TRENDS IN AGRICULTURE SCIENCE

Popular Article

Vol.2 Issue 12 December 2023, Page: 1068-1071

Pesticide Degrading Microorganisms

Aruna S. J, Jinisha Blessie J. P, Martin Thiagaraja S, and Anbu S
College of Agricultural Technology, Theni

Abstract

Pesticides, vital for modern agriculture, have inadvertently led to environmental challenges through their persistent presence in ecosystems. Microorganisms, including bacteria and fungi, have demonstrated a remarkable ability to metabolize and degrade various pesticide classes. From organophosphates to pyrethroids, these microorganisms showcase a spectrum of biodegradation capabilities that hold promise for environmental restoration. By unraveling the mysteries of these microscopic allies, we can pave the way for sustainable and eco-friendly solutions to mitigate the environmental impact of pesticides.
Keywords: Pesticides, Microorganisms, Biodegradation, Sustainable, Eco-friendly

Introduction

The escalating use of pesticides in modern agriculture has undeniably played a crucial role in enhancing crop yields and ensuring food security. However, the pervasive presence of these chemical compounds in environment has raised significant concerns regarding their long-term impact on ecosystems. Microorganisms, including bacteria and fungi, have evolved intricate metabolic pathways and enzymatic mechanisms that enable them to break down and neutralize lot of pesticide classes. The study of pesticide-degrading microorganisms represents a promising frontier in environmental science and biotechnology. As we delve into the intricate interactions between microorganisms and pesticides, we gain insights into nature's own cleanup mechanisms.

Microorganisms engaged in the biodegradation of pesticides

Various reservoirs of microorganisms possessing the capability to break down pesticides exist. Isolation and characterization of microorganisms proficient in pesticide degradation offer new tools for remediating contaminated environments or treating waste materials prior to their final disposal. *Pseudomonas* stands out the most effective bacterial genus in breaking down harmful substances. Efficiency of these bacteria in degrading such compounds is influenced by factors like duration of exposure to the compound, the environmental conditions in their development, and their adaptability (Abo-Amer *et al*., 2012). *Botrytis cinerea* exhibits a high capability to eliminate linuron and metroburon herbicides almost entirely. Numerous bacterial genera have adapted to thrive in soils

Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com

Published: 28 Dec 2023

contaminated with pesticides. These microorganisms possess enzymes which play crucial role in hydrolyzing bonds such as P-O, P-F, P-S, and P-C, which are commonly present in a diverse range of organophosphorus pesticides (Singh *et al*., 2006).

Mechanisms of biodegradation

Biodegradation is the process of breaking down an organic compound into inorganic components. Fungi and bacteria are recognized as outstanding extracellular enzyme producers. White rot fungi, are considered as promising agents for bioremediation, especially for compounds resistant to bacterial degradation. For pesticide degradation, three main enzyme systems play a role: hydrolases, esterases (also hydrolases), mixed-function oxidases (MFO) in the initial metabolism stage, and glutathione S-transferases (GST) system in the second phase. Various enzymes facilitate metabolic reactions, including hydrolysis, oxidation, addition of oxygen to a double bond, oxidation of an amino group (NH_2) to a nitro group, addition of a hydroxyl group to a benzene ring, dehalogenation, reduction of a nitro group (NO_2) to an amino group, replacement of sulfur with oxygen, metabolism of side chains, and ring cleavage. Success of biodegradation relies on metabolic potential of microorganisms to detoxify or transform pollutant molecules, influenced by accessibility and bioavailability (Ramakrishnan *et al*., 2011).

