Microbial and Nanofertilizer For Mitigating Stress In Medicinal Plants

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CANDIDATE'S DECLARATION

I Ankita Yadav, Roll Number: 2K22/MSCBIO/11, student of M.Sc. Biotechnology , here by declare that the work which is presented in the Major Project in entitled- **Microbial And Nanofertilizer For Mitigating Stress In Medicinal Plants** in the fulfilment of the requirement for the award of the degree of Master of Science in Biotechnology and submitted to the department of biotechnology, Delhi Technological University, Delhi, is an authentic record of my own carried out during the period from January-May 2024, under the supervision **of Dr. Navneeta Bharadvaja.**

The matter presented in this report has not been submitted by me for the award for any other Institute/University. The has been accepted in SCI/SCI expanded/SSCI/Scopus Indexed Journal OR peer-reviewed Scopus Index Conference with the following details:

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CERTIFICATE

This is to certify that the thesis titled " Microbial And Nanofertilizer For Mitigating Stress In Medicinal Plants " submitted by Ankita Yadav (2K22/MSCBIO/11) to the Department of Biotechnology, Delhi Technological University in partial fulfilment of the requirement for the award of the degree of Master of Science, is a bonafide record of the work carried out by them under our supervision and guidance.

The contents embodied in the thesis have not been submitted for the award of any other degree or diploma in this or any other university.

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Abstract:

Providing food, feed, and agricultural products has significant challenges due to the world's expanding population, particularly in emerging nations. Synthetic fertilizers promote plant growth, but their traditional use has contaminated ecosystems, altered soil ecosystems, and may pose health hazards to humans. Climate conditions aggravate the effects of non-living stressors on crops, resulting in decreased agricultural productivity. Crop health and productivity are negatively impacted by both biotic and abiotic stressors, including diseases, temperature fluctuations, drought, and salt of the soil. In this context, biofertilizers are increasingly being used as a remedy to the issues listed above that carry out organic processes such as nitrogen fixation, nutrient solubilization, hormone synthesis and enzyme activity. The biofertilizer, microbial fertilizer was found to be most important in powering the health of plants and reducing stress of the plants. In the current review, we aim at elaborately discussing the importance of medical plants over the other groups of plants, how the concept of microbial fertilizers is precious, the impact of stress over medicinal plants and links it toward affecting their curative properties. Our main focus of this review will be to evaluate the efficacy of an The objective of this research is to enhance the ability of plants to withstand both living and non-living stressors. By studying the underlying mechanisms, this research also aims to gather valuable insights into sustainable agricultural practices. Additionally, this research seeks to explore the potential of microbial fertilizers as a more effective alternative for mitigating stress in medicinal plants. Climate change impacts agriculture productivity.Applicability of such microbial fertilizers resolves the constraints faced while using conventional chemical fertilizers, besides it is environmentally friendly, practical, economic and ecological.It promotes nice crop growth. It is an effective way to use microbes as a substitute to synthetic fertilizers and will improve natural plants for human health with microbial bio-fertilizers therefore the study also has global food safety importance in the herbal plants field

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Introduction

Based on forecasts The Food and Agricultural Organization (FAO) predicts that the global population will reach 9 billion by 2050, resulting in an increase in food consumption.

Increasing agricultural production is therefore essential. The soil, which is an essential resource for food production, has experienced significant degradation. Due to the implementation of intensive agricultural practices, such as the utilization of synthetic fertilizers and pesticides. Reduced fertility, fewer species, and disruptions in biogeochemical cycles are the results of environmental degradation, and these factors have a detrimental effect on the health of the soil and plant productivity [96]. The overall soil health and plant productivity are greatly impacted by the interactions of plants, microorganisms, and the soil. [96]. By carrying out essential functions, soil microbes and plant roots collaborate to preserve ecological equilibrium in the soil [43]. While negative interactions hinder plant growth, positive interactions between plants and microbes enhance plant life, nutritional status, and agricultural productivity. Soil fertility and the relationship between microbes and plants are closely related. Using biofertilizers is seen to be a viable way to improve soil health since it can affect nutrient availability, encourage the growth of beneficial microorganisms, and modify the microbial makeup of the soil. [8]. Empirical studies have indicated that The utilization of biofertilizers in apricot production has the potential to alter the microbial composition and degradation mechanisms, resulting in improved soil nutrient cycles under real-world conditions [8. 26]. For sustainable farming methods, biofertilizers increase soil microbial diversity, which boosts crop output [43]. Numerous investigations have emphasized the critical importance of biofertilizers, particularly microbial fertilizers, in enhancing plant development overall, encouraging root growth, and facilitating the absorption and conversion of nutrients [75], Viable or dormant microorganisms, known as biofertilizers, facilitate the transfer of nutrients to plants by means of biological processes such nitrogen fixation, phosphorus solubilization, and the synthesis of compounds that promote growth [34]. In order to improve soil fertility and thus boost microbial activity, biofertilizers can be applied by a variety of methods, including foliar spraying, soil, roots, or seeds [114]. This increases crop health and yield. Biologic pathogenic organisms induce stress, whereas climate conditions worsen the illness. Abiotic stressors, such as environmental factors, can have a substantial impact on the productivity of crops. Biofertilizers play a crucial role in mitigating the adverse impacts of both living organism-related (biotic) and environmental (abiotic) stresses on crops by promoting plant growth and development and enhancing stress resistance mechanisms [41]. Further investigation is needed to determine the degree to which beneficial soil microorganisms, particularly when combined in a consortium, improve crop productivity [10]. Abiotic stress produced by climate variations leads to a decrease in crop output. Biofertilizers have demonstrated their ability to mitigate the consequences of abiotic stressors, including as soil-related problems, waterlogging, drought, and humidity. The microorganisms found in biofertilizers support plants' stress tolerance mechanisms, promote plant growth, and help mobilize nutrients. Thus, it contributes to sustainable agriculture [41]. The use of microorganisms for nutritional purposes is called "biofertilizers" in India. However, the term "microbial bio-preparations" is used in other countries. Both types of biofertilizers, organic residue-based and microbial-based, provide cost-effective and environmentally friendly solutions to improve soil fertility, nutrient availability and agricultural productivity [8]. Biofertilizers have several advantages for sustainable agriculture; phosphate solubilization, disease control and nitrogen fixation are just a few examples of direct and indirect benefits [8]. In summary, this study highlights the value of biofertilizers, specifically microbial fertilizers, in addressing issues of crop stress, nutrient access, and soil degradation. Through analyzing the mechanisms that drive environmentally friendly agricultural practices, their impact on crop productivity, and their contributions to reducing biotic and abiotic stress, the journal seeks how to provide relevant information about these activities. This data has the potential to improve environmental sustainability and food security.

Nanotechnology has the potential to revolutionize several industries, including biology, environmental engineering, transformation energy, water resources, safety and security, as well as the food industry. To do this, it emphasizes the special properties of materials that result from the nanometer size (Baruah et al., 2008). Theoretical applications of nanotechnology in agriculture are gradually giving way to practical results. Research in molecular and cellular biology is progressing thanks to the development of new equipment with nanometer capabilities. By delivering drugs and genes to specific regions and genetically modifying plants and animals (Kuzma, 2006; Scott 2007), nanotechnology offers the potential to boost agricultural production in plants and creatures at the cellular level (Maysinger, 2007). With the distinguishing proof of fitting strategies and sensors, the potential for exactness agribusiness, normal asset administration, early illness and contaminant location in nourishment items, successful agrochemical conveyance frameworks, such as fertilizers, is developing. Pesticides, improved frameworks integration for nourishment preparing, bundling, and extra zones such as rural and nourishment framework security checking (Moraru et al., 2003; Chau et al., 2007; Subramanian and Rahale, 2009). With more headways within the field of horticulture utilizing nanotechnology, it is conceivable to imagine this industry developing as a essential driver of financial development that will offer assistance ranchers and shoppers without hurting the environment. As open concern around the destructive As the effects of chemical fertilizers on the agro-ecosystem have grown over time, so has interest in using nonporous zeolites in cultivation. Nanotechnology involves the precise manipulation or self-assembly of individual molecules, atoms, or atomic clusters in order to create new and significantly different materials and systems. The advancement of nanotechnology and the application of previously unused nanomaterials and nanodevices enable innovative applications in agriculture. "The understanding and control of matter at measurements of generally 1-100 nm, where one of a kind properties make novel applications conceivable" is how nanotechnology is defined. By modifying particles at the billionth of a meter scale, scientists have produced materials with "nearly mysterious accomplishments of conductivity, reactivity, and optical affectability, among others". This could also be the beginning of a financial revolution. More than 300 products that make use of nanotechnology are currently available in stores (Science Arrangement Committee, 2007).

