birth weight and malnutrition especially when combined with feeding practices such as cowmilk or total parental nutrition.

High concentration of Cu also results in copper toxicity affecting overall growth and biomass (Marschner, 1995). Oxidative stress is also caused due to

Cu-toxicity and photosynthetic process is reduced (Luna et al., 1994).

According to Baker and Senef (1995), the average Cu content in plant tissue is 10 µg/g dry wt., normal range of copper content in agricultural crops is reported to be 5 to 30 mg kg-1 dry weight (Gupta, 1979), critical deficiency level of copper in vegetative parts is generally in the range of 3 to 5 µg g-1 dry weight (Marschner, 1986). But according to Robson and Reuter (1981) this range can be larger depends on the plant species, plant organ, developmental stage and nitrogen supply available. In copper tolerant species range as high as 0.1% of the dry weight (Morrison et al., 1981) and as per stated by Munson (1998) that sufficient cu concentration of plant leaf is about 5 to 30 ppm.

In current investigation under control condition highest 243.12 ppm copper content found in *Ipomoea pes-caprae* and lowest 29.03 ppm observed in Salvadora persica among all studied plants. In *Sonneratia alba* 30.82 ppm copper contents, that 92.98 ppm in *Acanthus ilicifolius*, 29.92 ppm in Derris trifoliate and 29.03 ppm in *Salvadora persica*, 46.43 ppm.

In case of leaf extract treatment of *Chromolaena odorata* rather than *Sonneratia alba* all other studied plant shown decline in copper contents as compare with control one of same. In *Sonneratia alba* under this leaf extract treatment maximum elevation 11.29% in treatment of copper content observed which is higher than that of leaf leachate treatment 4.61% elevation. In other studied plant under same leaf extract treatment 6.92% lowest decline in copper content in *Salvadora persica* as compare with control of same. In *Acanthus ilicifolius* 9.38% decline, in *Derris trifoliata* 18.58% decrease and that in *Ipomoea pes-caprae* 11.08% reduction in copper content observed under that leaf extract treatment as compare to control.

In leaf leachate treatment of *Chromolaena odorata* except *Sonneratia alba* all other plants studied found showing decline in copper content more than that of leaf extract treatment of some plant. Minimum 13.17% reduction in copper content observed in *Acanthus ilicifolius* under this leaf leachate treatment. The reduction % of copper uptake in studied plants found as 28.04% in *Derris trifoliata*, 24.70% in *Salvadora persica* and that 19.54% reduction in *Ipomoea pes-caprae* under this treatment as compare with control of same. Percentage reduction pattern observed in studied plants for copper contents found as *Derris trifolita* > *Salvodora persica* > *Ipomoea pes-caprae* > *Acanthus iliifolius* under this treatment. While in *Sonneratia alba* there is elevation of 1.42 ppm in copper content observed under same leaf leachate treatment of *Chromolaena odorata*.

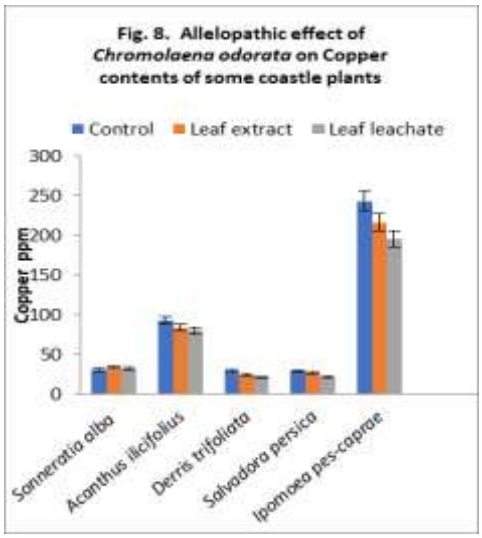


Fig. 8. Allelopathic effect of *Chromolaena odorata* on Copper contents of some coastle plants

Therefore, it may be concluded from result that *Chromolaena odorata* advesaly influence on plant productivity, via altering/disturbing synthesis of numerous metalloenzymes and also affect adversely electron transport chain. It can also be determined that *Chromolaena odorata* responsible to create deficiency syndrome of copper in examined coastal plants i.e. it directly/indirectly effect on iron metabolism and decline therapeutic characteristics of plants.

Manganese (Mn++)

Effect of leaf leachate and leaf extract treatment (allelochemicals) of Chromolaena *odorata* on manganese content of some coastal plant viz. S*onneratia alba, Acanthus ilicifolius, Derris trifoliata, Salvadora persica and Ipomoea pes-caprae* have been illustrated in Fig. 9. It is evident from result both treatments found responsible to decline manganese content in studied plants (Except *Sonneratia alba* in leaf leachate treatment).

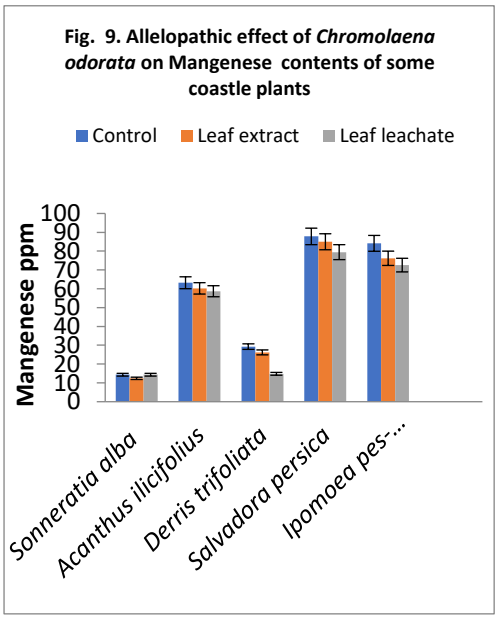


Fig. 9. Allelopathic effect of *Chromolaena odorata* on Mangenese contents of some coastle plants

Manganese plays a critical part in linked with the Oxygen Evolving Complex in the process of photosynthesis. As described by Malkin and Niyogi (2000), manganese atoms are capable of water oxidation in the light reaction of photosynthesis. It acts as electron storage pool and transporting it to the chlorophyll reaction centre (Diedrick, 2010). It also has important role in catalyzing many metabolic processes (Mousavi et al., 2011) by activating more than 35 different enzymes as IAA oxidase, RNA polymerase (Mengel and Kirkby, 1982), Mn-SOD (Clemens et al., 2002), Mn-catalase, carboxylase, carboxykinase (Ducic and Polle, 2005), Nitrite reductase (Nicholas, 1961), glutamine synthase (Elliott, 1953), dehydrogenases and decarboxylase (Marschner, 1995) and so on. Manganese plays key part in biosynthesis of various substances such as ATP fatty acid, acyl lipids and proteins, chlorophyll, tyrosine, lignin, flavonoids and isopprenoids (Pfeffer et al., 1986; Ness and Woolhouse, 1980).

Manganese requirement of plant species differs from species to species. According to Manganese concentration required for optimal for plant growth is 2 - 30 mg 100 g-1 dry tissue (Munson,1998), the critical deficiency levels of manganese are between 10-20 mg g-1 dry (Marschner, 1986), Stout (1961) reported 0.005% is an adequate concentration of manganese required by any plants, 50-300 mg Mn kg-1 dry wt. is an adequate leaf Mn concentration (Clarkson, 1988). In present study, the manganese content found in studied plant showing pattern as *Salvadora persica* > *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Derris trifoliata* >

Sonneratia alba under control condition. The values of Mn in studied plants recorded in present investigations fall in the range quite higher (Fig.30). At this condition minimum 14.35 ppm manganese contents observed in *Sonneratia alba*. At the same condition 63.19 ppm manganese content observe in *Acanthus ilicifolius*, that 29.26 ppm in *Derris trifoliata*, 81.87 ppm in *Salvadora persica* and that 84.13 ppm in *Ipomoea pes-caprae.* Terenteva and Dorozhkina, (1967) reported, 110-118 mg kg-1 the uptake of Mn by potato plants leaves and stems as the maximum content at the ripening stage.

In leaf extract treatment of *Chromolaena odorata* decline in manganese contents observed in all studied plants. Highest 13.45% decline and lowest in 3.25% decline in manganese content observed in *Sonneratia alba* and *salvadora persica* respectively under this treatment if leaf extract. Percentage reduction pattern in manganese content under this leaf extract treatment found as *Sonneratia alba* > *Derris trifoliata* > *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Salvadora persica.* It indicates that leaf extract of *Chromolaena odorata* alters manganese metabolism in all plants by reducing its content as 4.70% reduction of manganese in *Acanthus ilicifolius*, that 10.53% in *Derris trifoliata*, 12.26% in *Crotalaria verrucosa*, 4.48% in *Crotalaria retusa* and 9.44% loss of manganese content found in *Ipomoea pes-caprae*.

In case of leaf leachate treatment of same plant more decline in manganese level observed than leaf extract treatment except *Sonneratia alba* among all studied plants. Under this treatment highest 49.35% decline and lowest 7.14% decline in manganese contents observed in *Derris trifoliata* and *Acanthus ilicifolius* respectively in all studied plants under this leachate treatment. In *Sonneratia alba* only there is no any kind of alteration observed in manganese uptake and accumulation found. In other studied plant percentage decrease pattern found as *Derris trifoliata* > *Ipomoea pes-caprae* > *Salvadora persica* > *Acanthus ilicifolius* under leaf leachate treatment. This treatment found responsible to decline manganese content as 9.53% decline in *Salvadora persica* 18.27% loss in manganese content of *Ipomoea pes-caprae* as compare to control one of them.

From the result it can be claimed that *Chromolaena odorata* adversely influences micronutrient uptake potential of other plant and generate shortage of nutrient among them to reduce competition. Manganese act as ingredient in chlorophyll component indicating its amount directly affect photosynthetic efficiency. Hence, it may be concluded that *Chromolaena odorata* adversely affect photosynthetic efficiency of other plants.

Iron (Fe++)

The change in concentration of Fe +3 in few coastal plants under allelochemical treatment of *Chromolaena odorata* (Leaf extract and leaf leachate treatments) is recorded in Fig. 10. It is evident from result that both leaf extract and leaf leachate treatment of *Chromolaena odorata* have significantly inclined the ferrous contents of all studied plants. In control state highest 892.27 ppm and lowest 59.52 ppm iron contents found in *Acanthus ilicifolius* and *Derris trifoliata*

respectively among all studied plants. Same kind of iron concentration in different plants have been reported by Karadge (1981) in *Portulaca oleracea* leaves 0.08 % (dry wt.) iron, in *Cassia* species, 0.376 % (dry wt.) iron by Patil (2009), in Cleome sps in range of 0.04326 to 0.312 % (dry wt.) iron by Aparadh (2011) and many others. The pattern of Fe +3 concentration found in studied plants is *Acanthus ilicifolius* > *Ipomoea pes-caprae* > *Salvadora persica* > *Sonneratia alba* > *Derris trifoliata* under control condition. The concentration of Fe +3 this control condition is found as 267.79 ppm in *Sonneratia alba*, 592.45 ppm *Salvadora persica* and that 884.04 ppm Fe +3 concentration in *Ipomoea pes-caprae*. These iron values are much higher than adequate value of it for optimal growth of plants is 100 ppm (0.01%) as reported by Stout (1961) and Epstein (1972).

