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Bioprospecting of endophytic nanotechnology: A new biocontrol agent against pathogenic microbes

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Abstract:

With the revolution in the field of science, nanotechnology has evolved as one of the most promising areas which has good promising potential capabilities. But this fact cannot be neglected that nanotechnology has not expanded its full roots in the area of agriculture and the environment. As these nanoparticles have different structures and shapes such as nanospheres, nanocubes, and nanoshells, thus they are considered as one of the most stable materials. On the other hand, the advent of plant endophytes is also simultaneously emerging as one of the key sources to explore different interactions and plays a pivotal role in promoting plant growth and crop improvement. The association of endophytes with nanoparticles could provide a great breakthrough in the bioprospecting of a sustainable environment. Endophytes have the potential to produce various types of nanoparticles that have anti-pathogenic properties against many pathogenic microorganisms that are responsible for causing diseases in humans as well as in plants. The biological synthesis of nanoparticles that can be explored from endophytes can be efficient enough to control all forms of pathogens. This will in return contribute to the environment in a very effective manner. This paper will focus on exploring the importance of endophytic nanoparticles in the form of nano-fertilizers, nano-bionics, etc. also focussing on major breakthrough and its prospecting role in the environment.

Keywords: Bioprospecting, endophytes, interactions, nanoparticle, pathogens, nano-bionics

Introduction:

The immediate need for new as well as novel compounds to provide assistance and relief in all aspects has increased tremendously. The uncontrolled and unregulated use of many chemical fertilizers has in return degraded the quality of soil thus making it unsustainable. To overcome this problem, strategies and applications should be implemented that are eco-friendly, and thus we can fully explore the actual potential of microorganisms that are associated with plants as bioinoculants.[2] There have been sufficient studies done that are related to the discovery of several beneficial microorganisms. Many recent studies have explored that endophytic microorganisms (both bacteria & fungi), reside asymptomatically within the host cell and they can influence the health of humans as well as animals. They can also impact the overall yield of crops. Endophytes and the associated studies are emerging as one of the most promising areas in the field of research & development.[1] The overall production of bioinoculants of endophytes and their increased demand in the agriculture sector have channeled the attention in gaining prominence and enhanced the gross market scale.

Once we are at a stage where we can implement the actual use of these bioinoculants, the actual focus will shift to process development, optimization, and even production at a very large scale. These endophytic microbes tend to contribute to the overall plant growth by helping in soil mineralization, production of many bioactive molecules, synthesis of phytohormones, etc. [3] The association between the host plant and microorganisms can help in enhancing the health of a plant as it will uptake the nutrients and will overall improve the resistance of plants to pathogens as well as stress. These endophytic microorganisms are helping to contribute to the overall physiological and biochemical roles of plants. Under specific conditions, microbial activity can be affected by the less phytohormone synthesis which is very much essential for the nutrition of plants. In recent times, less study has been done in the context of several strategic methods to harness many endophytic microorganisms in the breeding of crops. So, in this regard, a wide range of techniques and methods can be implemented to determine the genotype of plants and to know the range of microorganisms that can be beneficial for crop production.

Also, nanotechnology has come up as one of the most promising fields. Nanotechnology is trying to contribute to and mitigate the problems that are associated with managing diseases in several crops and plants. They are helping in lowering the excessive usage of chemical substances as they are very harmful to humans as well as the environment. Many nanoparticles as well as their derivatives tend to show antimicrobial activities as per their morphology, size, and chemical attributes.

In the current review, we will try to focus on the overall product development optimization that will be completely based on the experience and several aspects of endophytes. We will also emphasize shifting our major focus to various underexplored areas and on the identification as well as characterization of important endophytes. We will discuss the microbiome of endophytes, various mechanisms, several factors responsible for the actual recruitment of endophytes, and also various approaches to shape the microbiome of plants and crops in a much better and more efficient way. The efficient use of nanoparticles can be then incorporated to mend the needs of the future. We will also highlight the use of endophytic nanoparticles and their importance in the fields of medicine, environment, pharmaceuticals, and agronomy.[9]

With the revolution in the field of science, nanotechnology has evolved as one of the most promising areas which has good promising potential capabilities. But this fact cannot be neglected that nanotechnology has not expanded its full roots in the area of agriculture and the environment. As these nanoparticles have different structures and shapes such as nanospheres, nanocubes, and

nanoshells, thus they are considered one of the most stable materials. On the other hand, the advent of plant endophytes is also simultaneously emerging as one of the key sources to explore different interactions and plays a pivotal role in promoting plant growth and crop improvement. The association of endophytes with nanoparticles could provide a great breakthrough in the bioprospecting of a sustainable environment. Endophytes have the potential to produce various types of nanoparticles that have anti-pathogenic properties against many pathogenic microorganisms that are responsible for causing diseases in humans as well as in plants. The biological synthesis of nanoparticles that can be explored from endophytes can be efficient enough to control all forms of pathogens. This will in return contribute to the environment in a very effective manner. This paper will focus on exploring the importance of endophytic nanoparticles in the form of nano-fertilizers, nano-bionics, etc. also focussing on breakthrough and their prospecting role in the environment.