By 2015, the commerce is anticipated to create $1trillion in income yearly (Roco, 2003). It is an amazingly promising innovation with a wide extend of logical and innovative employments. Later a long time have seen a fast enhancement in Nano science and nanotechnologies, opening up unused conceivable outcomes for numerous. Farming and related segments are included within the mechanical and shopper segments that are thought to be the epicenter of a modern mechanical transformation. Concurring to Kuzma and Verhage (2006), nanotechnology is rapidly getting to be the modern science and innovation stage for the era of agro-food framework advancement and change as well as for improving the living conditions of the devastated. Typically due to later logical headways within the field. It is conceivable to construct nanoscale materials and gadgets utilizing "bottom-up" or "top down" strategies. Bottom-up approaches make nanomaterial or structures by carefully controlling the amassing of particles or particles through thermodynamic instruments like self-assembly (Ferrari, 2005). On the other hand, nanoscale contraptions and structures can be made utilizing the headways in microtechnologies. The term "top-down nanofabrication innovations" alludes to a bunch of strategies that incorporate photolithography, nanomolding, dippen lithography, and nanofluidics (Peppas, 2004; Sahoo and Labhasetwar,2003). Concurring to Abdul-Kalam (2007), nanotechnology holds the key to introducing within the another awesome improvement in agronomically arranged common asset administration. It has introduced in a unused field of intrigue inquire about by bringing engineering and science along with agrarian and food frameworks.

Worldwide edit efficiency has been contrarily affected by unexpected changes within the climate and environment brought almost by man-made or characteristic forms. This stress has brought consideration to the need of making prudent and environmentally inviting arrangements, particularly in arrange to meet the requests of the extending populace. The feasible generation of crops enters a unused stage with the application of nanobiofertilizers in horticulture. The improvement and stretch resilience of plants are improved by the utilize of nanoparticles. In horticulture, another strategy being examined is the vaccination of biofertilizers. When biofertilizers and nanoparticles are ordinarily, nanoparticles of silicon, zinc, copper, press, and silver are utilized within the creation of nanobiofertilizer. These nanoparticles have made strides properties and execution due to their green blend. When compared to other ordinary strategies, the utilization of nanobiofertilizers yields more prominent comes about. Also, they carry out their work more viably than the conventional salts that were previously employed in farming to extend trim yields. Comparing nanobiofertilizer to customary chemical fertilizers, the previous produces way better and more solid results. It improves the soil's structure and utilization, as well as the morphological, physiological, biochemical, and reproductive characteristics of plants.The creation and utilize of nanobiofertilizer could be a valuable step toward cleverly fertilizer that advances edit improvement and yield. There's a shortage of writing on the creation and utilize of nanobiofertilizer in field settings. This item ought to be utilized carefully since it can move forward combined, they make nanobiofertilizers, which are more temperate, compelling, and ecologically inviting than either substance utilized alone. Biofertilizers encased in nanoparticles make up nanobiofertilizers. Nanoparticles are little (1–100 nm) particles with numerous benefits, whereas biofertilizers are plant-based carrier arrangements containing useful microbial living beings. It improves plant morphology, physiology, biochemistry, and surrender, as well as the structure and utilization of soil. This paper describes how nanobiofertilizer enhances plant growth and development and emphasizes its composition and application on a variety of plant species. nanobiofertilizer in cultivating. Future approaches and limitations for making an effective nanobiofertilizer are talked about.Utilizing nanobiofertilizer significantly improves plant advancement. Biofertilizers are more viable when coated on nanoparticles, and this comes about in a slow and drawn out discharge of nanoparticles into the rhizosphere of the plant. They reduce the probability of filtering and protect fertilizer disintegration [120]. Also, they move forward the quality of crops by expanding the generation of auxiliary metabolites counting phenols and flavonoids and nonenzymatic cancer prevention agents like superoxide dismutase, peroxidase, and catalase. These metabolites give a number of wellbeing points of interest and amplify the rack life of natural products and vegetables. When connected to plants, the combined impacts of nanoparticles and biofertilizer deliver opened up responses. It causes a few plant frameworks that make strides plant improvement and generation to ended up dynamic. Furthermore, they reduce or halt the arrangement of pathogens within the rhizosphere of plants, as well as the negative impacts of poisonous substances. Nanobiofertilizers reestablish crucial supplements to the soil and back bioremediation. They reduce the destructive impacts of ROS on plants, protect the structure and work of the cell, and up regulate the qualities that create stress-related proteins, osmolytes, and cancer prevention agents. Moreover, they keep up the expanded hormone union and action of layer transporters . Figure 4 outlines how plant cells respond to water push and how applying nanoparticles and biofertilizers influences the plants. The antioxidant components of the plants enact in reaction to these medicines, protecting the organelles and cell layer from the harming impacts of stretch. Moreover, they create less stretch hormone (abscisic corrosive) and more development hormones (cytokinin, indole acidic corrosive, and others). These adjustments upgrade the plant's capacity to resist push and raise the probability of trim foundation in unfavorable natural circumstances.

Microbial Fertilizers and types

In India, using microorganisms in agriculture to meet dietary needs is referred to as "biofertilizer" most of the time. The term "microbial bioinoculant" is used in certain nations. Organic fertilizers derived from living or deceased microbial cells, plants, or animals are known as biofertilizers. They possess the capacity to enhance the availability and accessibility of nutrients, a vital factor for the growth of plants.[3]. One crucial component of biofertilizers is the presence of living microbiological mass. The technical definition of biofertilizers is formulations that contain live microorganisms. By taking part in processes like breaking down organic waste, phosphorus solubility, atmospheric nitrogen conversion into a useable form, and growth hormone synthesis with a broad range of biological functions, these microorganisms contribute in a variety of ways to improving soil fertility.

Biofertilizers are usually applied to appropriate carriers in a dry or solid form after being carefully prepared. The carriers listed are used to improve the stability of biofertilizers and make their application easier. These include lignite, clay minerals, humus, rice bran, peat, and wood charcoal [34]. The application of biofertilizers in agriculture has several benefits. These elements consist of affordability, better enhanced soil fertility, protection against soil-bone diseases, nutrient availability, and sustainable farming methods, increased resilience to biological and environmental stress, heightened production of phytohormones, promotion of soil health, decreased pollution from the environment, and long-term improvement of soil fertility [8,9]. Based on content and source, biofertilizers fall into two main categories in the realm of international marketing. Materials such as farming waste, organic matter, residue from сторь, and treated sewage and sludge are examples of organic residue-based biofertilizers. On the other hand, the components of microorganisms that offer advantages in biofertilizers are algae, bacteria, and fungi. Both direct and indirect plant development mechanisms are influenced by biofertilizers based on microorganisms and organic materials. Biological processes include Direct mechanisms include phosphate and micronutrient solubilization, phytohormone production, and nitrogen fixation. Indirect defense strategies are employed by plants to shield themselves against diseases' harmful effects.

OVERVIEW OF MICROFERTILIZERS: CLASSIFICATION AND THEIR IMPORTANCE IN CROP CULTIVATION AND SOIL FERTILITY MANAGEMENT

Microorganism-associated bacteria and fungus are classified as biofertilizers, meaning that, as shown in Fig., they are essential for improving soil fertility and promoting crop development that is sustainable.