Iron deficiency responsible to cause degradation of chlorophyll structure and loss of chlorophyll. Iron deficiency studied in human being indicates reduction in haemoglobin, myoglobin and iron containing enzymes which may cause fatigue, restlessness and impaired work performance allied with anemia (Strain and Cashman, 2003). Iron is an immobile microelement. Iron is engrossed by plant roots in its ionic form Fe2+ or as Fe chelate, which are soluble and therefore available to roots. It involved in many metabolic reactions in plant as well as animal bodies as in oxidation, reduction reactions, ferredoxin formation and chlorophyll synthesis (Spillar and Teny, 1980 and Machold and Stephan,1969), it acts as component of electron transmitters in chloroplasts and mitochondria, it takes part in formation of cytochromes (Hochmuth, 2011). Iron is a constituent of enzymes like peroxidase, catalase, nitrate reductase, cytochrome oxidase and many other enzymes. Iron deficiency causes reduction of nitrate reductase activity and chlorosis (Bennett, 1945; Perur et al., 1961). Iron serves as cofactor for enzyme aconitase in TCA cycle (Curie and Briat, 2003). Iron plays imperative role in ribonucleotide dinitrogen reduction and energy yielding process of electron transfer chain (Guerinot and Ying, 1994).

In current study it is clear from results that leaf extract treatment of *Chromolaena odorata* decrease in Fe+3 concentrations observed in all studied coastal plants. Under this treatment maximum 23.96% decrease in iron content observed in *Acanthus ilicifolius* and *Sonneratia alba* respectively. Under this treatment decline in ferrous content was observed as 15.33 ppm in *Sonneratia alba* (5.72% decline), 213.79 ppm loss of ferrous in *Acanthus ilicifolius* (23.96%), 5.46 ppm decline in *Derris trifoliata* (9.17%), 49.17 ppm decrease in *Salvadora persica* (8.30%) and that 211.26 ppm reduction in Fe +3 contents observed in *Ipomoa pes-caprae* as compared to control one. In case of *Sonneratia alba* only leaf extract treatment found highly responsible to maximum decline in Fe +3 contents than leaf leachate treatment of *Chromolaena odorata*.

In case of leaf leachate treatment same kind of decline but maximum decline that of leaf extract treatment observed in all studied plants (except *Sonneratia alba*). Under this treatment maximum prominent iron decrease 56.05% and that minimum 3.78% observed in *Acanthus*

ilicifolius and *Sonneratia alba* respectively (i.e. loss of 500 ppm and 10 ppm Fe +3 content respectively). The percentage decline pattern of Fe +3 found as *Acanthus ilicifolious* > *Derris trifoliata* > *Ipomoea pes-caprae* > *Salvadora persica* > *Sonneratia alba* as compare with control one. In *Derris trifoliata* 45.55% decline, in *Salvadora persica* and that 35.04% decrease in Fe +3 content of *Ipomoea pes-caprae*.

In current study from fundamental observations, it can be concluded that rather than *Acanthus ilicifolius* all other studied plants in their natural state may have their utility in medicine to control iron deficiency anemia. As per reported by Curie and Briat (2003) in free state Fe in the cell iron interacts with oxygen and form hazardous oxygen species. Therefore, it may be concluded from finding that *Chromolaena odorata* will be useful to regulate generation of reactive oxygen species radicals. Hence it is useful to boost antioxidative potential of other plants. From overall results of Fe +3 content, it may be deduced that *Chromolaena odorata* impacts iron metabolism adversely. There it may be mentioned that plant competition of *Chromolaena odorata* may experience iron deficiency problem hence they back-off from competition. It also implies *Chromolaena odorata* extract or leachate may be useful as herbicide or weedicide directly or indirectly.

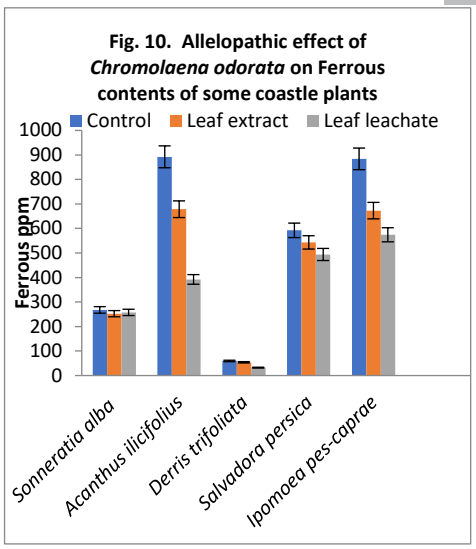


Fig. 10. Allelopathic effect of *Chromolaena odorata* on Ferrous contents of some coastle plants

Zinc

Effect of *Chromolaena odorata* on zinc contents some coastal plants through leaf extract and leaf leachate treatments of it have been demonstrated in Fig. 11. Except *Acanthus ilicifolious* all other investigated plant exhibited unfavorable influence of these treatments regarding zinc accumulation.

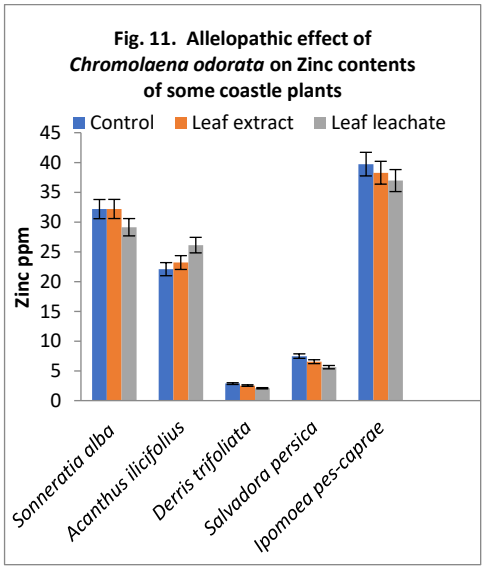


Fig. 11. Allelopathic effect of *Chromolaena odorata* on Zinc contents of some coastle plants

Zinc is considered as the third most significant limiting nutrient (micronutrient) in crop yield after N and P. Zinc is needed for carbohydrate metabolism and regulation of ingestion of carbohydrates, nitrogen metabolism, protein synthesis, auxin production, notably IAA synthesis. It is necessary primarily for chlorophyll biosynthesis. As per mentioned by Skoog (1940) and Tsui (1948), zinc involve in biosynthesis of indole acetic acid (IAA) from its precursor, tryphtophan. It is closely linked in nitrogen metabolism. Its significance in membrane stability by amendable the level of oxidizing O2 species is documented by Pinton et al. (1994). Zinc acts either as a metal factor or as a functional, structural or regulatory cofactor of a large number of enzymes viz. superoxide dismutase, alcohol dehydrogenase, glutamic acid dehydrogenase, carbonic anhydrase, aldolases, isomerases, transphosphorylases and RNA and DNA polymerases as well as proteinases and peptidases (Ohki, 1976; Dell and Wilson, 1985, Vitosh et al., 1994, and Marschner, 1995).

Zinc deficiency is characterized by a reduction in internodal growth resulting into rosette habit of a plant. Zn deficiency in wheat plant decreases NR activity and NO3 content (Harper and Paulsen, 1969). Deficiency of zinc is reported to cause chlorotic conditions of the mulberry leaves (Rangaswami et al., 1978). The activity of many enzymes is congested under zinc deficiency conditions. Ghildiyal et al. (1986) have observed a dwindle in protein, nitrogen substance and boost in free amino acid content of linseed varieties under Zn deficiency which indicates that Zn is playing an outstanding role in plant metabolism. Epstein (1972) reported 0.002 g/100g (dry wt.) zinc essential for optimal growth of plant. The critical deficiency levels of Zn are below 15–20 mg kg-1 dry weight of leaves and critical toxicity levels of zinc in leaves of crop plants are more than 400–500 mg kg-1 dry weight basis (Marschner, 1986). According to Vitosh et al., (1994) the plants having lower than 20 ppm zinc in their tissues suffer from zinc deficiency. In case of present investigation, it is evident from result that highest 39.72 ppm zinc contents observed in *Ipomoea pes-caprae* and that lowest 2.86 ppm observed in *Derris trifoliata* under control condition in all studied plants. The pattern of zinc content in studied plant under control condition found as *Ipomoea pes-caprae* > *Sonneratia alba* > *Acanthus ilicifolius* > *Salvadora persica* > *Derris trifoliata* under control condition Zn content in *Sonneratia alba* as 32.17 ppm, in *Acanthus ilicifolious*, 22.08 ppm, in *Salvadora persica*. Therefore, from this result, it can conclude that coastal plants like *Salvadora persica, Crotalaria verrucosa* and *Derris trifoliate* may endure from zinc deficiency problems. But these plants haven't shown any kind of deficiency syndrome.

In leaf extract treatment of *Chromolaena odorata* except *Sonneratia alba* and *Acanthus ilicifolious* all other studied plant shows significant reduction in zinc concentration. In *Sonneratia alba* Zn concentration found elevated by 0.02 ppm and in *Acanthus ilicifolius* 1.08 ppm elevation / increase observed under this leaf extract treatment. While this treatment for other studied coastal plant found responsible to decrease zinc

concentration as 11.54% decline in *Derris trifoliata*, 12.57% decline in Salvadora persica and that lowest 3.63% decline in Zn concentration observed in *Ipomoea pes-caprae* as compare with control one of them.

Under leaf leachate treatment of *Chomolaena odorata* all plants studied except *Acanthus ilicifolius* shown decline in their zinc concentration (uptake and translocation). At this treatment maximum 41.51% reduction and minimum 6.95% reduction observed in *Crotalaria retusa* and *Ipomoea pes-caprae*. Under same treatment percentage decline Zn concentration pattern found as *Derris trifoliata* > *Salvadora persica* > *Sonneratia alba* > *Ipomoea pes-caprae*. While Acanthus ilicifolius under this treatment shown significant increase 18.30% in Zn concentration. It indicates that *Acanthus ilicifolius* is more tolerant to any kind of environmental stress than other studied plants. In *Sonneratia alba* 9.48% decline, in *Derris trifoliata* 27.27% decline, in *Salvadora persica* 24.87% decrease under this leaf leachate treatment of *Chromolaena odorata*.