Genetic factors that impact the breakdown of pesticides

Various microbial enzymes, capable of breaking down the pesticides have been recognized, including organophosphorus hydrolase (OPH) encoded by the opd gene. Methyl-parathion hydrolase (MPH), encoded by the mpd gene, associated with *Pseudaminobacter, Achrobacter, Brucella*, and *Ochrobactrum* genes, identified through comparison with the mpd gene from *Pleisomonas* sp. M6 strain. The gene for organophosphorus hydrolase consists of 996 nucleotides and features a typical promoter sequence TTGCAA N17 TATACT, to the *E. coli* promoter (Zhang *et al*., 2005). Hydrolysis of endosulfan in certain bacteria, such as *Pseudomonas aeruginosa* and *Burkholderia cepaecia*, leads to the formation of the less toxic metabolite known as endosulfan diol. In alkaline conditions, endosulfan can spontaneously undergo hydrolysis to produce the diol, making it challenging to distinguish bacterial-driven hydrolysis from abiotic processes. The diol, in turn, can be transformed into endosulfan ether or endosulfan hydroxyether, eventually yielding endosulfan lactone. Hydrolysis of endosulfan lactone results in the formation of endosulfan hydroxy-carboxylate. These diverse pathways in endosulfan degradation all involve desulfurization while retaining the chlorine components, showcasing resistance to bioremediation similar to that observed in numerous organohalogen aromatics are depicted in Fig.2 (Hussain *et al*., 2007).

Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 28 Dec 2023

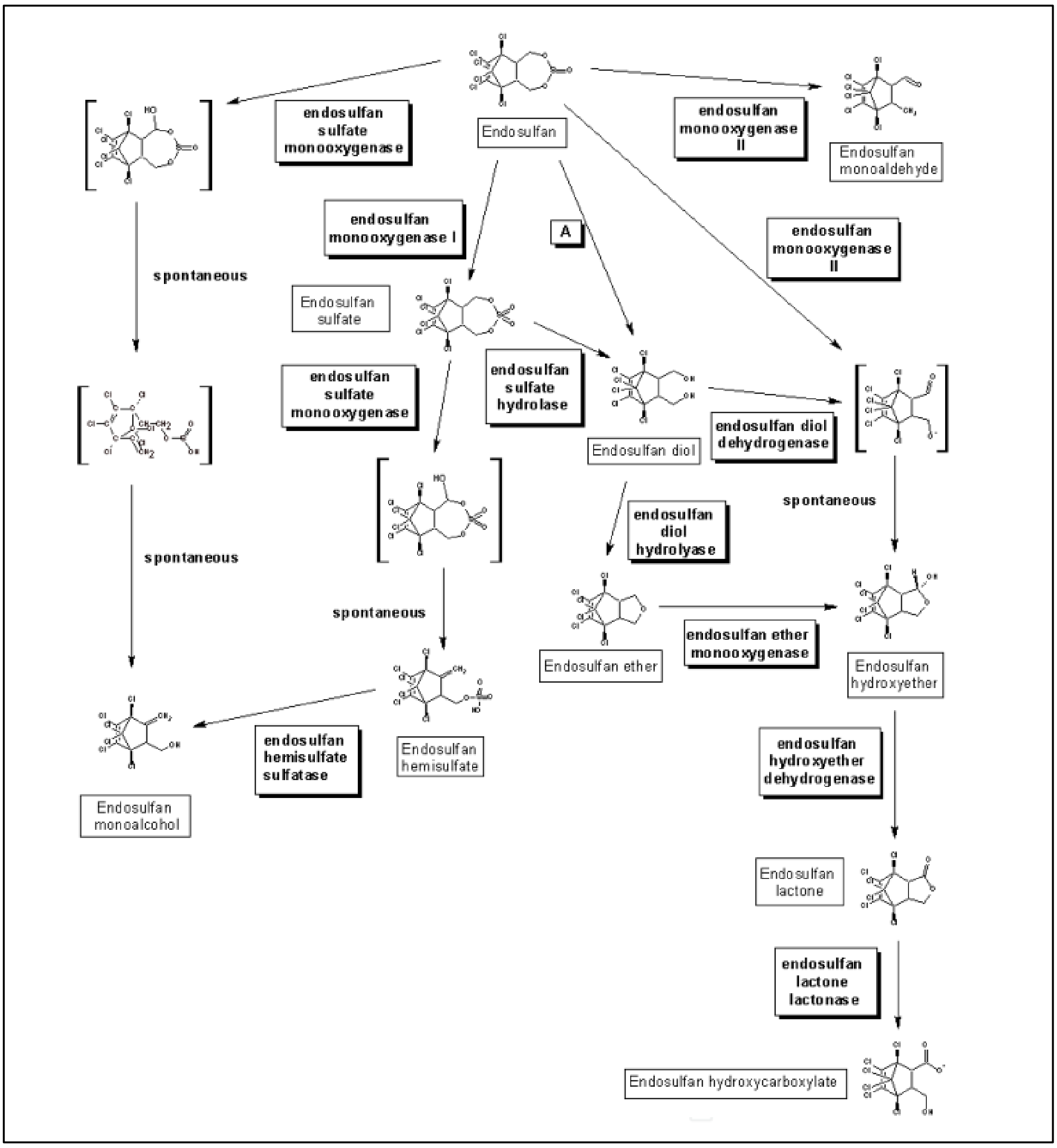

Fig. 1 Endosulfan breakdown process. (University of Minnesota. Biocatalysis/Biodegradation Database, http://www.umbbd.ethz.ch/end/end_map.html