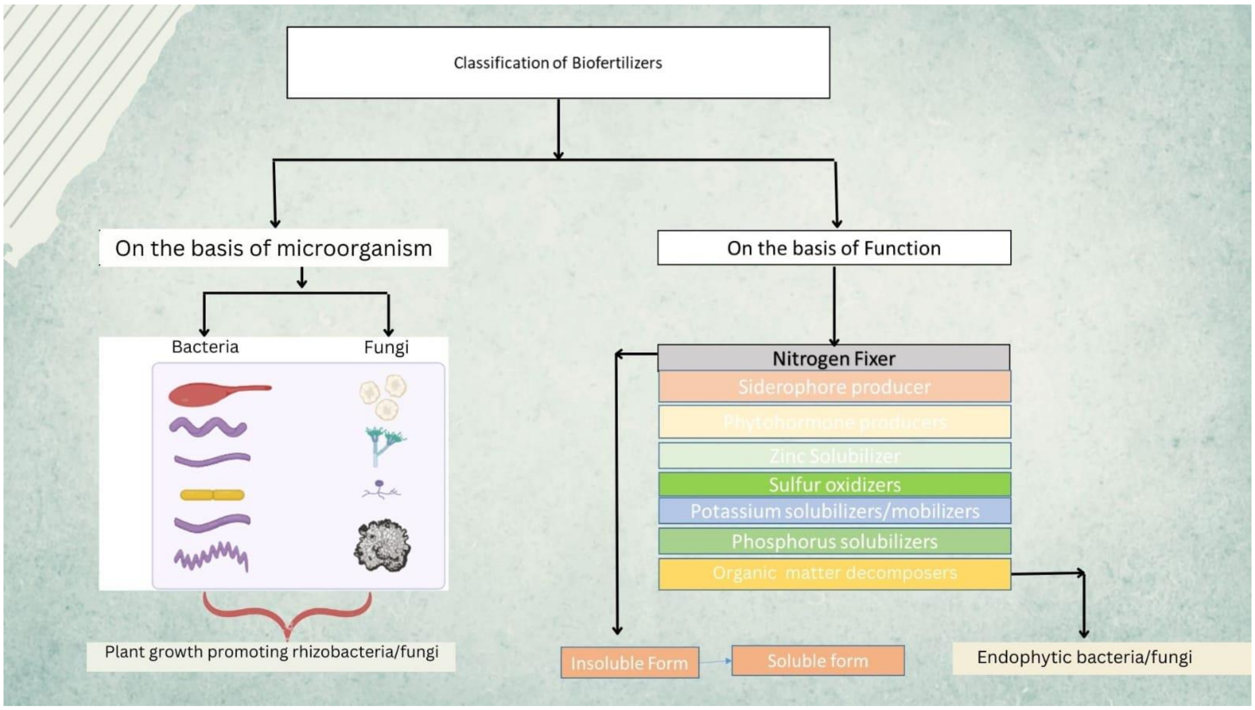

Figure 1 Classification of Biofertitilizer based on Microorganism

A. Nitrogen-fixing biofertilizers

Because nitrogen is a macronutrient that is required for plant growth, nitrogen-fixing biofertilizers are essential for transforming atmospheric nitrogen into forms that plants can use. It has been discovered that Bradyrhizobium japonicum, Bacillus sp., and Azotobacter enhance nitrogen fixation, which in turn promotes plant growth and raises biomass [71, 24, 105].

B. Symbiotic nitrogen-fixing microbes

Nitrogen-fixing microorganisms that create symbiotic associations with plants, such legumes and Rhizobium bacteria, are essential to the nitrogen fixation process. The investigation conducted by the researcher demonstrated Rhizobium meliloti's ability to boost peanut plant productivity.

Rhizobium and alfalfa work together symbiotically to provide nitrogen fixation in plants, promote phytohormone synthesis, and support general plant growth. [74].

C. Autonomous nitrogen-fixing Bacteria:

The autonomous bacterium Azotobacter chroococcum is a special kind of biofertilizer since it can fix nitrogen and create plant hormones. Plant growth, stress resistance, and nutrient uptake have all improved when Bacillus sp. and Azospirillum brasilense have been applied [85,77].

D. Phosphorus-solubilizing Biofertilizers:

Microorganisms that solubilize phosphorus, such as Bacillus, Rhizobium, Aspergillus, and Penicillium, convert phosphorus compounds that plants find difficult to utilize into forms that they may quickly absorb. Increased yield, improved plant development, and higher soil enzyme activity have all been linked to these biofertilizers [6, 109, 95, 8].

Nanofertilizers

The nanoparticles in nanofertilizers can be retained by plants, increasing trim yields. Despite significant differences in their classification, they are the product of new invention that will find application in farming. All things considered, Some definitions may include additional elements such as nanoscale transportation systems and nanobiosensors. The scientific world has been astounded by the various definitions of nanofertilizers. Nanofertilizers are a specific type of fertilizer that falls under the area of both fertilizers and nanotechnology. Due to this vulnerability, the precise definition and categorization of nanofertilizers remain unclear, potentially resulting in erroneous assumptions when evaluating their application and potential benefits.

The composition of the fabric used in a nanofertilizer can also serve as a basis for its classification. For instance, certain nanofertilizers are composed of metallic substances, whilst others consist of polymers or carbon nanotubes. Every frame of nanofertilizer has different properties and possible effects on plants. According to their activities, consistency, and the supplements they take, they are grouped generally in this evaluation. Understanding the characteristics of nanofertilizer is necessary to choose the best application technique. Nanofertilizers can be administered to plants by foliar, foliar, or soil application.

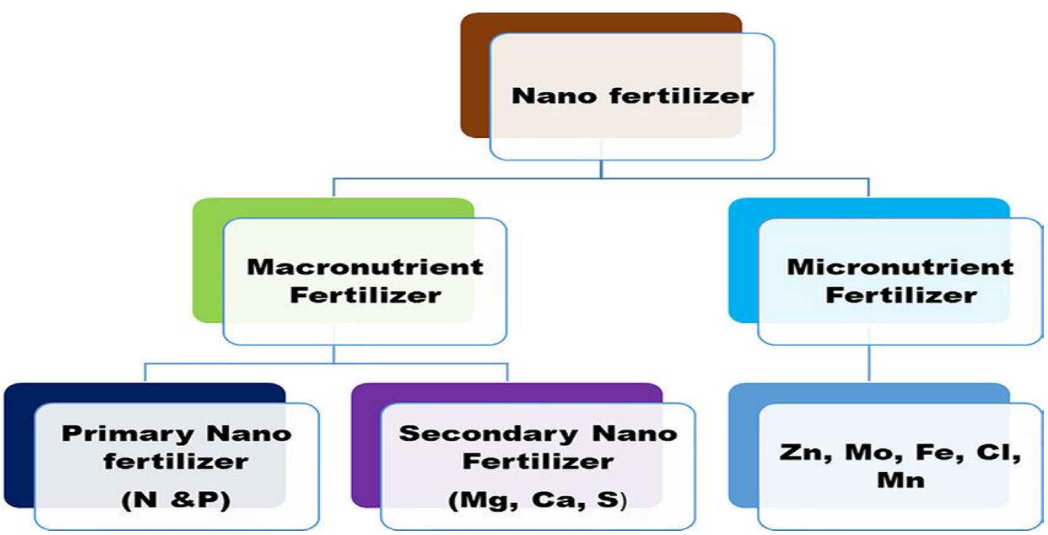

Fig 2.2 Types of Nanofertilizers

Types Of Nanofertilizers

1. Action based-

There are five different types of nanofertilizers available: transport-oriented, action-oriented, controlled-release, plant growth-promoting, and supplement and water-constricting. Some of the benefits of these state-of-the-art fertilizers include increased supplement uptake.controlled supplements in a way that advances feasible farming through expanded plant development, focused on supplement conveyance, supplement discharge, and diminished supplement misfortune.

2. Controlled-Release Nanofertilizers-

Nutrient leaching and inefficient nutrient usage are two problems with conventional fertilizers that controlled-release nanofertilizers have shown promise to remedy [7]. Nanoparticles are used in these fertilizers to regulate the release of nutrients, enhancing the absorption of nutrients and lessening their influence on the environment. The supplements in controlled-release nanofertilizers are Typical of carrier polymers at the nanoscale. Agrochemicals 2023, 2 300 consisting of inorganic materials, polymers, or lipids.

3. Carbon-Based-

Since carbon is a component of all organic substances and is engaged in biological processes, it is vital for supporting life. Additionally, plants can benefit greatly from nanostructured carbon , as demonstrated by the application of biochar, which is a leftover biomass from field plants. There are many carbon nanostructures in the charcoal, and when they come into contact with air, they oxidize and create pores on the surface.

4. Chitosan-Based

Experts in food, health, and agriculture all concur that chitosan, a biopolymer, is a great choice. It is a chitin derivative obtained from the shells of arthropods, with the acetyl groups removed Chitosan, being a cationic polymer, can have detrimental interactions due to its structure materials that are charged. Fertilizer molecules combine with chitosan to generate complexes that increase the nutrients' availability to plants. It also has the bonus feature of being able to be adjusted in size.

5. Clay-Based

Clay-based NPs have a lot of surface area and are reactive to nanolayers; they can be used to create CRF formulations. As nanoclay provides an active surface for numerous physicochemical and biological processes, it is an essential component in the synthesis of CRF.

6. Layer Double Hydroxides

Two-dimensional layered compounds known as layer twofold hydroxides (LDH) are composed of anionic components intercalated within an interlayer splitting. The regulated discharge of any form of anions modifies the positive charge of the LDH.

7. Nanocapsule-Based

Fertilizers are delivered and encapsulated in nanocapsules, which are little capsules usually made of either organic or inorganic material [30]. Carbon nanotubes, lipids, metal oxides, silica, and biopolymers are the materials used to make them [31].

8. Nanogel-Based

Fertilizers or other chemicals can be ingested by nanogels, which are springy materials made of a polymer combined with a fluid and dynamically discharged over time. The basic components nitrogen, phosphorus, and potassium are imbued into the nanogels for advancing the development of plants . Water purification, medication delivery, and fertilizers are among the industries that use nanogels.