From results it appears that zinc uptake and translocation is highly altered due to leaf leachate than leaf extract of *Chromolaena odorata*. Higher concentration of zinc indicates higher stress tolerance capacity of plant. Therefore, it can be concluded from result *Ipomoea pes-caprae* naturally more stress tolerant plant. It also can conclude that allelochemicals from *Chromolaena odorata* may positively or negatively alters this stress tolerance capacity of other plant by changing zinc content in them.

Conclusion

Chromolaena odorata is fast growing perennial ever green shrub native to south America and central America. It has become an aggressive invasive weed in tropical Asia, Africa and in some parts of Australia. Leaf leachate and leaf extract treatment of *Chromolaena odorata* both adversely affect nitrogen contents of all studied coastal plants. The allelochemicals of *Chromolaena odorata* hampers the net productivity of other plants and the nitrogen metabolism seems to be rather sensitive to allelochemicals of *Chromolaena odorata* in all studied plant species.

Phosphorous contents get decreased under both these treatment of *Chromolaena odorata* as compared to control. It can be concluded the allelochemical treatment of *Chromolaena odorata* adversely affect phosphorus uptake potential of other plants.

Potassium content was decreased in all studied coastal plants under both leaf extract and leaf leachate treatment. Nitrate reductase enzyme activities were reduced with decline in potassium contents. It can also be concluded that allelochemicals of *Chromolaena odorata* influences sodium contents and show adverse impact on growth and development of studied plants. *Chromolaena odorata* affects calcium uptake potential adversely which may lead to decline in activation of various enzymes. This directly or indirectly affects metabolic processes in those plants. The decline in calcium under studied treatment showed decline in productivity of those plants via decline in catalyzing rate of nitrate reductase, nitrogenase and other essential enzymes.

Due to allelopathic treatment of leaf extract of *Chomolaena odorata* there was decreased magnesium level observed in all studied plants. Leaf leachate treatment caused higher loss in magnesium level than that of leaf extract treatment among all studied plants. The treatment of *Chromolaena odorata* declines sulphur contents, due to this inhibition of protein synthesis and ultimately results in reduction of biomass production in influenced plant. *Chromolaena odorata* adversely affected micronutrient uptake potential of other plant and created scarcity of nutrient among them to minimize competition. Copper, manganese, iron and zinc contents were found decreased under both leaf extract and leaf leachate treatment among all studied plants. The allelochemicals from *Chromolaena odorata* may positively or negatively alters stress tolerance capacity of other plant by changing zinc content in them.

Hence it is required to eliminate the *Chromolaena odorata* an invasive plant from coastal line vegetation. This will help to rebuild the mangrove vegetation over the coastal line and also aid to protect them in their natural habitat (in situ conservation).

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The Intricacies of Rust Fungi: Ecology, Pathogenicity, and Genomics

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Abstract

Rust fungi, classified as Pucciniales, are complex pathogens with significant ecological and agricultural impacts. They exhibit intricate life cycles and infect a wide range of hosts, posing challenges for management. Taxonomic classifications have evolved from morphology to include molecular insights, revealing new families and genera. India's diverse climate supports a rich diversity of rust species. Genomic studies have uncovered genes crucial for pathogenicity, offering potential targets for control strategies. Integration of genomic data promises ongoing advancements in mitigating rust fungi's global agricultural impact.

Keywords: Rust fungi, Pucciniales, genomics, taxonomy.

Introduction

Fungi are a crucial component of Earth's ecosystems, playing pivotal roles in decomposition, nutrient cycling, and symbiotic relationships with higher plants. They inhabit nearly every plant species on the planet, including both endophytic fungi, which live within plant tissues, and mycorrhizal fungi, which form beneficial partnerships with plant roots. Despite their beneficial roles, fungi can also be formidable pathogens, causing significant damage to plants and leading to substantial economic losses in agriculture, horticulture, and forestry worldwide (Agrios, 2005; Doehlemann et al., 2017).

Among the diverse group of plant pathogens, rust fungi (Order Pucciniales) are particularly noteworthy due to their complexity and impact. Rust fungi are responsible for some of the most destructive plant diseases, affecting a wide range of host plants from crops and medicinal herbs to shrubs and trees. Their infections can lead to severe reductions in crop yield and quality, making them a significant concern for agriculture and forestry (Aime, 2006; Aime & Mc Taggart, 2020; Gutam et al., 2021).

The Diversity and Impact of Rust Fungi

Rust fungi are classified within the order Pucciniales, which is distinguished by a

range of life cycle forms and host interactions. These fungi are predominantly obligate biotrophs, deriving their nutrients exclusively from living host tissues. Their complex life cycles often involve multiple spore stages and can span across different host species, making them particularly challenging to manage and control.

Rust fungi are known for their wide host range and diversity. They infect not only agricultural crops but also non-agricultural plants such as medicinal herbs, shrubs, trees, and even weeds. This broad host range contributes to their status as a limiting factor in the successful cultivation and growth of plants. Rusts are classified into various families based on characteristics such as teleutospore morphology, and their life cycles can be autoecious (completed on a single host) or heteroecious (requiring two different hosts) (Laundon, 1973; Cummins & Hiratsuka, 1984).

Taxonomy and Classification

The taxonomy of rust fungi has evolved significantly over time. Early classifications were based primarily on the morphology of teleutospores (the resting spores). Dietel (1900) divided rusts into two families: Melampsoraceae and Pucciniaceae. Melampsoraceae was characterized by sessile teleutospores, while Pucciniaceae was defined by pedicellate teleutospores. Further refinements in taxonomy have introduced additional families such as Coleosporiaceae and Cronartiaceae, although the traditional two-family system remains influential.

The classification of rust fungi has been challenged by the limitations of morphological criteria alone. Recent advances in molecular techniques have led to a more nuanced understanding of rust taxonomy. The identification of spermogonial types and other morphological features has provided additional insights into the evolutionary relationships among rust fungi. This has resulted in the recognition of new families and genera, reflecting a more comprehensive view of rust diversity (Hiratsuka & Cummins, 1963; Savile, 1976; Cummins & Hiratsuka, 1984).

Rust Fungi in India

India, with its diverse climatic conditions and rich flora, is home to a significant number of rust fungi. Taxonomical studies of Indian rusts began over 150 years ago, with pioneering work by researchers such as Berkeley, Butler, Bisby, and J.D. Hooker. Despite these early efforts, the information on rust fungi in India has often been scattered and incomplete.

Recent studies have focused on cataloging the rust flora of India, with substantial contributions from researchers like Thirumalachar, Mundkur, Ramachar, and others. The rust fungi of Maharashtra, in particular, have been extensively studied due to the state's varied climatic conditions, which support a diverse fungal population (Mundkur, 1944; Patil, 1966; Sathe, 1965). This research has revealed a rich diversity of rust species, contributing to our understanding of their distribution and impact.

The Life Cycle of Rust Fungi

The life cycle of rust fungi is complex and can involve up to five distinct spore stages. These stages include:

1. **Teliospores:** The overwintering stage, which germinates into a basidium.

2. **Basidiospores:** Dispersed by wind to infect a new host.
3. **Pycnia and Pycniospores:** Involved in sexual reproduction.
4. **Aecia and Aeciospores:** Infective stage in heteroecious rusts.
5. **Uredinia and Urediniospores:** Responsible for asexual reproduction and repeated infections.

Each of these stages plays a crucial role in the pathogen's ability to spread and cause disease. The transition from one stage to another can be influenced by environmental factors such as temperature, moisture, and host availability (Leonard & Szabo, 2005; Anikster, 1986; Kolmer et al., 2009).

Advances in Genomics

The study of rust fungi has entered a new era with the advent of genomics. Unlike many other fungi, rust fungi often possess large and complex genomes, reflecting their intricate life cycles and host interactions. Recent genomic analyses have provided insights into the genetic basis of rust pathogenicity and adaptation.

Genomic studies have revealed that rust fungi have relatively small and compact genomes compared to other eukaryotes, with notable exceptions among some plant pathogens (Raffaele & Kamoun, 2012). The genomes of rust fungi often contain large numbers of transposable elements and repetitive sequences, which contribute to their size and complexity. Additionally, the presence of multigene families, particularly those encoding effector proteins, is crucial for successful plant infection (Duplessis et al., 2011; Martin et al., 2010).

The sequencing of rust fungal genomes has led to the identification of genes involved in cell wall degradation, nutrient acquisition, and modulation of host immune responses. These findings have enhanced our understanding of the molecular mechanisms underlying rust pathogenicity and have opened new avenues for developing effective control strategies (Kemen & Jones, 2012; Spanu, 2012).

Conclusion

Rust fungi are among the most complex and impactful plant pathogens, with a significant role in agriculture, horticulture, and forestry. Their intricate life cycles, broad host ranges, and diverse spore stages make them a challenging group to study and manage. Advances in genomics have provided valuable insights into the biology of rust fungi, revealing the genetic and molecular mechanisms underlying their pathogenicity.

Ongoing research and the integration of genomic data will continue to enhance our understanding of rust fungi and inform strategies for their control. As our knowledge of these fascinating organisms expands, so too will our ability to mitigate their impact on plants and agriculture worldwide.

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Synthesis And Characterization of *Allium cepa* Bulb Bioplastic

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Abstract

Plastic pollution is one of the most serious issues facing the environment as a result of the rapid manufacture of plastic. Synthetic plastic takes a very long time to decompose, reported at 500-1000 years, and becomes hazardous after decomposition. The only alternative available for synthetic plastic is bioplastics which are more economic, ecofriendly, and bio-degradable. The objective of this study is to synthesize biodegradable plastic from the dried peel of *Allium cepa* (ACP). One of the most consumed vegetables *A.cepa* (onion), contains the highest levels of cellulose (41–50%) and hemicelluloses (16–26%) which is important for the production of bioplastic. The main procedure in the preparation of *A.cepa* peel (ACP) bioplastic was delignified, bleached, acid hydrolyzed and neutralized which culminated in successfully extracting cellulose. By mixing the key components i.e., 15 g extracted cellulose, 10gms starch, and 5ml glycerol and 15ml acetic acid ACP bioplastic was obtained. This ACP bioplastic sample was subjected to various tests followed by soil degradability, water solubility, water absorption, and ash weight test respectively, to determine the properties of bioplastic. In this research paper, Bioplastic was made by using ACP, showing effective degradation with environmental factors. As a result, *A.cepa* peels bioplastic can be considered an excellent eco-friendly remedy for alleviating the adverse effects on the environment of synthetic plastic.

Keywords: Bioplastic, Environment, Cellulose-based, allium cepa peel, Bio-degradable.

