BIO-REMEDIATION OF MONOCROTOPHOS PESTICIDES BY ACTINOBACTERIA

ABSTRACT

Background: The persistent use of pesticides in agriculture is an issue of global concern due to their potential environmental impact and adverse health effects. Despite their efficacy in controlling pests and improving crop yields, pesticides can disrupt ecosystems, contaminate soil and water, and endanger non-target species. Additionally, the widespread reliance on these chemicals can lead to pesticide resistance in pests, reducing their effectiveness over time. These challenges underscore the need for more sustainable and environmentally friendly pest management strategies.

This study introduces Actinobacteria as a potential solution to these challenges. Actinobacteria, a diverse group of Gram-positive bacteria, have been recognised for their potential in agricultural applications due to their unique metabolic capabilities. Remarkably, some Actinobacteria strains have demonstrated the ability to degrade various pesticides, mitigating their environmental impact. This study examines the feasibility of utilising indigenous Actinobacteria strains to degrade monocrotophos, a commonly used pesticide in agricultural practices. The findings provide valuable insights into the potential of these microorganisms as a sustainable alternative to conventional pesticide use.

Materials and Methods: This study conducted extensive sampling across various agricultural regions in Uttarakhand, an area characterised by its heavy use of monocrotophos pesticides. 120 soil samples were systematically collected from these sites, specifically from Tehri-Garhwal, Chamoli, Srinagar, Uttarkashi, and Haridwar. These samples offered a wide variety of microbial communities, which potentially possess the capability to degrade monocrotophos, a commonly used organophosphorus pesticide. The selection of these diverse sites enhanced the likelihood of identifying the most promising strains of Actinobacteria, thereby optimising the potential success of this bioremediation strategy.

An intensive microbial analysis was conducted after carefully collecting soil samples. Of the 280 microorganisms identified, 24 distinct strains belonged to the Actinobacteria class, accounting for approximately 8.57% of the isolated microorganisms. These Actinobacteria strains were initially screened based on their unique morphological features, colony appearance and staining characteristics. The isolates' pigment production and colony characteristics were assessed to provide a comprehensive profile of each isolate.

The classification was further refined through advanced molecular testing, facilitating the identification of three significant genera within the Actinobacteria class: Micromonospora (65%), Actinomycetes (25%), and Streptomyces (10%). This identification is critical as it allows for leveraging these strains in bioremediation efforts, particularly in monocrotophos degradation.

The isolated Actinobacteria strains demonstrated substantial Plant Growth Promoting Rhizobacteria (PGPR) characteristics. This quality lends itself to the prospect of these strains serving as potential bio-fertilizers, bio-pesticides, or bio-insecticides. Each strain was subjected to a series of PGPR tests, revealing impressive capabilities, including Indole Acetic Acid (IAA) production, phosphate solubilisation, siderophore and HCN production, and catalase activity.

The degradation potential of the isolates was specifically scrutinised concerning monocrotophos pesticides, a compound prevalent in the sampled agricultural areas. The isolates showed varying but generally effective degradation rates, providing a promising insight into their capacity for pesticide bioremediation. This degradation potential was quantified, offering valuable information about the relative performance of the isolates in breaking down monocrotophos. The information gleaned from this study enriches our understanding of the degradation capabilities of these Actinobacteria strains, thereby enabling more effective strategies for managing pesticide pollution in the future.

Results: A significant aspect of this study was the genetic manipulation of Actinobacteria strains, explicitly focusing on the opd gene - a gene known for its relevance in pesticide degradation. To further explore the potential of these bacteria, the opd gene was isolated from the Actinobacteria and integrated into vector DNA to form recombinant DNA.

This recombinant DNA was then introduced into E. coli cells, a procedure that resulted in the formation of a mix of recombinant (transformed) and non-recombinant (non-transformed) colonies. This methodological approach allowed for amplifying the Actinobacteria's inherent pesticide degradation abilities within a host organism, thereby providing a scalable model for future applications. This portion of the study demonstrated the feasibility of using genetic manipulation techniques to boost the inherent capabilities of these microorganisms and achieve targeted objectives such as enhanced pesticide degradation. . Our investigation into the role of actinobacterial formulations in maize cultivation over a 20-day period yielded noteworthy results. The experiment involved six distinct actinobacterial treatments compared with three control groups. The outcomes revealed a consistent trend of improved growth in maize plants treated with these formulations. Among them, the CC-CMC and FLO-KAO variants, especially in bead and powder forms, stood out for their significant impact on growth enhancement. The CC-CMC powder (Test 3) was particularly effective, showing an impressive 41.67% growth increase, the highest recorded in the study. These results highlight the potential of actinobacterial formulations as effective agents for growth promotion in agricultural practices, suggesting a viable method for boosting maize crop yields.

Potential Applications: The study uncovered promising applications of Actinobacteria isolates in agricultural settings. The identified isolates showcased characteristics that could be harnessed for bio-fertilizers, bio-insecticides, and bio-pesticides. They produced effective growth hormones and metabolites that can be utilised in formulating various agricultural products. Additionally, their ability to biodegrade and detoxify harmful pesticides and insecticides was significant. The study provides a foundation for developing sustainable and eco-friendly farming practices.

Conclusion and Future Directions: The investigation concludes with a confirmation of the role of Actinobacteria in pesticide degradation, thereby providing a sustainable alternative to traditional pesticide use in agriculture. It has also opened up a new avenue for exploiting these microbes in developing bioformulations that could replace the harmful synthetic agrochemicals. While this study has made strides in understanding the role of Actinobacteria in monocrotophos degradation, it is recommended that further research be carried out to explore other possible applications of these strains and to thoroughly understand the genetic and biochemical mechanisms that enable this degradation. This would allow us to harness the full potential of these organisms in the quest for sustainable and environmentally friendly agricultural practices. Future studies should aim to conduct extensive field experiments to evaluate the long-term effectiveness and ecological implications of these actinobacterial treatments. Investigating the underlying biological processes that facilitate plant growth and exploring the adaptability of these formulations for various crops will be essential for their wider use in agriculture.