9. Polyurethane-Based

The features of polyurethane nanoparticles (NPs), which are composed of organic units connected by urethane linkages, are leveraged by a new class of fertilizers called polyurethane-based nanofertilizers. Ring-opening metathesis polymerization (ROMP), The process, which involves the synthesis of a monomer from two distinct molecules with a double bond and subsequent polymerization, is commonly employed for the production of nanofertilizers based on polyurethane.

10. Starch-Based

Starch-based nanofertilizers are made of starch nanocrystals that are effectively broken up in water and connected to plants as a fluid or airborne [41]. These nanocrystals utilize a predominant renewable vitality source to fertilize crops in an proficient way without creating squander chemicals .

MANAGING BIOTIC STRESS WITH MICROBIAL AND NANO FERTILIZERS IN MEDICINAL PLANTS

In order to create sustainable agriculture with less dependency on agrochemicals, plant diseases—a significant environmental and agricultural hazard stemming from the ongoing use of pesticides—must be addressed [14]. Excessive and prolonged use of pesticides not only poses a risk to soil and plant health but also significantly reduces crop yields. It is essential to use effective and environmentally benign methods, including biofertilizers, to tackle phytopathogens [54]. Utilizing biofertilizers endophytically has the potential to reduce crop plant illnesses brought on by bacteria and fungi. Collinge and associates (2022). In order to produce sustainable agriculture with less reliance on agrochemicals, plant diseases are a major environmental and agricultural concern caused by advantageous microorganisms like Pseudomonas, Pantoea, Streptomyces, and Bacillus species, as well as the constant use of pesticides [14]. When pesticides are used indiscriminately and for extended durations, it not only affects the health of soils and plants but affects crop yields as well. Various approaches like biofertilizers must be used to combat phytopathogens which are environmentally friendly based and highly efficient [54]. The use of endophytic biofertilizers can help prevent crop diseases caused by bacteria and fungi. Collinge and associates (2022). Beneficial microbes including Bacillus species, Pantoea, Streptomyces, and Pseudomonas In order to create sustainable agriculture with less dependency on agrochemicals, plant diseases—a significant environmental and agricultural hazard stemming from the ongoing use of pesticides—must be addressed [14]. Prolonged and hazardous application of all types of pesticides can not only put the soil and plant health at risk, but also causes a significant decrease in crop yield. To control phytopathogenic infections, the application of efficient and ecofriendly methodology is required, which is biofertilizers [54]. Since the symbiotic endosymbiont biocontrol agents colonize the internal tissues of the plant, they render a symbiotic association to the plant as they remain in their "defend" mode and do not cause any visible harm over the whole life span. In fact, Bacillus sp. traditionally used in agriculture to suppress pests and promote crop growth, reducing the importance of this organism. The powerful endotoxin-producing ability of the biological pesticide

Bacillus thuringiensis (Bt) has been widely recognized. These endotoxins are genetically engineered to make plants resistant to insects in addition to their inherent ability to act as biopesticides.

Biofertilizers, as effective biological control agents, provide a stable alternative to hazardous materials such as pesticides, herbicides, fertilizers and insecticides [104]. Their efficacy has been acknowledged in the control of plant diseases such as viruses, bacteria, fungi, aphids, and nematodes. Because biofertilizers are found in many different places and have a remarkable capacity to live in plant tissues, they can have various interactions with the host plant. The variations among endophytic microbes are substantial.The plants include a wide variety of species, from small non-vascular plants to large conifers such as Pinus radiata. Bacillus, Rhizobium, Microbacteria, Burkholderia and Stenotrophomonas species are among the most important endophytic bacteria [115]. In adverse circumstances, several chemicals can support plants, including lipoxygenase, chitinase, phenylalanine ammonia lyase, polyphenol oxidase, and peroxidase (39). Lipoxygenase chemicals act as signaling particles in the plant-endophyte-pathogen communication system. By encouraging lipid breakdown through oxidation, they contribute to reaction prolongation [44]. Endogenous microorganisms boost plant resistance via stimulating systemic resistance (SAR) and activating systemic resistance (SAR) through the synthesis of phytohormones in response to pathogen attack. Endogenous bacteria produce pathogen-associated proteins that have antibacterial effects.Thanks to certain components, these proteins can strengthen the plant's defenses against oxidative attack. Lipopeptides such as mycosubtilim, plipastatin and surfactin are essential auxiliary metabolites in protecting the immune system against diseases [43]. Metabolites, such as surfactin, possess the capacity to regulate the colonization and inhibit the proliferation of many plant pathogens [67].

Abiotic Stress in the Environment and the Production of Secondary Metabolites in Medicinal Plants

The presence of overflowing sums of anti-oxidants, cytotoxic nature, and other restoratively critical highlights make restorative plants that deliver a assortment of auxiliary metabolites exceedingly profitable to us. In this way, Both contemporary pharmaceutical medications and many homegrown therapeutic remedies use medicinal plants as raw materials. Large-scale medicinal plant farming has advanced and expanded dramatically in recent years. Still, because of increased natural changes, a variety of abiotic weights can now affect medicinal plants. Medicinal plants change not only in their chemical makeup but also in their physiological makeup When exposed to abiotic challenges such as variations in light intensity and quality, high temperatures, water scarcity or flooding, nutrient availability, and the presence of heavy metals. In response to abiotic pressure, plants have evolved various morphological, anatomical, biochemical, and atomic strategies to mitigate its impacts.One strategy involves altering the synthesis of auxiliary metabolites.Plants, be that as it may, are incapable to resist delayed periods of push and at last die. To assist the plants survive the period of seriously stretch, a number of stress-reduction methods have been created, counting the utilize of endophytes, chemical treatment, and biotechnology methods. Moreover, as modern innovation to assist plants persevere troublesome situations, nanobionics is being investigated.

MICROFERTILIZERS ROLE IN ABSORPTION STRESS

The increasing influence of abiotic factors caused by climate change, including salt, drought, high heat, and heavy metal pollution, is significantly affecting agricultural output on a global scale [102]. These pressures have a detrimental effect on the physiological, morphological, and biochemical features of plants, leading to significant decreases in rural agriculture. The adverse impacts of abiotic stressors on the abdicate, which range from 51% to 82%, compromise the goal of achieving long-term and environmentally sustainable food production [62]. Using biofertilizers, especially as endophytes, is one possibility for mitigating abiotic pressure in many crops. Endophytic biofertilizers do not harm host plants; instead, they promote symbiotic, para-sitic, and mutualistic associations with the plants [9]. Their particular quality is essential to the hardiness and general health of plants. Endophytes, or biofertilizers, take up nutrients from their host plants, help the soil absorb minerals, and promote overall plant growth in order to establish mutualistic connections [27]. It has been shown that actinobacteria and other biofertilizer strains are essential for promoting plant growth because they produce metabolites and antibiotics in harsh circumstances. It has been shown that Pseudomonas sp. can improve plant growth in high temperature circumstances by lowering the levels of reactive oxygen species and heat shock proteins (HSPs).

TYPES OF ABIOTIC STRESS

A. Drought Stress

A major abiotic stressor, water scarcity reduces photosynthetic rates, germination rates, and agricultural productivity by hindering plants' capacity to grow normally. It has been shown that using biofertilizers—Pseudomonas putida in particular—boosts the synthesis of vital substances including lactic acid, abscisic acid, salicylic acid, and flavonoids, which increases the drought tolerance of maize and soybean plants [116]. Baccillus thuringiensis and Microbacterium sp., in turn, improve the drought stress tolerance of maize and chickpeas, respectively [20].

B. Salinity Stress

This alludes to the harmful consequences that elevated soil salt levels have on the physiological processes of plants. It especially affects essential processes including photosynthesis, the conversion of CO2 into organic molecules, and the rate at which plants release water vapor through transpiration. It has been demonstrated that the biofertilizers Pantoca agglomerans and Bacillus megaterium effectively boost the salt tolerance of crops such as tropical corn and maize. This is achieved by controlling aquaporins and promoting root growth [86]. Azospirillum negro. Beneficial microorganisms like Pseudomonas spp. help to protect plants from the harmful effects of salt-induced stress by upregulating antioxidant enzymes.

C. Temperature stress

Plant improvement and development are debilitated by worldwide warming. In specific, warm push represses the blend of proteins and delays seed germination [111]. Bacillus cereus and Azospirillum are illustrations of biofertilizers that decrease the impacts of warm stretch by advancing the amalgamation of phytohormones, warm stun proteins, and biofilms [98]. Wheat plants are shielded from cold stress by Bacillus velezensis, which demonstrates cold stress resilience by boosting the synthesis of cold stress-induced proteins.

D. Heavy metal stress

When too much fertilizer is applied, hazardous metals build up in the soil and cause soil metal pollution. Plants are at risk from the buildup of this material because it inhibits growth and causes oxidative stress [83]. Biofertilizers, such as Bacillus aryabhattai, Rhizobium, and Candida Parapsilosis, which stimulates the manufacture of vital chemicals and enzymes such antioxidant enzymes and phenylalanine ammonia, reduces the effects of stress caused by heavy metals.-lyase [23].