Abbreviations: *ACP- Allium cepa peels, EDAX- Energy- dispersive X-ray spectroscopy, SEM- Scanning Electron Microscopy*

Introduction: Today, synthetic plastic has been employed substantially in industries and household appliances. Synthetic plastics are utilized extensively in the manufacturing process of a broad spectrum of products, notably beverage bottles, toys, alimentary packaging, furniture, and clothing. (Bezirhan and Bilgen, 2019). Bioplastics are created from renewable resources such as starch, cellulose, chitosan, and protein. Bioplastics are sustainable, degradable and eco-friendly. Bioplastic shrinks carbon dioxide emissions, is recyclable, environmentally conscious, and minimizes the need for fossil fuels. Natural resources like lignin's, proteins, lipids and polysaccharides (such as starch, chitin and cellulose) can be directly used to make bioplastics (Krishnamurthy and Amritkumar, 2019). In the present work, A. cepa peels were used to make cellulose-based bioplastic that has the potential to reverse the scenario impacting increasing plastic production. A. cepa peels contain cellulose (41–50%) and hemicellulose (16–26%) (Anjaneyulu et al., 2020), much of which is degraded over time. Dried A. cepa peels is readily available in excess amounts. The advantage of using A. cepa peels is that it is cost-effective and found to be non-toxic after degradation. Bioplastics after investigations were further found to be soluble in water and degradable in soil, making them ecologically beneficial. Because of the positive eco-friendly characteristics they possess, bioplastics can be utilized efficiently in packaging and various other industries.

Allium is a genus of monocotyledonous flowering plants in the family Liliaceae. *Allium cepa* grows commonly all over the world (Marrelli et al., 2018). It is a bulbous biennial herb and consists of 500 species. *A.cepa* has fibrous and adventitious roots, and the bulb is made up of concentric leaf bases which are fleshy .This plant is a bulbous geophyte that primarily grows in temperate biomes. It has environmental and social uses (POWO, 2023). The outermost covering of the bulb dries and forms a thin protective coat whereas the inner layer thickens and develops into a bulb. These bulbs are elongated and ovoid and their size varies depending on the species.

Materials And Methodology

Materials

Dried *A. cepa* peel, Magnesium hydroxide (Mg (OH)2, Sodium chlorate (NaClO3), Sulphuric acid (H2SO4), Corn starch, Acetic acid, Glycerol analytical grade chemicals were used.

Methodology

Collection and preparation

The dried peels of *A. cepa* were collected, ground to a fine powder and weighed (15 g). The powdered A. cepa peels was boiled at 110°C for 1 h in a water bath. 18% Magnesium hydroxide was prepared in distilled water. This slurry of 18% magnesium hydroxide and powdered ACP was then kept in a water bath at 80°C for 1 h. The treated powder was washed with distilled water twice to ensure there should be minimum traces of 18% magnesium hydroxide. The lignin was removed from the material sodium chlorate, 0.7% sodium chlorate solution was prepared in distilled water, this washed powder was added to the solution. The slurry of 0.7% sodium chlorate and powdered ACP was then kept at 110°C for 1 hour in a water bath

until the odour and colour were lost. The slurry was then washed twice using distilled water, this slurry treated with 0.7% of sodium chlorate was added to 17.5% magnesium hydroxide and kept at room temperature for 30 min. Finally, the A. cepa pulp was subjected to acid hydrolysis using 40% sulfuric acid, for 1hour at 40°C, which was washed to neutralize the slurry completely. The resulting product was cellulose obtained from the dried peels of A. cepa. (Fig.I) (Reddy et al.2018).

Fabrication of Bioplastic

10 grams of starch, 15ml of Acetic acid, 5 ml of glycerol, 60 ml of D.W., and 20-gram cellulose extracted from ACP was added, this mixture was kept in a hot plate stirrer for 15 mins stirred on continuous interval. Until a thick viscous slurry of the mixture is obtained.

Fig.A. Extracted cellulose

Fig. B. Allium cepa bioplastic

It is spread into an acrylic mold for 24 hours to air dry, resulting in a sheet of ACP bioplastic (Bezirhan and Bilgen 2019).

Analysis

Physical Characterization of cellulose bioplastic (Marichelvam et al., 2019)

Thickness test

The sample of bioplastic was measured (2 cm × 2 cm), and the thickness was calculated using a Vernier caliper. For the measurements, readings were taken from 10 different spots and the means average of the same has been calculated for the thickness.

Water solubility test

The test of water solubility was carried out by taking 4cm x 4cm square of sample of bioplastic and weighed (1.0g). This sample was kept at 22oC for 10 days, stirred with a glass rod twice after the interval of 24 hours. The sample bioplastic was removed after 10 days, dried and weighed. Where, (Wi) is the Initial weight, and (Wf) is the final weight.

Moisture content (%) = [(Wi-Wf)/Wf] ×100

Ash weight

To determine the ash weight of the sample of bioplastic, the sample is weighed into an empty crucible and then kept into muffle furnace at 300 0 C temperature for 5 min to obtain ash. Let us assume the weight of the sample (WA), weight of crucible added to the ash content will be taken as (WB), the initial weight (Wi), take the weight of the empty crucible which is (Wo).

Ash weight (g) = [(WB - Wo)/WA] x 100

Absorption weight

The test of water absorption was carried out by a 5cm x 5cm square of sample of bioplastic. later, this sample was placed into D.W. and kept at 22oC. The measured bioplastic was placed into the D.W. for 10 days. The sample bioplastic was removed removed after 10 days, let us assume, Initial weight (Wi) and Final weight (Wf) (Bezirhan and Bilgen 2019).

Moisture Content (%) = [(Wi-Wf)/Wf] ×100

Soil degradability test

The test of soil degradability was carried out by burying the sample of bioplastic in the soil, a layer of 13 cm of soil was use to completely bury the bioplastic. This was sprinkled with water twice each day for 10 days and then the degradability of bioplastic was determined. Let us assume, Initial weight (Di) and final weight (Df) is the weight obtained from bioplastic after buried time.

Rate of Soil Degradation (%) = [(Di-Df)/Df] ×100

SEM Analysis

The surface characterization of bioplastic was determined through Scanning Electron Microscope (SEM) using (Model: Quanta 200) analysis (Amin et al., 2019).

EDAX (Energy Dispersive X-ray Spectroscopy)

The physio-chemical characterization of A. cepa bioplastics were analyzed using the EDAX-analysis, to determine the chemical component of A. cepa bioplastic (Amin et al., 2019).

Tensile Strength Analysis

The Texture analyzer with TA-DGF probe was utilized to examine the bioplastic's tensile strength in order to ascertain the sample's tensile strength.

Results & Discussion

Bioplastic Sample	Initial weight	Final weight	Difference
Water solubility	1.00 gm	0.42gm	0.58 gm
Water absorption	1.00gm	1.73gm	0.73 gm
Soil degradability	5.00gm	4.79gm	0.21 gm
Ash weight	1.00gm	0.86gm	0.74 gm

Tab.I Physical property of bioplastic samples

Physical characterization

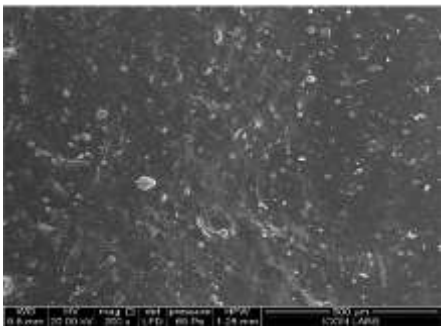
The thickness of the bioplastic was measured where, the result showed thickness to be 0.30mm (300 micron). According to the regulation, the mandatory thickness for plastic is 500 microns, the research is successful in synthesizing a bioplastic of 300 micron. As the major constituent in the self-life of any biological derived or material made from waste or plant origin is the moister content in it, A. cepa peels bioplastic showed 16% of moisture content, this minimum percentage of moisture content can be considered as a decent amount enhance the shelf life of the bioplastic. Water solubility of the films is an indicator of the presence of hydrophilic compounds in the film (Sharma et al., 2016). The plastic made form the mixture of A. cepa peels and glycerol made has shown substantial water resisting property as it represents greater intermolecular interaction between the molecules, hence the A. cepa peels film has low water solubility percentage (Tab.I). The easiest method

to determine the degradability of any material is the weight loss of the sample, in the case of A. cepa peels bioplastic the sample of 5 g were used calculate the degradation rate, in the initial 10 days the sample was of the same weight and strength after 20 days the sample started to change the structure as well as lost it weight in the amount of 0.023g for the 24th day. The sample started to break down into pieces on the 30th day of the test (Tab.I). These results showed that the A. cepa peels bioplastic is completely degradable and lasts for longer duration of time than any other organic component (Bilo et al., 2018).

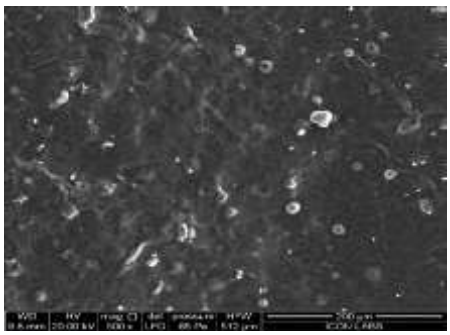
SEM (Scanning Electron Microscopy)

The machine used for micro structure or magnified observation of bioplastic was (Model: Quanta 200). The surface microscopic images of cellulose-based bioplastic, when it was observed at 200000X magnification it showed some starch molecules did not show any structural conformations to show binding to cellulose molecules (Amin et al., 2019). SEM imaging of cellulose bioplastic depicted some insoluble molecules, but these molecules are 1% of the area of investigation (white structure (Fig.III.3), the surface structure studied at the magnification of 200X, emphasized that the components of cellulose-based bioplastic are completely gelatinized and dissolvable (Fig.III.3). This analysis also discovered that cellulose bioplastic has a slightly irregular structure with furrows and grooves (Fig.III.1). Although outwardly it shows plain and uniform surface. However, showed uneven structure in higher magnification. This bioplastic has more compatibility in binding of molecules; however, presence of some non- gelatinized molecules has cause hinderance in strength and durability of the bioplastic in accordance to morphological structure. SEM analysis and (Fig.III.4) shows starch, glycerol, acetic acid the plasticizer and cellulose *has given bioplastic a considerable amount of homogenous structure similar results was shown by (Amin et al., 2019), whereas presence of grooves might be due to the non-gelatinized molecules. The smooth and uniformity in surfaces has increased due starch-cellulose binding in a significant amount. This cellulose bioplastic shows more compactable structure than another starch-based bioplastic.*

