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Utilizing Yeasts for Biological Control: Environmental Implications

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ABSTRACT

The role of yeasts in biological control strategies against fungal pathogens and mycotoxin contamination in cereals has been demonstrated. In this review, methods of using yeasts in a biological control and relationships with the environment are discussed.

Increased interest in biologically based approaches which use less chemical pesticides and fungicides, because they are more sustainable and less environmentally damaging, has arisen due to current concerns over the use of chemical pesticides and fungicides. These yeasts were able to effectively colonize plant tissue and to reduce fungal growth and mycotoxin production making them ideal biocontrol agents. But proper management of these strategies and taking cognisance of environmental factors is required for the successful application.

In this paper, mechanisms by which yeasts can inhibit phytopathogenic fungi and mycotoxin producing molds are considered, as well as environmental impacts of their use. Also described in this work is the integration of yeast based biocontrol with other management practices for a more holistic approach to disease and mycotoxin control in cereal crops.

This paper examines the mechanistic pathways for the use of yeasts in biological control, the environmental impacts associated with their use, and the challenges and opportunities for transition to more sustainable food production practices based on recent literature.

Keywords: yeasts, biological control, mycotoxins, environment, sustainable agriculture

Introduction

For a long time, the versatility of yeasts in different industries has been recognized, including food and beverage production up to bioremediation (1). Recently, the use of yeasts as biological control agents has become a subject of great interest to researchers, who are interested in their power to suppress the growth of harmful microorganisms and to assess their links with the environment.

Saccharomyces cerevisiae, commonly referred to as baker's yeast, has served as a model organism in eukaryotic research contributing significantly in the understanding of complex pattern of metabolic pathways and genetic mechanisms as the basis for diverse biological processes (2). Results from these studies have helped us understand molecular biosynthetic pathways for volatile organic compounds released by yeasts and have important implications for use in biological control (3).

Specifically, marine yeasts have received interest, by virtue of their involvement in many ecological roles, including degradation of organic matter and production of valuable metabolites (4). However, most yeast species are beneficial to plants and animals, because some can act as pathogens and some play an important role of converting organic matter into biomass and other by products, which other organisms can use (4).Yeast based products have a multifold potential as a source for the pollution prevention, in microbial growth and bioprocesses as well as for the human (5), and animal consumption, and their relation to the environment is the different ways focused on (6).

The continued evolution of the field of industrial biotechnology will lead to the need for more strategic use of yeasts in biologic control, and with higher environmental implications. More sustainable and effective biological control strategies require that researchers continue to explore the complex interactions between yeasts and their target organisms in their environment(7) .

Methods of Using Yeasts for Pest Control

Biologically controlling yeasts by producing antimicrobial compounds to inhibit the growth of pathogenic micro organisms (3). For instance, there are examples showing the production of volatile organic compounds, for example isobutyric acid, that effectively suppress the growth of plant pathogens by some strains of *S. cerevisiae* (3).

Also, yeasts' capability to compete for resources and take ecological niches help to explain their effectiveness as bio control agents also. Yeasts inhibit pests and diseases growth and spread, by outcompeting harmful microbes for nutrients and physical space(8).

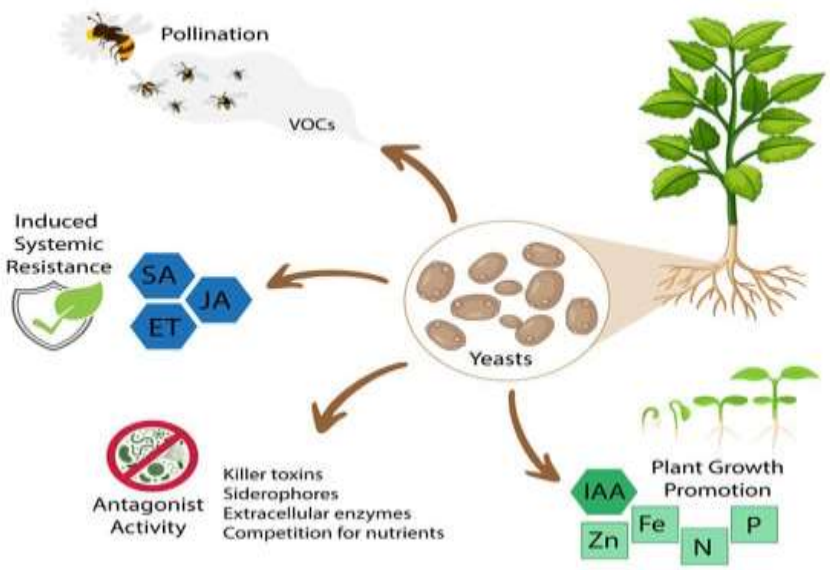

Figure 1 : Examples of ecological services performed by plant-associated yeasts (9)

Several marine yeasts have been evaluated for their potential to be used in bioremediation, capable of degrading a broad spectrum of organic pollutants and heavy metals to reduce the environmental damage caused by these contaminants (4). The biology of this yeast property can be exploited in the application of biological control, in which yeasts can be employed to reduce the impacts of harmful substances on target organisms, as well as their natural environments.