Table of various bacterial species used as microbial fertilizer for mitigating plant stress-

S No.	Microorganisms	Type of stress in plants	Plant Response
[1]	Diazotrophs	Nitrogen Stress - Pathogen	Improved nitrogen absorption, development of nodules.[1]
[2]	Piriformospora indica	Abiotic Stress - Fungus	Offer a practical approach to cope with Zn deficiency,enhances growth and nutrient status , improves antioxidant enzyme activities.[2]
[3]	Azospirillum brasilense	Drought Stress - Bacteria	Reduces the generation of reactive oxygen species and somewhat alters the metablome. [4]
[4]	Bacillus velezensis	Biotic Stress - Pathogen	Improved survival under abiotic stress metabolic reprogramming, differential protein expression.[5]
[5]	Rhizobium spp.	Nitrogen Stress - Symbiont	Enhances antioxidant system, produces ACC-deaminase and phytoharmones, improve nitrogen

			fixation and phosphate solubilization.[7]
[6]	Citobactor wekmanii (WWN1) Enterobacter cloacae (JWM6)	Heavy Metal Stress - Symbiont	Minimize the accumulation of toxic heavy metals in plant tissues, enhance plant growth under conditions of heavy metal stress, and exhibit the capacity for fertilization and restoration. .[11]
[7]	Bacillus cereus	Abiotic Stress – Drought	Enhances growth and nutrient availability in potato plants, increases soil available K Improves overall yield of potato.[13]
[8]	Bradyrhizbium sp.	Nitrogen Stress	Considerably improves growth yield and nitrogen concentration in mungbean, enhances total yield and protein content in seeds, shows potential as biofertilizer.[15]

[9]	Pseudomonas P.putida R32	Biotic Stress - Pathogen	Exhibits antiphytophthora activity hydrogen cyanide contributes to mycelial growth inhibition, multiple factors involved in disease inhibition.[17]
[10]	Arbuscular mycorrhizal fungi	Drought and salinity Stress - Fungus	Enhanced growth , improved water status, osmolyte concentration, and mineral nutrition under water deficit condition.[18]

Application

The green transformation raised trim yields per unit of arrive and met the developing nourishment needs of the individuals, but it too driven to a rise within the utilize of counterfeit fertilizers in agribusiness. The broad utilize of these fertilizers based on inorganic chemicals ensures worldwide nourishment security, but too postures a major danger to human and natural wellbeing. The standard the annual addition of artificial additions to the soil that are not used by plants, the use of chemical fertilizers results in an astounding amount of mineral waste, nursery gas emanations, eutrophication of sea-going environments, and salinization of the soil. A changing climate, an expanding populace, and the misfortune of arable arrive are all putting negative pressure on agribusiness, which implies that agrarian hones ought to be adjusted—possibly revolutionized. Ensuring global nourishment security could be a critical worldwide challenge. Farming may advantage from nanotechnology within the future within the taking after areas: creation of modern rebellious for cellular and organic inquire about; reusing of agrarian squander; security necessities for nourishment generation and dissemination frameworks; and shrewdly frameworks for diagnosing and treating plant maladies. Hence, to extend agrarian yield, focused on, controlled-release fertilizers must be created. Nanoparticles boost trim abdicate by improving the proficiency of agrarian inputs to empower site-targeted, controlled supplement dispersion and ensure the slightest sum of agri-input utilization. The capacity of distinctive NPs to advance plant growth and abdicate, diminish infection, and progress nourishment has all been assessed. The leaf's capacity to retain nanoparticles is enormously changed by the nanoparticles' conveyance strategies. Nanofertilizers can help make strides human wellbeing and nourishment by diminishing the require for biocides, reinforcing plants to outlive abiotic challenges, and expanding metabolite generation to make strides taste and rack life (Figure 3). Since nanofertilizers as it were require little sums and have a slow-release rate in expansion to their tall retention rate, they can minimize fertilizer utilization and natural hurt. It is significant to realize that choosing the right NP concentration is basic to optimizing productivity for a specific agriculture characteristic.

METHODOLOGY

Material and preparation of Leaf Broth

The antecedent salt utilized in this handle was cupric chloride dihydrate (E. Merck), and the neem (Azadirachta indica), Eucalyptus clears out were assembled from Delhi Technological University (OAT) Delhi, India. The complete examination was conducted utilizing deionized water. Neem and Eucalyptus takes off that are new and sound ought to be well-rinsed two to three times with deionized water to induce freed of tidy and other undesired particles. The clears out were dried in an broiler set to 50 degrees Celsius for 15 minutes . The 250 mL Erlenmeyer flask was heated to 60 °C for 20 minutes while holding 20 g of tiny leaf fragments and 100 mL of deionized water. The leaf broth was obtained, and it was kept for later testing at 4 C after being filtered twice through Whatman paper.

Fig 3.1 Dried Neem Leaves

Green synthesis of copper nanoparticles

CuNPs were produced synthetically using a green reduction process. An oil bath was used to heat the flask containing the aqueous salt solution CuCl2$2H2O (7.5~ 10~3 M) to 85 °C. magnetic agitation Next, dropwise additions of 20% neem leaf broth were made to this mixture. The dispersion's color steadily varied over time, going Depending on the number of intermediate stages, Green turned to yellow then orange then radish brown then brown and finally dark brown. The dark brown fluid was next centrifuged at 6000 rpm for 15 minutes. Two months of 4 °C were spent with the supernatant dispersion. many methods of spectrophotometry such as FTIR, Zetasizer, XRD, TEM, and SEM The generated CuNPs were analyzed to look at their stability, crystalline nature, form, and functional group.

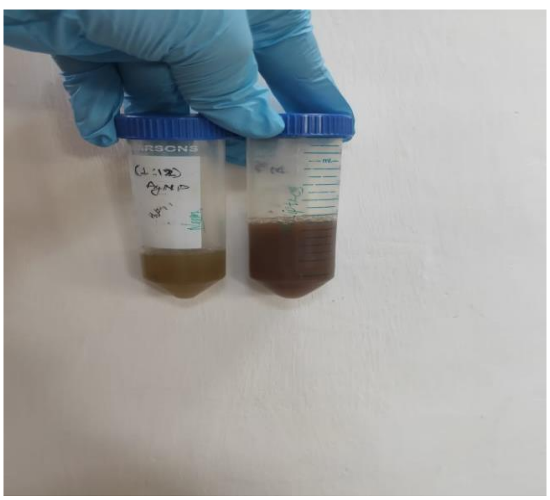

Fig 3.2 Extract of Neem and Eucalyptus

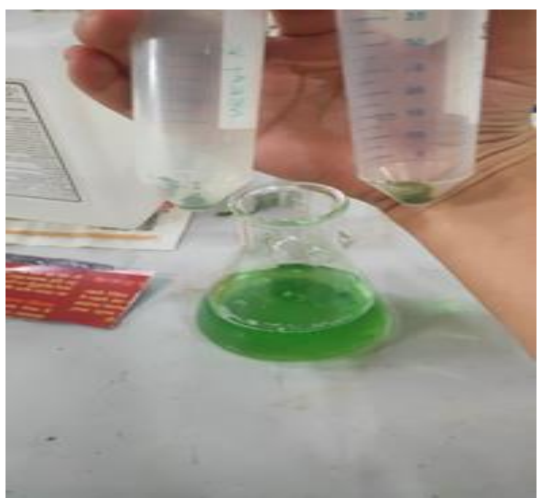

Fig 3.3 Synthesis of Nanoparticles

Characterization

The UV 3000Í LABINDIA twofold pillar spectrophotometer was used to record the characteristic optic properties of the colloidal NPs. It has a way length of 1.0 cm and a ghostly run of 200–800 nm is the wavelength range. Far Infrared Neem leaf broth and synthetic CuNPs have their spectra captured as KBr pellets. within the 4000–400 cm^1 range using an ALPHA-T eBruker demonstration. The dispersed NPs were ultrasonically treated for 40 minutes (Ultramet 2005, Buehler, USA) and centrifuged (Research facility Centrifuges Remi, display R-8C) in order to prepare them for analysis. Following that, 30 mL aliquots were removed and placed on the stub in order to be examined under a SEM. This made it possible to consider the CuNPs' morphology. Photographs obtained with the 200 kV Tecnai G2 20 (FEI) S-Twin show confirmed the shape of the freshly produced CuNPs. One drop of an ultrasonicated dispersion suspension was applied to standard carbon-coated copper networks for TEM investigation, and the test was then dried under an infrared light for fifty minutes.The Cu Ka radiation's XPERTPRO X-Ray Diffract meter (l ¼ 0.1540 nm) was utilized for the XRD characterization, with a filtering rate of 2~/min and 2q extending from 10~ to 89~. Zetasizer ver. 7.11 Malvern was utilized to survey the steadiness of the delivered CuNPs, and the MAC (MSW-552) computerized pH meter was utilized to degree ph..