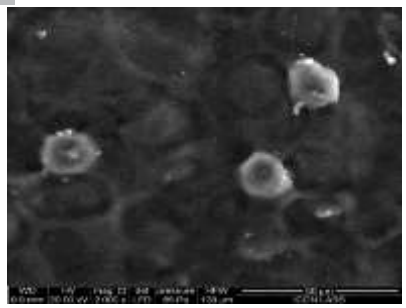
Fig. SEM photograph of cellulose bioplastic



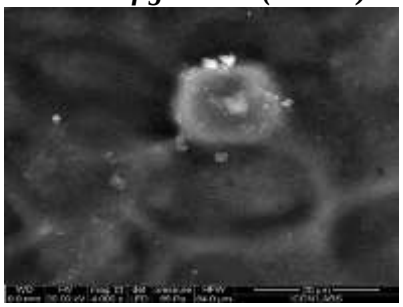
(1) Surface of bioplastic, Presence of grooves & furrows (200 X)



(2) Non-gelatinized Starch molecule in bioplastic (4000 X)



(3) Presence of granules (2000 X)



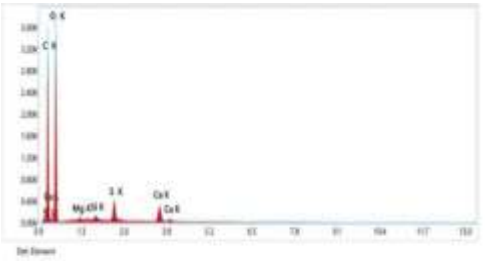


Fig. EDAX (Energy Dispersive X-ray Spectroscopy)

Element	Weight	MDL	Atomic (%)	Net Int.	R	A	F
C K	54.8	0.31	62.4	636.7	0.9344	0.1427	1.0000
O K	42.8	0.21	36.6	748.4	0.9425	0.0868	1.0000
Mg K	0.1	0.05	0.1	15.6	0.9542	0.4160	1.0025
Si K	0.2	0.04	0.1	26.6	0.9591	0.6853	1.0062
S K	0.9	0.04	0.4	119.4	0.9635	0.8457	1.0114
Ca K	1.3	0.09	0.4	106.1	0.9712	0.9585	1.0288

Tab. II eZAF Quant Result

EDAX (Energy Dispersive X-ray Spectroscopy)

Energy-dispersive X-ray spectroscopy (EDX) is a powerful technique for elemental analysis of materials. In this study, EDX analysis was conducted sample showed the presence of carbon, oxygen, magnesium, silicon, sulfur, and

calcium. The weight percentages of these elements in the sample were found to be 54.8%, 42.8%, 0.1%, 0.2%, 0.9%, and 1.3%, (Tab. II) respectively. carbon and oxygen were the predominant elements in the sample, which is consistent with the composition of organic materials. The presence of magnesium and calcium suggests that the sample may contain minerals or In the same study, they investigated the elemental composition of soil samples and it was found that carbon and oxygen were the major elements present (Sharma et al., 2016). Similarly, in a EDX analysis was used to determine the elemental composition of ACP bioplastic and it represented that calcium and carbon were the predominant elements.
degradable and non-hazardous which are not harmful even when dissolved in to the water or soil, over it this all elements can be used by the biological process i.e., by plants and animals.

biominerals. The small amount of silicon and sulfur may indicate the presence of impurities or trace elements. The results of this EDX are a simple and versatile technique, quickly used for quantification of macro elements (i.e. C, O, S, Cl, Na, Mg, Al, Si, P, K, Ca, Ti, Fe, Mn and Ni) in soil which organic materials and minerals.

Tensile Strength Analysis

Tensile strength Analysis is basic done to determine the amount of stress material can withstand when being stretched. In the current finding tensile strength analysis of sample measuring 8 x 2.8 cm was done in triplicate. The sample was named as Trial sample, Final sample-1 & Final Sample-2. The results obtained that the bioplastic can bear maximum peak load of 16563.00 g & the deformation at the peak load was 9.26 mm, However the results show discrepancy in the Peak load which can be accounted to the uneven surface area of the bioplastic.

Sample	**Trial Sample**	**Final Sample-1**	**Final Sample-2**
Dimensions	8 x 2.8 cm	8 x 2.8 cm	8 x 2.8 cm
Load Cell Used (Kg)	50.00	50.00	50.00
Peak load (g)	9321.00	136976.00	16653.00
Deformation at Peak Load (mm)	2.21	8.52	9.26
Work (mJ)	482.60	1107.30	1361.90
Mean Load Between 1 to 10 (s)	171.00	2377.00	2942.00

Table III showing results of Tensile strength.

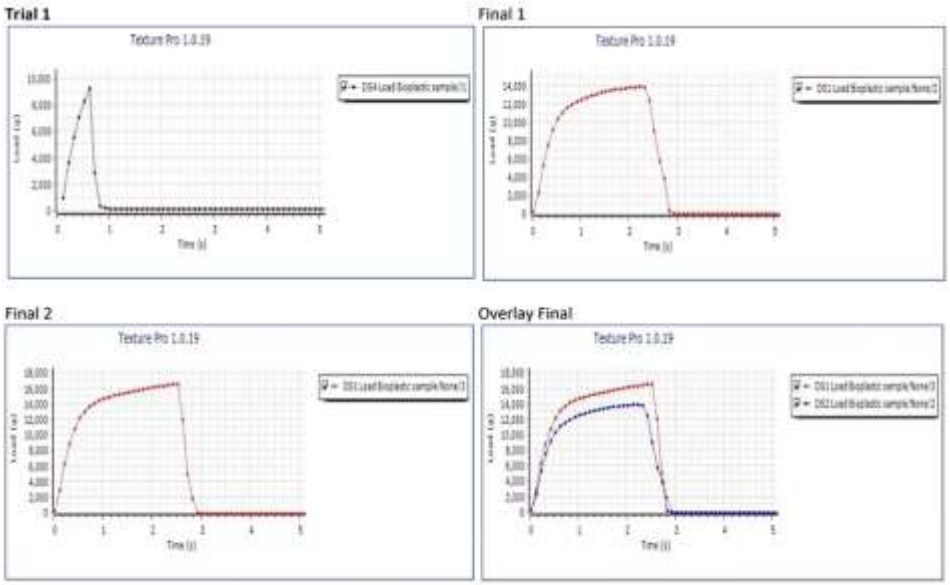


Fig. Tensile strength Analysis of Sample using Texture Analysis CTX model TA-DGF Probe.

Conclusion

The study presents that the formation of bioplastic which is eco - friendly and provides high durability and biodegradable properties. Various characterization techniques and physical tests were used to evaluate these characters. The surface analysis carried out through SEM represents the irregularity in structure with the presence of furrows and grooves. However, it represented the presence of non-gelatinous molecules (Fig.III.2). Accordingly, these molecules cause hindrances in the strength of the bio-plastic (Amin et al., 2019). The chemical characterization of bio-plastic was done by EDAX (Tab. II) (Sharma et al., 2016) analysis which determines that in the process of making the bioplastic there were no use of any hazardous elements. The physical properties of synthesized bio-plastic have an average thickness of 0.034 cm. The biodegradability test was performed by soil burial method in which the sample showed a degradation of 15% in the duration of 10 days from its initial weight. Whereas the same sample when was kept for 24 days it showed over 40% loss of its structure, reduction in size. The solubility test results showed that the bioplastic dissolved only 9.3% in the water after 20 days, whereas the water absorption capacity has determined that bioplastic after the duration of continuous 20 days submerged into water holds 16% of water (Tab.I) at temperature of 28oC (Marichelvam et al., 2019). The properties confirm that the bio-plastic produced using the peels of A. cepa is more efficient and can be used as an alternate source over synthetic plastic. Resulting from the interaction of

cellulose with starch has proven the possibility that it is easily soluble, degradable, and recyclable in terms for CO2 emission extensive evaluation is need, improvement of A. cepa bioplastic can be utilized for packaging purposes (Singh et al., 2012). Furthermore, efficient research is required to improve the thickness and tensile strength of the bio-plastic and as well as to incorporate bio-plastic based products that are both cost effective and sustainable.

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An ethnobotanical study on Asteraceae family at Kandi subdivision of Murshidabad district in West Bengal, India.

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Abstract

An ethnobotanical study on Asteraceae family was carried out at Kandi subdivision of Murshidabad district in West Bengal. The rural people and tribes of this district still dependent on various medicinal plants to cure their different types of primary health treatment. The study is therefore undertaken from March 2022 to February 2023 to gather the knowledge to create a record related to important and documented. Hence these plants and related knowledge should be properly enlisted and investigated. In the present study total 78 medicinal plants were recorded for different ailments. Out of 78 plants only 32 plants were belonged to Asteraceae family. The indigenous knowledge of local traditional uses was collected through questionnaire and personal interviews during field trips. On the other hand, 42 human diseases recorded through the information getting from old men, women and tribal peoples of different study sites. Among them very common diseases fever, cold and cough, dysentery, skin disease and anemia were recorded during study period. About 65 % villagers and 95% tribal people like Santal, Mal, Rajbonshi were used medicinal plants for their different ailments. It was observed that the availability of these plants is decreasing at an alarming rate. This observation also reveals that habitat destruction, over exploitation and unplanned agriculture were the reasons for depletion of medicinal plants. Therefore, the present investigation reveals that the medicinal plants are used as traditional healthcare system need urgent conservation and cultivation.

Keywords: Ethnobotany, Asteraceae, Rajbonshi, Ailments

Introduction

Ethnobotany is the study of relationship between plants and people. The first-person John Harshberger in 1895 defined ethnobotany as “The study of plants used by primitive and aboriginal”. It involves the indigenous knowledge of plant classification, cultivation and used as

food,medicine and shelter. The World Health Organisation (WHO) has estimated that as many as 80% of the world population in developing countries is dependent on traditional medicine for their primary needs (Bannerman,1982, Pareek,1996, Mukhopadhyay, 1998, Azaizeh, 2003). At present 65% of Indians are dependent on the traditional system of medicine (Bhatt,et.al 2002). Medicinal plants used as antipyretic agents by the traditional healers of Darjeeling Himalayas (Chhetri,2004). In western countries also the use of herbal medicine is steadily growing with a high percentage of the population reporting the use of herbs to treat medical illnesses within the past few years. "The people living in countries such as India (83%), Indonesia (88%), Mayanmar (85%), Nepal (75%) and Srilanka (65%) have preference for traditional medicine" (Kar and Borthakur,2008). The focus of ethnobotany is on how plants have been used, managed and perceived in human society and includes plants used for food, medicine, divination, cosmetics, dyeing, textile, for building, tools, currency, clothing, rituals and social life (Rahaman,2009). Ethnobotany will appear to be a bridge between botany and medicinal plants, but infact it is much more. It starts as step before ever botany in the sense supplies the idea and the basic material for botanical research and study. It goes a step further to help us in the application of the knowledge about the medicinal plants among primitive people by report through the medicine men (Jain,1996).