The association between virus-fungus-plant and the importance of endophytic microorganisms:

If we talk about the viruses that are present in the plants, they seem to be the most interesting area to explore. This happens because the various properties that are being exhibited by the host plant play a very important and crucial role in the transmission of viruses from one host plant to another. All the fungi can be infected by the viruses and so endophytic fungi too. All the viruses that tend to infect the fungi are called mycoviruses. They tend to control all the diseases that are caused by fungus. It causes various symptoms or changes their growth is irregular, abnormal pigmentation, etc. And so, in this regard, a lot of chemical pesticides and insecticides are used to control the various diseases.

To decrease the use of these chemical pesticides and insecticides, various eco-friendly techniques and methods are now being used to control these diseases. These fungi and viruses have the potential to cause several losses to the crops. All these chemical substances can't directly control these viral diseases in crops, so proper strategic management needs to be implemented. In this context, endophytes prove to be the suitable alternative in place of all these chemical agents. Endophytic fungi can be thus utilized in managing the various viral diseases in plants.[15]

Currently, the most emerging and trending topic is the discovery of endophytes and how they can be used in various ways for the betterment of society. Endophytes exhibiting symptomless nature make them outshine above all. They even show symbiotic or mutualistic associations with their host. Endophytes can be both fungi as well as bacteria. They can also be of some other microbial forms like mycoplasmas but less study has been reported in this context. Out of all the studies and reports it has been observed that endophytes prove to be one of the richest and most authentic sources of diversity at the genetic level. These endophytic microorganisms live in various biological niches and they tend to exhibit various secondary metabolites having a lot of important properties which could be thus used in the field of agriculture, and industry as well as can be helpful for sustainable development.

Various strategic approaches in the context of endophytic microorganisms:

We already know the relation and association between microorganisms and host plants. This has majorly contributed to knowing the exact function, importance, and nature of the microorganisms with the help of several biotechnological techniques and tools. All these strategic approaches have paved the way to know the exact importance of the same and how various derivatives can enhance the overall productivity and role of plant-microbiome interactions.[6] Various research-based methods can be implemented which can help in investigating the beneficial effects as well as helping

in the adaptation of endophytic microorganisms in plants, and can be also used to calculate the overall microbial biomass in the endosphere. Several antimicrobial agents as well as biosynthetic clusters of genes and antifungal agents that are produced by these endophytes have been studied in the context of greenhouse and field experiments. All these agents have the potential to show biocontrol activity against various phytopathogens.[7]

In this context, the various plant-based strategies play a very significant role in providing all kinds of mechanical support so that the plants can easily take up all the essential nutrients and help enhance the overall production of the plant/crop.[8]

Role of Nanotechnology and Nanoparticles-Plant Interaction:

The sudden onset of nanotechnology has paved the path in the field of science and technology and its application in several fields can thus help in overcoming the problems associated with sustainable agriculture and also managing the infestation of pests in the agricultural fields. [4] Since these endophytes exhibit various properties, they can be environment-friendly, non-toxic, etc. These endophytes are non-pathogenic so the active metabolites present in them can be of great use. These metabolites can be used in the manufacturing and production of several nano pesticides to control the infestation of pests and the associated diseases.[5]

The various nano-formulations can prove to be a boon in this context. They can have targeted delivery of the most active compound and this will in return help the farmers to not use all these insecticides and harmful pesticides. The direct intervention of all the transfer of genes mediated by nanoparticles into the most active endophytic microorganism can bring out a sudden and highlighting change towards the resistance of all the pests and the diseases associated with it. Also, developing several biosensors from the endophytes can help in a lot of ways. It will help farmers to observe and control the infestation of pests and diseases in the agricultural fields.

Various studies have highlighted the importance of interaction between nanoparticles and plants. Nanoparticles exhibit several properties which make them superior to others. But this fact cannot be denied that these nanoparticles do have some ill effects on the plants as well along with some positive effects.[11] The extensive interaction of these nanoparticles with the environment as well is also responsible for affecting the different properties of these nanoparticles. Microorganisms that are living in the soil also affect the intake of the nanoparticles to the host plant.

Conclusion:

This review focuses and emphasizes on the actual role and importance of endophytes in managing the infestation of pests and insects. This paper will also highlight how these endophytes can help contribute as a completely new source of safe and environment-friendly pesticides/insecticides for the management of diseases. The isolation and proper characterization of these endophytes can provide a platform for exploiting the actual importance and roles of these endophytes. We will also get to know about the interaction of plants and microbes and this will help in finding the bioactive compound which will thus increase the growth of plants and will also improve their biological activity. With the help of these endophytes, the goal of achieving sustainable development will be achieved.[10]

Several chemical compounds or even methods pose cause harm to the environment as well as human health. In this context, nanoparticles are considered to be biotechnologically attractive as they show various biological effects on microorganisms that are pathogenic as well as contribute towards plant growth promotion. Microorganisms associated with plants are achieving new heights and can be employed in the green synthesis of nanoparticles and implemented it in the agriculture sector.[13]

Despite continuous efforts and knowing the actual potential of endophytes, several challenges and hurdles still need to be overcome.

Plant-symbiont microbes constitute a rich and unexplored source of natural secondary metabolites. Also, the actual exploitation of the tropical microbiome needs to be critically monitored as there is an increased demand for eco-friendly practices in agriculture. All these practices will effectively improve the overall production as well as curb the problems associated with several biological threats.[14] Therefore, endophytic microbes play a very important role in ensuring the development of a nation, and overall productivity as well as protecting tropical crops in the distant time.[12]

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