Result

The natural union of nanoparticles using plants as bio reductants can be interesting since, in contrast to other natural techniques, it does not require the assistance of cell culture and can be appropriately scaled up for blend on a massive scale. Here, the nucleation of nanoparticles in arrangement was initiated by using a watery extract of Azadirachta indica leaves as a reactant. UV-visible spectroscopy and the reaction mixture's color change were the key techniques used to authorize the union of CuNPs. The creation of CuNPs was shown by the $CuCl_2$ solution's color changing from light blue to green and finally to dim brown when the leaf broth was added.. Plasmon resonance at the surface (SPR) phenomenon is the cause of the color shift in an aqueous solution. The results of this work are intriguing because they could provide a basis for identifying potential therapeutic plants to be used in the synthesis of CuNPs.

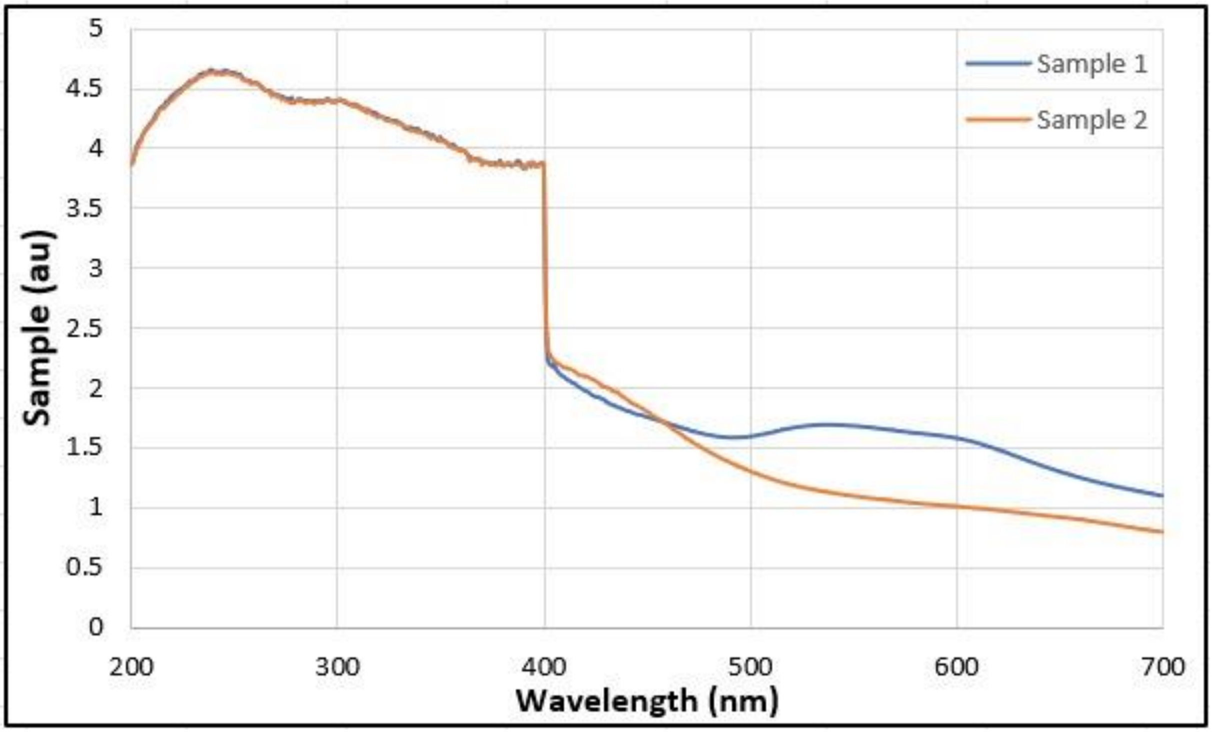

Fig 3.13 Absorbance measured using UV- VIS spectroscopy using Beer-Lambert Law.

Anti-Bacterial activity of Copper Nanoparticles-

The synthesized copper nanoparticles demonstrated a high level of antibacterial efficacy in an antibacterial test. Copper Microparticles demonstrated a suppressive impact on the E. Coli strain's proliferation. Therefore, copper nanoparticles may have some antibacterial properties.
The copper-based batch trials Alginate beads coated in nanoparticles revealed that 8 was the ideal contact time and dosage for reducing bacterial growth. grams and 60 minutes, respectively, with 100% efficiency as the maximum. The amount of nanoparticles and contact duration both boosted the percentage reduction of germs. Additionally, the column investigation revealed that 100% bacterial clearance was seen during a contact duration of 6 hours, indicating that copper alginate beads exhibit antibacterial efficacy. Therefore, we can say that copper alginate beads had an exceptionally high level of efficacy in lowering bacterial concentrations.
The polyurethane foams coated with Cu were effectively constructed. The Cu-coated polyurethane microbiological test findings in tube test conditions demonstrated that these materials have highly effective Gram-negative antibacterial properties. The antibacterial properties of these materials were validated by the microbiological test results conducted on Cu-coated polyurethane under flow test conditions. According to this study, copper-coated polyurethane foams have a number of uses in various industries requiring straightforward treatment systems and make good antibacterial water filters.

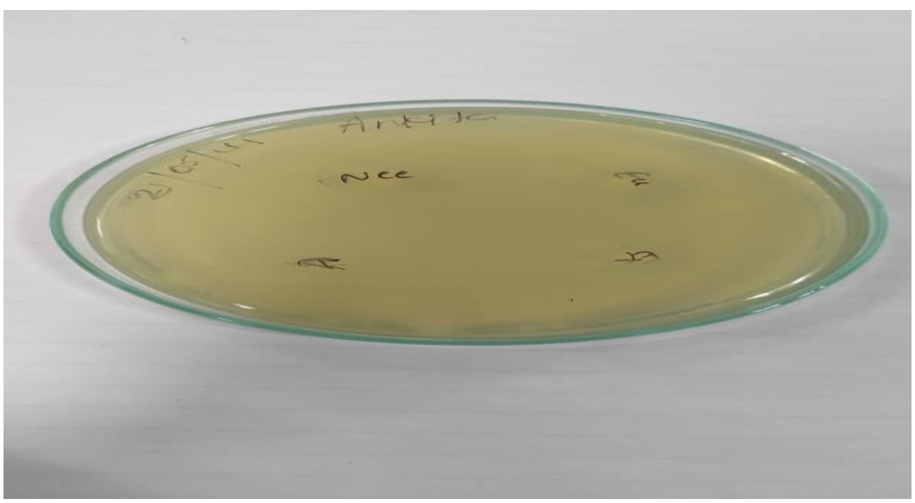

Fig 3.4 Antimicrobial activity of CuNP

QUALITATIVE ANALYSIS OF PHYTOCHEMICALS

1. Test for Saponin

When 2 mL of refined water is included to 1 mL of extricate and well disturbed, a 1 cm layer of froth shapes, showing the nearness of saponins .

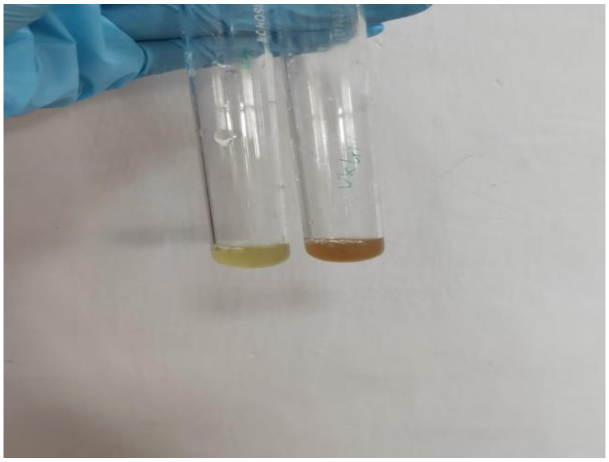

Fig 3.5 Positive test of Saponin

2.Test for Protien and Glucoside

Some drops of mercuric chloride were included to 1 mL of extricate. Protein is present when yellow coloration appears.