Murshidabad district of West Bengal is very rich in ethnocultural heritage and used traditional plant materials that may be of special interest in ethnobotanical information. About 85% people of this district live in the villages and a considerable proportion is tribals living in remote area. During ethnobotanical field study we visited a large number of Tribal and along with old village local people who are using wild and semi-wild plants for medicine and other purpose. They are very experienced in traditional medicine. They prescribed different plant materials to cure different diseases. Asteraceae family is one of the most diverse flowering plants with about 1911genera and 32913 accepted species (Panda et.al.,2019). Since ancient times, people have consumed various herbs of the Asteraceae family as food and as medicine. It has a great economic importance to provide human being as cooking oil, lettuce and sweeteners. The present paper deals with 36 medicinal plants which belongs to Asteraceae family and their uses in various ways. The data were collected either from local medicine man or tribal people who accompanied us in the study field. This is the first-time ethnobotanical research on Asteraceae family in the study area.

Objectives:

The main aims of the study are: a) To make an investigation about the present ethnobotanical status in the study area. b) To prepare a documentation of medicinal plants available in the study area. c) To know the extent of use of medicinal plants by the tribal and local villagers. d) To gain knowledge about few poisonous plants in the study area.

Methodology:

The ethnobotanical field survey was conducted according to the methods adopted by Shah and Joshi (1971), Jain (1981a) and Shah (1987). An

ethnomedicinal study was undertaken in different villages and remote area of Kandi subdivisions in Murshidabad district. The work was carried out throughout the seasons March 2022 to February 2023. It lies between 23o56'48N latitude and 88o 2'58E longitude. In the study area major group of tribals are Santal, Mali and Rajbonshi. The present work is mainly based on information gathered from the interview with the tribal and local village people on the plants having medicinal and economic importance to them. The participants were questioned individually in their homes and work places on the knowledge of using medicinal plants for their health care. The information was collected including the vernacular names of commonly used plants for their diseases, frequently used plant parts, methods of herbal preparation, mode of administration, dosages and possible side effects. The information was also cross verified with few local aged and experienced practitioners. Plant specimens were collected and identified following standard taxonomic methods (Prain, 1963, Guha,1984). Relevant plants were collected from the study area, identified and preserved at Herbarium of the Department of Botany, Kandi Raj College.

Result And Discussion:

The localities of Murshidabad district have been found to consist of a large number of medicinal plants. In the present study we have identified total 87 medicinal plants. Out of 87 plants only 32 plants belong to Asteraceae which are used by the local people in the ailments of different diseases. The different parts of plants are used in the treatment of a number diseases like skin scratches, epilepsy, ulcer, fever, cold and cough,hair growth,stomach problems etc.(Table-1). In this study it is observed that leaves of 20 plants, roots of 3 plants, flowers of 4 plants and whole plant of 8 plant species possess medicinal properties. The selected traditional plant species described were checked with available literature and it is found that numerous plant species were documented earlier by various workers from several districts of West Bengal. (Bandyopadhyay &Mukherjee,2009, Chowdhury & Mukherjee,2012, Mitra & Mukherjee,2014, Chowdhury & Karmakar 2015, Guha Bakshi,1984, Paria 2005).

Table-1. Shows ethnomedicinal plants used by local people and tribals of Kandi sub-division.

Sr.No.	Scientific Name	Family	Local Name	Parts Used	Uses
1	*Acanthospermum hispida* DC	Asteraceae	Gokhuru	Stem, Leaves	Leaf and young stem juice is used on skin scratches and wounds.
2	*Ageratum conyzoides* L.	Asteraceae	Janglipudina / Uchunti	Leaves	Boiled leaf paste is applied on skin before bed for treatment of Khasar (a type of skin

					disease).
3	*Anaphalis adnata* Wall. Ex DC	Asteraceae	Bugla	Whole plant	Flower heads and the hairs are employed to stop bleeding.
4	*Artemisia vulgaris* L.	Asteraceae	Nagdona	Leaves	Useful for Epilepsy, Hysteria.
5	*Bidens biternata* (Lour.) Merr & Sherff	Asteraceae	Durga	Whole plant	It is used in acute and chronic hepatitis, eczema, itching and ulcers.
6	*Blumea lacera* (Burm. f.) DC	Asteraceae	Kukshima	Whole plant	It is useful in vitiated conditions abdominal disordersand intestinal worms
7	*Calendula officinalis* L.	Asteraceae	Ganda	Leaves	Anti-viral, anti-septic, astringent also anti-inflamatory.
8	*Canscora diffusa* (Vahl) R. Br.	Asteraceae	Dhankuni	Whole plant	Fresh juice of plants used for headache and malarial fever.
9	*Centipeda minima* (L.) A. Braun & Ascher.	Asteraceae	Titila	Leaves, Seed,Flower	Leaf powder and minute seeds used in the preparationof snuff. Flower possesses antibacterial and antihypertensive properties.
10	*Chrysanthemum indicum* L.	Asteraceae	Chandramallika	Flower	Flowers sepal paste with few drops of lemon juice is use on scars on the facial cheeks externally to remove pimple.
11	*Chromolaena odorata* (L.) R. M. King & H. Rob.	Asteraceae	Assam lata / Mat mate	Leaf	Leaf paste applied on cuts and wound to stop bleeding.
12	*Eclipta alba* (L) Hassk.	Asteraceae	Keshute	Leaves	Leaf paste twice a day is effective for eczema and ringworm.

13	*Eclipta prostrata* (L.) Mant.	Asteraceae	Kalokeshi	Leaves, Root	Leaf extraction used to promote hair growth, protect hair fall and dandruff. Whole plant extraction used for any type skin diseases.
14	*Elephantopus scaber* L.	Asteraceae	Hastipada	Root, Leaves, Flower	Root & leaf decoction used for diarrhea. Root paste is useful for treatment of pain during discharge of urine. Flowers in vitiated conditions used for cough and bronchitis.
15	*Enhydra fluctuans* Lour.	Asteraceae	Hinche	Leaves	Leaves are used to cure headache, eye diseases, hook worms and in nervous affections.
16	*Eupatorium aromaticum* L.	Asteraceae	Kalonji	Leaves	Effective for sore mouth and sore nipples.
17	*Gnaphalium pensylvanicum* Willd.	Asteraceae	Janti	Leaves, Whole plant	Anti-inflammatory also useful for cough and dysmenorrhoea
18	*Helianthus annuus* L.	Asteraceae	Surjamukhi	Leaves	Leaf decoction is used for washing wounds.
19	*Sonchus asper* (L.) Hill.	Asteraceae	Boradoodhi	Whole plant	The plant is pounded and applied as a poultice to wounds and boils.
20	*Sonchus oleraceus* L.	Asteraceae	Doodhi	Leaves	Leaf juice is used for cuts and wounds.
21	*Sphaeranthus indicus* L.	Asteraceae	Chhagal Nudie	Whole plant	The leaf powder is used for skin disease. Root is used as hepatopathy
22	*Tridex procumbens* L.	Asteraceae	Tridaksha	leaves	Leaf juice used to check hemorrhage i.e. applied as antiseptic cream for healing cut wounds and also effective

					for scorpion bite.
23	*Vernonia anthelmintica* (L.) Willd.	Asteraceae	Somraj	seed	Seeds are taken to remove intestinal worms especially for children.
24	*Vernonia cinerea* (Linn.) Less.	Asteraceae	Kukshim	Whole plant	Leaves are useful for eczema, herpes. Flower juice is useful in conjunctivitis.
25	*Wedelia chinensis* (Osbeck) Merr.	Asteraceae	Bhringaraj	Leaves	Leaf juice is useful for heart disease, skin diseases.
26	*Xanthium indicum* Koenig.	Asteraceae	Bonokra	Fruis, Seed	Fruit is cooling, demulcent given in small pox and for eye ailments as ointment. Seed oil used for resolving inflammatory swellings.
27	*Xanthium strumarium* Linn.	Asteraceae	Okra/Chota Dhatura	Fruit	Fruit is used as antibacterial, antifungal antimalarial, anti pasmodic, cytotoxic and stomachic.
28	*Ericameria linearifolia*	Asteraceae	Goldenbush	Leaves and Stems	Used to treat cold,diarrhoea and stomach cramps.
29	*Tagetes erecta*	Asteraceae	Gandaphul	Leaves	Leaves used for wounds and to stop bleeding from cut area.
30	*Cichorium intybus*	Asteraceae	Cornflower	Leaves and Roots	Used to cure digestive disorder.
31	*Carthamus tinctorius*		Saf flower	Leaves and Flowers.	Used for cosmetics,irritation, rashes and inflammation.
32	*Artemisia absinthium*	Asteraceae	Wormwood	Leaves and Stems	Used in intestinal worms,gastric ulcers,and skin infections.

Conclusion: The popular use of herbal remedies among the tribal and village people of Murshidabad district reflects the revival of interest in traditional

medicine. The scientific validation of these remedies may help in discovering new drugs from the plant species. The information on therapeutic uses of plants may provide a great potential for promoting awareness among the people to use them as remedy in health care system. This study dealt with three major objectives i) identification of plant species having medicinal properties, ii) their botanical name, local name, family, parts used and uses of plant against different diseases and iii) awareness about importance of medicinal plants and over doses available in Murshidabad district. Although tribal medicines make use of several plants from Asteraceae family but the active compounds are not well studied using scientific approaches.

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Glimpse of Biostimulates

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Abstract

Modern agriculture uses a great deal of ineffective fertilizer, much of which is released into the environment and degrades the ecology. Reducing the amount of fertilizer applied without compromising plant nutrition can be achieved by using biostimulants to improve crop nutrient uptake. Specialty compounds called plant biostimulants are being utilized more frequently in the agricultural seed and chemical industry to boost crop yields. Biostimulants are distinct from conventional crop inputs like fertilizers or pesticides in that they can affect crop growth and development in numerous ways, depending on when and where they are applied. Thus, commercial products that contain combinations of these chemicals and/or microbes are also referred to as plant biostimulants. By extension, plant biostimulants also designate commercial products containing mixtures of such substances and/or microorganisms. This chapter provides an introduction to the biostimulants, their definitions, basic biostimulant categories, benefits, challenges and opportunities.

Keywords: Biostimulanta, Nutrient, Abiotic Stresses, Physiological, Produce

Introduction

Two distinctly diverse and different topics, albeit held by the same thread- plant propagation and sustainability- just so happen to be the need of the hour. To put both in simple terms, plant propagation is the process of multiplying or reproducing plants, sexually or asexually, and sustainability is gratifying current demands without sacrificing the capacity of subsequent generations, to meet the society's own wants. Every year, the proportion of cultivable land decreases due to population growth, urbanization, salination, desertification, while global warming and climate change associated disasters like floods, draught, wildfires, coupled with man-mediated risks of environmental degradation and soil toxicity due to intense usage of fertilizers, pesticides and monoculture, some of the biggest consequential shortcomings of Green Revolution, run rampant. To address these issues, we must adopt modern agricultural techniques that are not only sustainable, but also boost crop output and lower economic losses.