Genes capable of breaking down pesticides

Various organisms possess genes with pesticide degradation capabilities. Examples of bacterial species includes *Pseudomonas diminuta* (opaA), *Alteromonas* sp. (opdA), *Agrobacterium radiobacter* (adpB), *Nocardia* sp. (pepA), *Escherichia coli* (hocA), *Pseudomonas monteilli* (pehA), *Burkholderia caryophilli* (Phn), *Bacillus cereus* (ophB), *Burkholderia* sp. JBA3 (ophC2), *Stenotrophomonas* sp. SMSP-1 (OpdB), *Lactobacillus brevis* (Imh), *Arthrobacter* sp. scl-2 (Mpd), *Ochrobactrum* sp. Yw28, *Rhizobium radiobacter* (Oph), *Arthrobacter* sp. (Mph), *Arthrobacter* sp. (MpdB), *Burkholderia cepacia* (opdE), *Enterobacter* sp. Examples of fungal species includes *Aspergillus niger* (A-opd), and *Penicillium lilacinum* (P-opd). These diverse genetic elements highlight the widespread occurrence of pesticide-degrading capabilities across a range of organisms (Singh *et al*., 2006).

Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 28 Dec 2023

Challenges and Opportunities

While the potential of pesticide-degrading microorganisms is promising, challenges persist. Environmental factors such as temperature, pH, and its presence of other chemicals can influence microbial activity. Optimizing conditions for maximum efficacy remains a key challenge. Additionally, understanding the complex interactions within microbial communities and their adaptation to diverse pesticides requires ongoing research.

Future Directions

As technological advancements continue, metagenomics and other omics approaches offer exciting avenues to unravel the full potential of microbial communities. Genetic engineering provide the opportunities to enhance capabilities of these microorganisms, creating tailored solutions for specific pesticide formulations. Continued research and collaboration between microbiologists, environmental scientists, and biotechnologists will be pivotal in unlocking the full potential of microbial allies in the fight against pesticide pollution.

Conclusion

Pesticide-degrading microorganisms represent a beacon of hope in the quest for sustainable and eco-friendly solutions to pesticide pollution. By understanding their mechanisms, harnessing their capabilities in bioremediation, and addressing challenges through innovative research, we can work towards a harmonious coexistence between agriculture and the environment. Nature's microbial warriors offer a transformative path towards a greener and healthier future.

References

Abo-Amer AE. 2012.Characterization of a strain of *Pseudomonas putida* isolated from agricultural soil that degrades cadusafos (an organophosphorus pesticide). *World J Microbiol Biotechnol*. 28: 805-814

Hussain S. Arshad M, Saleem M, Khalid A. 2007. Biodegradation of alpha- and beta-endosulfan by soil bacteria. *Biodegradation*.18(6): 731-40.

Ramakrishnan B, Megharaj M, Venkateswarlu K, Sethunathan N, Naidu R. 2011. Mixtures of Environmental Pollutants: Effects on Microorganisms and Their Activities in Soils. *Reviews of Environmental Contamination and Toxicology*. 211: 63-120

Singh BK, Walker A. 2006. Microbial degradation of organophosphorus compounds. *FEMS Microbiol. Rev.* 30 (3): 428–471

Singh BK, Walker A. 2006. Microbial degradation of organophosphorus compounds. *FEMS Microbiol. Rev.* 30 (3): 428–471

Zhang R, Cui Z, Jiang J, Gu X, Li S. 2005. Diversity of organophosphorus pesticides de- grading bacteria in a polluted soil and conservation of their organophosphorus hydrolase genes. *Can. J. Microbiol*. 5: 337-343

Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com

Published: 28 Dec 2023