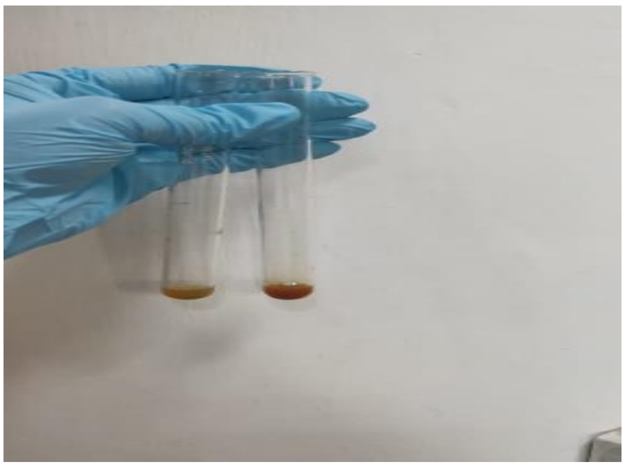

Fig 3.6 Positive test of Protein

3. Test for Tannin

Stir one millilitre of $FeCl_3$ into one millilitre of crude extract. Tannins are indicated by a blue-green or black colour.

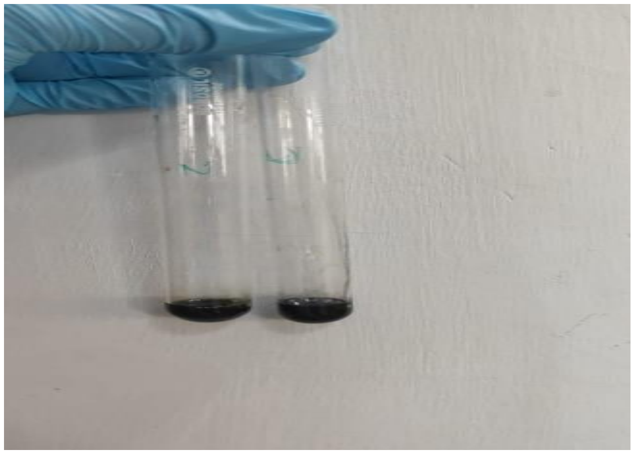

Fig 3.7 Negative test of Tannin

4. Test For Glycoside

Add 1 ml of GAA, $FeCl_3$ and H_2SO_4 to 2ml of extract.The presence of glycoside is indicated by green or blue precipitate.

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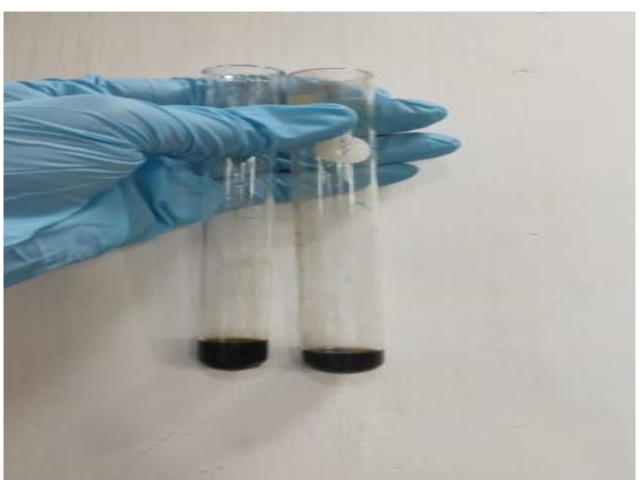

Fig 3.8 Positive Test Of Glycoside

5. Test For Cardiac Glycoside

Add one drop of $FeCl_3$ and one milliliter of glacial acetic acid to two milliliters of conc. H_2SO_4 in 2 ml of extract. The presence of cardiac glycoside will be indicated by forming brown ring.

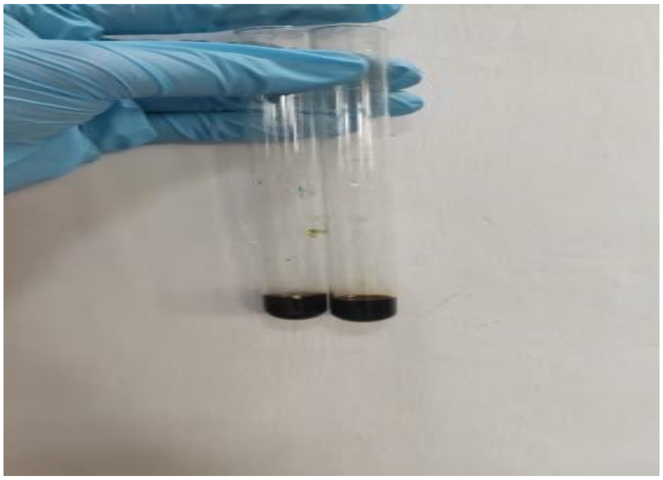

Fig 3.9 Positive test of Cardiac Glycoside

6. Test For Terpenoids

Add 2ml $CHCl_3$ and 2ml conc. H_2SO_4 in 2 ml extract Terpenoid presence will be indicated by the development of a reddish-brown ring at the junction.

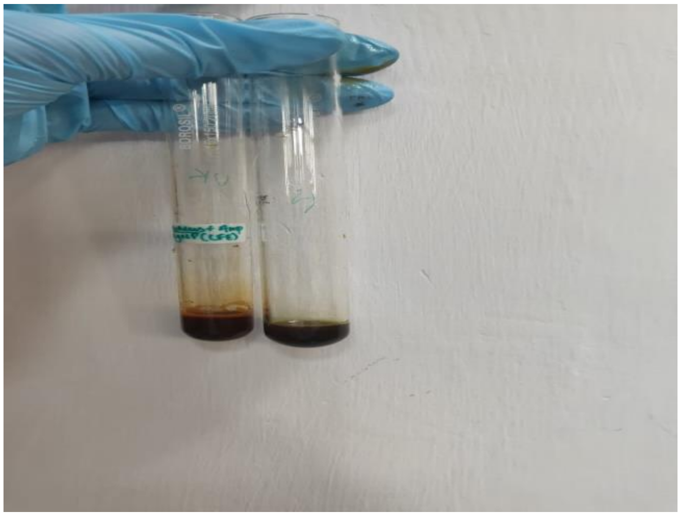

Fig 3.10 Negative test of Terpenoids

7. Test For Flavonoids

To 2 ml of extract, add 1 ml of lead acetate. The color yellow denotes the presence of flavonoids.

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Fig 3.11 Positive Test of Flavonoids

Table. Phytochemical analysis of Neem and Eucalyptus Extract

Extract and Tests	Leaf	
	Neem	Eucalyptus
Saponin	+	+
Protien and Glucoside	+	–
Tannin	+	–
Glycoside	+	+
Cardiac Glycoside	+	+
Terpenoids	+	–
Flavonoids	+	+