The current world population of 8.1 billion is estimated to increase to 9.7

billion by 2050 and in extended future, to 10.4 billion by 2100. This increase in population is directly proportional to increase in demand for food and basic raw materials which cannot be fulfilled by the traditional agricultural methods as they are high-input intensive and are essentially based on the production of high-performance crops which generally do not do well under low-input conditions. To meet ends, the production will have to be increased in accordance with the supply, however, as important as the yield is, conventional agriculture generally forgets to retain the phytochemical constituents of the produce. Food security cannot be reduced to a mere compromise with abundance in production with negligible or subpar nutritional value.

As people caught up with the fact that the farm-brought produce might not have the same nutritional value as compared to yesteryears, the infatuation with "organically rich" food caught wind and the sales started to increase from 15.2 billion USD in late 1999 and reached 134.76 billion USD in 2022. In 2022, there were over 96 million hectares of organic farms worldwide. In India alone there were nearly 2.5 million organic food producers, more than any other country (19). Though other than a smartly-veiled marketing strategy, organically grown produce does not possess more nutrition than their traditionally grown counterparts and on contrary, cost as much as 50% more than them (20). As for the sustainability aspect, organic agricultural practices are immensely beneficial for the environment without compromising the production in accordance with the demand; but it will not be enough alone in the foreseeable future due to reduction in arable land.

Additionally, estimates indicate that net global greenhouse gas emissions from agriculture, forestry, and other land use were approximately 12 billion metric tons of CO2 equivalent or about 21% of total global greenhouse gas emissions (21). In this regard, one of the most researched topics for the application and creation of sustainable horticultural, agricultural, and forestry production systems is the variety of soilless cultivation techniques such as Plant Tissue Culture (PTC), Hydroponics, Aquaponics and Aeroponics.

Literature Review

Contemporary plant propagation techniques play a pivotal role in promoting sustainable agriculture and enhancing environmental conservation efforts. The focus is on 'specialization', 'integration', and 'digitalization' to achieve sustainability in farming, in line with the need for sustainable growth in this field. This approach matches Plant Tissue Culture's (PTC) potential to boost crop yields, making plants more resistant to diseases, and preserve genetic resources, all of which support long-term farming sustainability (Fan & Li 2022). This method contributes to the Zero Hunger goal by offering a reliable way to multiply high-quality plants, ensuring food security for growing populations (Gorman et al. 2023, Choudhury et al. 2022).

Plant Tissue Culture has an impact on the commercial production of many secondary metabolites. These are key to sustainable farming practices. It also helps isolate and process active chemicals from plants that matter in business. By growing plants in vitro,

PTC becomes crucial for basic research and to produce plant-based chemicals that can support green companies. PTC also makes gene delivery easier which allows for the creation of transgenic plants with better traits. These plants boost resilience in farming systems and help protect the environment (A. Hasnain et al. 2022). To boost production and alter the strength of medicinal plants, we can use several methods. These include PTC/ micropropagation, artificial seed tech, and molecular marker-based approaches. PTC might lead to sustainability in the agricultural sector by improving crop yield and quality. These two factors are vital for future food security and to preserve our environment (Chen et al., 2016). Organic agricultural waste (OAW), which includes rejected or inedible plant tissues, is produced in vast quantities as a result of modern agriculture's dependence on linear and large-scale production methods. These waste materials may be repurposed through the use of PTC techniques, which would increase resource efficiency and contribute to sustainability in the agriculture industry (Khaksar et al., 2022).

PTC is also a biological control technique which provides sustainable management of pests and diseases in agriculture. This method helps to create a more sustainable agricultural production environment by using plant-based solutions (Shimada et al., 2021). With the advancement of technologies like somatic embryogenesis, direct/indirect organogenesis, and synthetic seed generation during the past few decades, PTC has made considerable strides. By facilitating the quick propagation of disease-free plants, conserving germplasm, and producing genetically uniform plant material, PTC presents viable paths toward agricultural sustainability. These steps also contribute to increased crop productivity and decreased environmental impact (BP et al., 2022).

Modern farming methods, especially in urban settings using Vertical farming/ Aeroponics or closed-loop systems like Hydroponics and Aquaponics are acknowledged for their capacity to address availability issues like that of limited space and water resources while advancing sustainable food production. These methods are examples of cutting-edge agricultural techniques that offer effective and environmentally friendly solutions, therefore making a substantial contribution to the agriculture industry's sustainability (S. Mukherjee et al., 2024, Akintuyi et al., 2024, B. Kotzen et al., 2019). These techniques address major issues with global food systems by optimizing crop productivity in limited areas, lowering water usage, and enabling pesticide-free food production. Rethinking agricultural methods to include these innovative farming methods can improve sustainability in the agriculture industry by reducing environmental effect and increasing efficiency (Galanakis, 2024).

These agronomic technologies have also shown a hand in optimizing the production of natural molecules with pharmaceutical and cosmetic significance (F. Nchu et al., 2018). Additionally, these techniques may help space agriculture achieve sustainability. The objectives of controlled environment agriculture in space are in line with these systems' well-known

water-use efficiency, which uses a great deal less water than conventional open agricultural (M. Kamran et al., 2023). Advancements and emerging trends in horticultural production and management emphasize the role of advanced technologies like automation, robotics, artificial intelligence, and genetics in transforming horticulture towards sustainability. They also highlight the potential of hydroponics, aeroponics, and aquaponics in enabling precision agriculture that is not limited by climate or soil conditions, thus contributing to more productive, efficient, and climate-resilient agricultural practices in the future (M. Janbandhu et al., 2024). By implementing these imaginative practices which have been shown to yield over twice the crop output compared to conventional agriculture, the agriculture sector can enhance sustainability by maximizing production efficiency and minimizing resource usage. These innovative techniques offer a promising solution to address global food challenges by reducing land and water requirements while potentially lowering carbon footprints associated with traditional farming practices.

To achieve sustainability in the agriculture sector, it is essential to prioritize the restoration and protection of ecosystems and implement sustainable food systems. This calls attention to the importance of innovative agricultural practices such as hydroponics, aquaponics, and aeroponics in urban and peri-urban areas to support food-growing practices and enhance urban sustainability and resilience. These methods offer opportunities for environmentally sustainable food production systems that can contribute to addressing the challenges posed by the current industrialized food system (Çakmakçı et al., 2023).

Plant Tissue Culture Against Traditional Farming

Mass Production of Plants via Clonal Propagation: Using tissue culture, it is possible to quickly produce a large number of genetically identical plants from a single parent plant. This is especially helpful for crops like potatoes, strawberries, and orchids that must be grown in big quantities.

- **Plants Free of Disease:**

Plantlets free of disease may be created using tissue culture. Growers may prevent soil-borne illnesses and pests that could compromise traditional multiplication methods by starting with a clean, sterile tissue sample.

- **Better Crop Varieties through Genetic Improvement:**

To create and propagate new plant varieties with desired qualities, such resistance to pests, diseases, or environmental conditions, tissue culture techniques are employed in combination with genetic engineering and breeding programs.

- **Faster Breeding Cycles:**

Tissue culture allows breeders to generate new plant kinds more quickly. This is due to the fact that plants can be evaluated and replicated quickly under controlled settings, which expedites the breeding process.

- **Standardization and Uniformity:**

The production of genetically uniform plants is ensured via tissue culture, which results in constant quality and performance. In commercial manufacturing, when it is expected to

have consistency in size, shape, and yield, this is essential.

- **Accelerated Growth:**

Compared to plantlets produced from seeds or cuttings in soil, plantlets grown in tissue culture may reach mature stages more quickly, which might shorten some crops' time to market.

- **Research and Development:**

Tissue culture offers a regulated setting in which scientists may examine how plants grow, develop, and react to different circumstances. Crop management and agricultural methods may advance as a result of this study.

- **Conservation of Rare and Endangered Species:**

By keeping rare, endangered, or important plant species in a controlled environment and facilitating their reproduction without requiring natural environments, tissue culture is a useful technique for saving these species.

Hydroponics And Aeroponics Against Traditional Farming

- **Effective Utilization of Resources:**

Hydroponic and Aeroponic systems requires a great deal less water than conventional soil farming. Aeroponics specifically uses less water because the nutrient solution is misted directly onto the roots, and excess water is recaptured and recycled. Minimizing fertilizer runoff and waste, nutrients are given directly to the roots of the plants in a regulated manner.

- **Greater Yields:**

Because contemporary systems allow more exact environmental control and more easily available nutrients, plants frequently develop more quickly in these environments. Because there is no soil and the growing conditions are better regulated, plants may be grown closer together, which increases the yields per square meter.

- **Reduced Usage of Chemical Pesticides and Herbicides:**

These closed-loop systems may be installed in controlled spaces like greenhouses, which lowers the danger of disease and insect infestation and frequently does away with the requirement for these chemicals.

- **Reduced Land Requirement:**

Vertical farms can be installed in urban settings to produce food inside or in locations with little arable land, which would also contribute to local food security.

- **Increased Control Over Growing Conditions:**

Compared to soil-based farming, growers have more exact control over pH levels, fertilizer concentrations, and environmental variables like light, temperature, and humidity. More uniform crop quality and productivity might result from consistent growth conditions

- **Resource Recycling:**

Waste may be minimized and the environmental effect can be decreased by recirculating water and nutrient solutions inside the system

Year-Round Production: Both these systems allow for year-round production independent of the outside weather as it may be used inside or in controlled greenhouses.

Role In Achieving Sustainable Development Goals (Sdgs)

- **Zero Hunger (Sdg 2)**

Enhanced Yield: Compared to traditional agricultural methods, these approaches can produce larger yields in

less land, which can aid in the fight against food poverty.

Year-Round Production: They make it possible to cultivate year-round, which lessens reliance on seasonal crops and increases the amount of food available.

- **Industry, Innovation, And Infrastructure (Sdg 9)**

Technological Advancements: By encouraging innovation in agricultural infrastructure and technology, these strategies support both economic growth and sustainable practices.

- **Sustainable Cities and Communities (Sdg 11)**

Urban Agriculture: By boosting local food production and lowering food miles, hydroponics and aeroponics may be used in urban environments.

Space Efficiency: Because these systems use less land, they are perfect for locations with high population density and limited space.

- **Responsible Consumption and Production (Sdg 12)**

Resource Efficiency: Compared to conventional agriculture, hydroponics and aeroponics use a great deal less water, protecting this valuable resource.

Pesticide Reduction: By using less/ no pesticides, these systems can produce better food with smaller/ no subsequent environmental effect.

- **Climate Action (Sdg 13)**

Diminished Carbon Footprint: Since food may be grown nearby, there is less need for shipping and packaging, which helps reduce greenhouse gas emissions. Additionally, precise usage of resources also cuts back on GHG emissions.

Adaptability to Climate Change: Stable food supplies may be produced in controlled conditions as they are less susceptible to climatic fluctuations, abiotic and biotic stresses.

- **Life Below Water (Sdg 14)**

Aquaponics Systems: Plant culture and fish farming work together to produce a symbiotic environment that reduces waste and conserves nutrients and water.

- **Life On Land (Sdg 15)**

Decreased Land Degradation: These methods contribute to the preservation of biodiversity and natural ecosystems by requiring less land and no soil.

Soil Conservation: Their efforts help lessen the negative effects of traditional agriculture on the soil, such as erosion and deterioration.

- **Partnerships For the Goals (Sdg 17)**

Collaborative Initiatives: Governments, non-profits, and the business sector can work together to build a robust and sustainable agriculture sector by implementing these systems and establishing alliances to meet objectives.

Conclusion

Plant Tissue Culture (PTC) is a very useful application for commercial farming, for large-scale propagation, disease control, breeding, and for ex-situ conservation. This includes the enhancement of effective, and quality plant production and thus plays a significant role in the success and innovation in the agriculture industry. Likewise, Hydroponics, Aeroponics and Aquaponics method can be a superior form of conventional agriculture, especially where there are constraints of resources and or where the grower requires and degree of control over the environment. All these modern techniques of plant propagation are important in the upcoming farming

systems. Because of the ability to increase organics' utilization, decrease the assertiveness on the surroundings, and increase the production, these methods can play a significant role in improving the agronomic industry's stability. In addition, the use of these contemporary methods of propagation in agriculture contributes to other features of the sustainable development goals through guaranteeing food security, adoptions of sustainable practices, and innovations. In general, as agriculture increasingly seeks solutions that harmonize economic, environmental, and social needs, the adoption of these contemporary techniques becomes essential in fostering a sustainable future for both agriculture and the environment.

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Role of Modern Plant Propagation Techniques in Achieving Sustainability

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Abstract

Humans have always been dependent on nature for their basic needs and demands, hence, with the increase in consciousness towards sustainable development in population, a positive shift has been quite visible with regards to bio-products. Owing to the present trend of decline in the number of plants, the demand to supply ratio has been hampered greatly, thereafter rendering insufficient the conventional methods of production of crops for various industries, and making them unfit for the future exigencies of the market. This review paper primarily focuses, at large, on the recent drift towards the utilization of plant-based bio-products, and the roles of modern plant propagation techniques such as Plant Tissue Culture (PTC), Aquaponics and Hydroponics in order to fulfil the necessities of the future, in terms of raw materials for food, as well as health and safety. The conclusion of this review stands in support of the usage of contemporary propagation proficiencies which will not only cater to the ever-increasing population, but also can be foreseen to be a massive aid in sustainable development.

Keywords: Plant Tissue Culture, PTC, Hydroponics, Aeroponics, Sustainability.

Introduction

Two distinctly diverse and different topics, albeit held by the same thread- plant propagation and sustainability- just so happen to be the need of the hour. To put both in simple terms, plant propagation is the process of multiplying or reproducing plants, sexually or

asexually, and sustainability is gratifying current demands without sacrificing the capacity of subsequent generations, to meet the society's own wants. Every year, the proportion of cultivable land decreases due to population growth, urbanization, salination, desertification, while global warming and climate change associated disasters like floods, draught, wildfires, coupled with man-mediated risks of environmental degradation and soil toxicity due to intense usage of fertilizers, pesticides and monoculture, some of the biggest consequential shortcomings of Green Revolution, run rampant. To address these issues, we must adopt modern agricultural techniques that are not only sustainable, but also boost crop output and lower economic losses.

The current world population of 8.1 billion is estimated to increase to 9.7 billion by 2050 and in extended future, to 10.4 billion by 2100. This increase in population is directly proportional to increase in demand for food and basic raw materials which cannot be fulfilled by the traditional agricultural methods as they are high-input intensive and are essentially based on the production of high-performance crops which generally do not do well under low-input conditions. To meet ends, the production will have to be increased in accordance with the supply, however, as important as the yield is, conventional agriculture generally forgets to retain the phytochemical constituents of the produce. Food security cannot be reduced to a mere compromise with abundance in production with negligible or subpar nutritional value.

As people caught up with the fact that the farm-brought produce might not have the same nutritional value as compared to yesteryears, the infatuation with "organically rich" food caught wind and the sales started to increase from 15.2 billion USD in late 1999 and reached 134.76 billion USD in 2022. In 2022, there were over 96 million hectares of organic farms worldwide. In India alone there were nearly 2.5 million organic food producers, more than any other country (19). Though other than a smartly-veiled marketing strategy, organically grown produce does not possess more nutrition than their traditionally grown counterparts and on contrary, cost as much as 50% more than them (20). As for the sustainability aspect, organic agricultural practices are immensely beneficial for the environment without compromising the production in accordance with the demand; but it will not be enough alone in the foreseeable future due to reduction in arable land.

Additionally, estimates indicate that net global greenhouse gas emissions from agriculture, forestry, and other land use were approximately 12 billion metric tons of CO2 equivalent or about 21% of total global greenhouse gas emissions (21). In this regard, one of the most researched topics for the application and creation of sustainable horticultural, agricultural, and forestry production systems is the variety of soilless cultivation techniques such as Plant Tissue Culture (PTC), Hydroponics, Aquaponics and Aeroponics.

Literature Review

Contemporary plant propagation techniques play a pivotal role in promoting sustainable agriculture and enhancing environmental conservation efforts. The focus is on 'specialization',

'integration', and 'digitalization' to achieve sustainability in farming, in line with the need for sustainable growth in this field. This approach matches Plant Tissue Culture's (PTC) potential to boost crop yields, making plants more resistant to diseases, and preserve genetic resources, all of which support long-term farming sustainability (Fan & Li 2022). This method contributes to the Zero Hunger goal by offering a reliable way to multiply high-quality plants, ensuring food security for growing populations (Gorman et al. 2023, Choudhury et al. 2022).

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To achieve sustainability in the agriculture sector, it is essential to prioritize the restoration and protection of ecosystems and implement sustainable food systems. This calls attention to the importance of innovative agricultural practices such as hydroponics, aquaponics, and aeroponics in urban and peri-urban areas to support food-growing practices and enhance urban sustainability and resilience. These methods offer opportunities for environmentally sustainable food production systems that can contribute to addressing the challenges posed by the current industrialized food system (Çakmakçı et al., 2023).

Plant Tissue Culture Against Traditional Farming

Mass Production of Plants via Clonal Propagation: Using tissue culture, it is possible to quickly produce a large number of genetically identical plants from a single parent plant. This is especially helpful for crops like potatoes, strawberries, and orchids that must be grown in big quantities.

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Plantlets free of disease may be created using tissue culture. Growers may prevent soil-borne illnesses and pests that could compromise traditional multiplication methods by starting with a clean, sterile tissue sample.

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To create and propagate new plant varieties with desired qualities, such resistance to pests, diseases, or environmental conditions, tissue culture techniques are employed in combination with genetic engineering and breeding programs.

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By keeping rare, endangered, or important plant species in a controlled environment and facilitating their reproduction without requiring natural environments, tissue culture is a useful technique for saving these species.

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Hydroponic and Aeroponic systems requires a great deal less water than conventional soil farming. Aeroponics specifically uses less water because the nutrient solution is misted directly onto the roots, and excess water is recaptured and recycled. Minimizing fertilizer runoff and waste, nutrients are given directly to the roots of the plants in a regulated manner.

- **Greater Yields:**

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- **Reduced Usage of Chemical Pesticides and Herbicides:**

These closed-loop systems may be installed in controlled spaces like greenhouses, which lowers the danger of disease and insect infestation and frequently does away with the requirement for these chemicals.

- **Reduced Land Requirement:**

Vertical farms can be installed in urban settings to produce food inside or in locations with little arable land, which would also contribute to local food security.

- **Increased Control Over Growing Conditions:**

Compared to soil-based farming, growers have more exact control over

pH levels, fertilizer concentrations, and environmental variables like light, temperature, and humidity. More uniform crop quality and productivity might result from consistent growth conditions

- **Resource Recycling:**

Waste may be minimized and the environmental effect can be decreased by recirculating water and nutrient solutions inside the system

Year-Round Production: Both these systems allow for year-round production independent of the outside weather as it may be used inside or in controlled greenhouses.

Role In Achieving Sustainable Development Goals (Sdgs)

- **Zero Hunger (Sdg 2)**

Enhanced Yield: Compared to traditional agricultural methods, these approaches can produce larger yields in less land, which can aid in the fight against food poverty.

Year-Round Production: They make it possible to cultivate year-round, which lessens reliance on seasonal crops and increases the amount of food available.

- **Industry, Innovation, And Infrastructure (Sdg 9)**

Technological Advancements: By encouraging innovation in agricultural infrastructure and technology, these strategies support both economic growth and sustainable practices.

- **Sustainable Cities and Communities (Sdg 11)**

Urban Agriculture: By boosting local food production and lowering food miles, hydroponics and aeroponics may be used in urban environments.

Space Efficiency: Because these systems use less land, they are perfect for locations with high population density and limited space.

- **Responsible Consumption and Production (Sdg 12)**

Resource Efficiency: Compared to conventional agriculture, hydroponics and aeroponics use a great deal less water, protecting this valuable resource.

Pesticide Reduction: By using less/ no pesticides, these systems can produce better food with smaller/ no subsequent environmental effect.

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Diminished Carbon Footprint: Since food may be grown nearby, there is less need for shipping and packaging, which helps reduce greenhouse gas emissions. Additionally, precise usage of resources also cuts back on GHG emissions.

Adaptability to Climate Change: Stable food supplies may be produced in controlled conditions as they are less susceptible to climatic fluctuations, abiotic and biotic stresses.

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Aquaponics Systems: Plant culture and fish farming work together to produce a symbiotic environment that reduces waste and conserves nutrients and water.

- **Life On Land (Sdg 15)**

Decreased Land Degradation: These methods contribute to the preservation of biodiversity and natural ecosystems by requiring less land and no soil.

Soil Conservation: Their efforts help lessen the negative effects of traditional agriculture on the soil, such as erosion and deterioration.

- **Partnerships For the Goals (Sdg 17) Collaborative Initiatives:** Governments, non-profits, and the business sector can work together to build a robust and sustainable agriculture sector by implementing these systems

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Conclusion

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