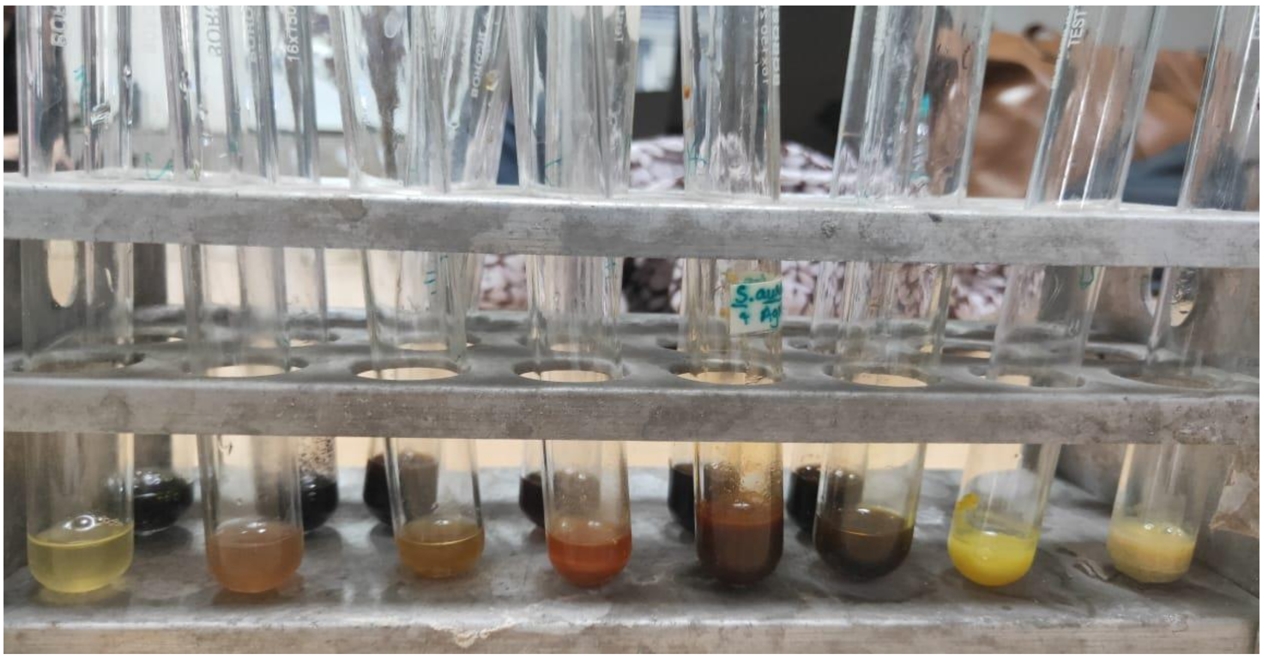

Fig 3.12 Phytochemical Test Of Nanoparticles

Discussion

For most people on the planet, medicinal plants provide their main supply of life-saving drugs. They continue to be an essential therapeutic tool for the treatment of human ailments. Many different types of flowering medicinal plants can be found in India. From ancient times to the present, plants have been used as medicine in all communities. Medicinal plants are crucial for human healthcare due to their role as the basis of traditional medicine, which is used by more than 80% of the global population. Currently, the World Health Organisation (WHO) estimates that there are approximately 150 billion cases of diabetes globally. Global; by 2025, that number is expected to quadruple. The results showed that the ethanolic and methanolic leaf extracts of C. roseus had the greatest antibacterial activity against S. typhi. The antimicrobial activity of the ethanolic extract may be caused by the presence of special phytochemical ingredients. The therapeutic value of the C. roseus plant is extremely high. This fact was amply demonstrated by the large body of research, publications, and 295 patents pertaining to the plant and its products. The majority of research on this plant has focused on its ability to fight diabetes, hypertension, and cancer. Consequently, the development of substitute antimicrobial medications is required to treat infections acquired from many sources, including medicinal plants.The presence of secondary metabolites of different chemical kinds in the plant material, either separately or in combination, may be responsible for the antibacterial action observed in this study. The utilization of plants as biological reducing agents in the biosynthesis of nanoparticles may offer several advantages compared to other biological methods. This approach avoids the need for maintaining cell cultures and may be easily scaled up for large-scale synthesis. The work utilized an extract derived from the leaves of Azadirachta indica as a reagent for the nucleation of nanoparticles in a solution. The confirmation of CuNP generation primarily relied on the color alteration of the reaction mixture and was further supported by UV-visible spectroscopy. Upon the addition of leaf broth to the $CuCl_2$ solution, the solution's color transitioned from a bright blue hue to green and ultimately to dark brown, signifying the creation of CuNPs. The alteration in color observed in a solution containing water is a result of the occurrence of surface plasmon resonance (SPR). The results obtained in this work are quite intriguing as they can serve as a foundation for identifying prospective therapeutic plants for the synthesis of CuNPs.

These biomolecules, terpenoids and nimbaflavones reacts with [Cu/A. indica leaf broth]2 to create [Cu/A. indica leaf broth] by producing the functional groups with A. indica leaf broth [ProgressHUD]. In this research we dealt with the study of absorption spectra for CuNPs manufactured with the extract of Neem, Eucalyptus. The results showed that the copper ions were reduced completely to copper nanoparticles, with the rate of bio reduction almost reaching 100%. It was confirmed by qualitative tests of the supernatant liquid after making the purification of the copper nanoparticles for SEM. The differences in recalcitrant bio reduction rates might be due to differences in the performance of amino acids in aqeous extract of Neem. The reaction solution is grey-brown and the optical absorption band of copper nanoparticles around 579 nm occurs during surface plasmon resonance. The reaction mixture in the current study exhibited a single surface plasmon resonance (SPR) band, indicating the copper nanoparticles were spherical. Transmission electron microscopy (TEM) imaging also confirmed this. This study was conducted to evaluate the impact of citrus juice extract and produced copper nanoparticles (CuNP) on Escherichia coli and Staphylococcus Aureus using (A) agar well diffusion technique and (B) disc diffusion technique.

Conclusion

This paper established Phytochemicals analysis, antioxidant activity, antibacterial activity, and in vitro anticancer activity using Water and Methanol extracts of Catharanthus roses . Based on the results obtained in both the extracts used in the test, methanol extract was determined to be the better extract for all the studies. The methanol extract was then loaded on to a silica gel column to obtain the impure compound, and the fortunate last step of gc-ms was done. An experiment using thin-layer chromatography (TLC) helped in the identification of a chemical compound in the plant extract.

The antibacterial investigations have demonstrated the pathogen's effectiveness in killing Pseudomonas aeruginosa and Bacillus subtilis. In addition, He La cell lines were utilized in a study using cytotoxins, resulting in a mortality rate of 23 percent for the cells. A GC-MS investigation uncovered the presence of chemicals in the extracts that possess antibacterial, anticancer, and anti-inflammatory properties. Copper nanoparticles (CuNPs) were produced by a straightforward and eco-friendly biosynthetic method employing the leaf broth of A. indica. This is a straightforward and cost-effective option that does not necessitate the use of any harmful or poisonous chemicals. The leaf broth contains biological substances that not only decrease metal ions but also stabilize metal nanoparticles. Analyzed were several reaction circumstances using distinct instrumental approaches for the synthesis. The CuNPs that were produced have a high level of crystallinity and a cubic structure. On average, they have a size of 48 nm. These nanoparticles are stable for a period of 2 months when stored at a temperature of 4°C. This stability is due to their high zeta potential, which measures 17.5 mV. These perfect conditions contribute to their long-term stability. The neem leaf broth demonstrated a significantly higher rate of metal ion reduction compared to earlier research involving microorganisms. This highlights the potential of biosynthetic approaches for nanoparticle creation to achieve synthesis rates similar to those of chemical synthesis methods.

Future Prospect

The possibility for biofertilizer research in the future presents a big chance to develop sustainable agriculture and address new challenges. Here are some potential directions for further investigation: Examine the complex molecular mechanisms that control how plants respond to biofertilizers under various stressful conditions. Understanding the intricate gene expression patterns and signaling networks will be crucial to understanding the precise processes by which biofertilizers improve plant growth and resilience to stress. Consider the vast array of microbial species and their possible application in biofertilizers. Discovering new strains with distinct qualities, such improved nutrient solubility or stress tolerance, can expand the range of available biofertilizers.Create customized biofertilizer solutions that are appropriate for particular crops, soil types, and climates. Optimizing microbial consortia and fine-tuning nutrient ratios can improve efficacy and guarantee appropriate interactions between microorganisms and plants in a variety of agricultural situations. Field research: Conduct in-depth field research to confirm the biofertilizers' efficacy in actual agricultural settings. This type of holistic comprehension of practical implications and sustainability from using biofertilizers will be derived from in-depth research on several crops conducted across various agricultural environments. Synergy can be identified and utilized between biofertilizers and innovative agriculture technologies with the aid of this. This paper speaks of several factors such as the monitoring by the use of sensors, data analysis, and the accuracy of farming that will offer the integration needed in the improvement of the biofertilization application in order to provide efficiencies of resources and decrease impacts of the environment. There is also a need to enhance the capability and quality of the local biofertilizers to withstand more the impact of the climate change. New microbial strains have to be chosen or naturally occurring bacteria have to be selected which are better suited to the climatic changes or the agricultural benefits may have to be retained with corresponding environmental changes

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OT-27

Microbial Fertilizer for Alleviating Stress in Medical Plants

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Abstract - The increasing world population represents significant challenges in meeting the growing need for food, feed, and agricultural goods, especially in developing nations. The tradition application of chemical fertilizers, although promoting plant growth, has resulted in environmental pollution, changes in soil ecology, and risks to human health. Climate conditions worsen the impact of non-living stressors on crops, reducing agricultural productivity. Crop health and productivity are negatively affected by abiotic and biotic stresses, including soil salinity, drought, temperature fluctuations, and infections. To address these issues, there is an increasing trend towards the use of bio fertilizers, which harness natural mechanisms such nutrient solubilization, nitrogen fixation, hormone synthesis, and enzyme activity. Microbial fertilizers are essential for enhancing plant health and reducing stress conditions among the various types of bio fertilizers. This review seeks to offer a thorough evaluation of the significance of medical plants, present the notion of microbial fertilizers, and discuss the matter of stress in medicinal plants and its influence on their medicinal characteristics. The main objective of this review is to investigate the effectiveness of microbial fertilizers in reducing stress in medicinal plants. This research aims to provide significant insights into sustainable agricultural practices by analyzing the mechanisms of action, contributions to crop productivity, and involvement in biotic abiotic stress tolerance of various factors. The use of microbial fertilizers not only resolves the issues related to chemical fertilizers but also aligns with environmentally friendly and economically reasonable methods to promote robust crop growth. This review highlights the importance of microbial fertilizers in the context of growing medicinal plants and their potential to enhance global food security.

Keywords- Medicinal Plants, Microbial Fertilizers, Abiotic Stress, Crop Productivity, Sustainable Agriculture.

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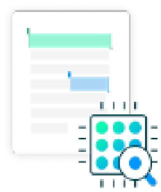

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