In addition, the ease with which yeasts may be genetically manipulated has created new avenues for the development of genetically engineered strains with improved biocontrol properties. Metabolic pathways of yeasts can be changed by researchers to increase antimicrobial compound production or render them more effective at out competing harmful microbes (5).

In addition, the use of genetically modified yeast strains enables novel biological control. Thus, metabolic engineering has enabled researchers to manipulate yeast metabolism toward the production in increased quantities of desired compounds (such as antimicrobial agents or insecticidal toxins) making them more effective as biocontrol agents(10).

Environmental Considerations

Application of yeasts in biological control has considerable implication from the environment. Yeasts serve as saprophytes for the decomposition of organic matter, converting plant and animal matter to biomass and by products that are suitable to other organisms (4).

The introduction of genetically modified or non native yeast strains into the environment however can have undesired consequences disrupting the perfect balance of ecosystems (11). When using yeasts as biological control agents, they must be considered carefully for potential ecological impacts on surrounding environment if the use is not bringing adverse effects.

As well, research on yeast based biocontrol products can also have associated environmental implications including energy and resource use, waste generation and the potential release of volatile organic compounds.

In addition, the production and usage of yeast based biocontrol products should be made in a sustainable way with respect to the environmental footprint and assuring any potential health and safety issues arising in their use(12).

Given the increasing demand for other environmental friendly pest management solutions, the strategic use of yeasts in the control of insects also represents a very interesting area of future study and development.Further, waste streams associated with production of yeast biomass for industrial purposes, i.e. ethanol production or animal feed, contribute to generating substantial amounts of waste that should be adequately handled to minimize environmental pollution (6)(12).

Environmental Considerations in Yeast-based Biological Control

This has important implications for the environment, since the use of yeasts in biological control. As saprophytes, yeasts are important in decomposing organic matter turning it into biomass and by products that can be used by other organisms; (4). Yet the introduction of genetically modified or non native yeast strains into the environment can have unexpected consequences, and can change the delicate equilibrium of ecosystems.

Consequently, yeasts are chemical and biological control agents that must be used with care so that they cause no adverse effect on the environment. An example is the production of yeast biomass for industrial application, like the production of ethanol or animal feed, to generate large waste streams whose proper management has to counteract to minimize environmental pollution (13)(14).

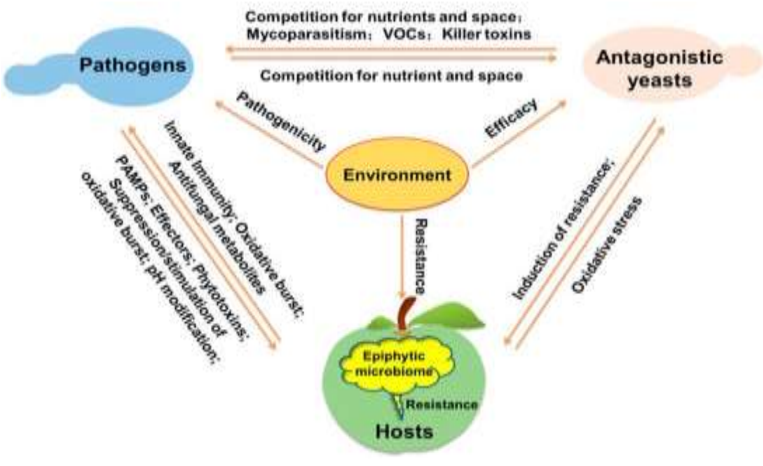

Figure 2 : Schematic diagram of the possible interactions among components of the biocontrol system, including the pathogens, antagonistic yeasts (15)

Also, marine yeasts have been studied for their capability as bioremediators as they are able to debase a large variety of organic pollutants and heavy metals and therefore asses the enviromental effect of such contaminannts (4). In the context of biological control, however, this property of yeasts could be applied since they can absorb and neutralize harmful substances on target organisms and their ecological surroundings(16).

Overall, as well as their capacity to coexist with competitors to utilise resources and to compete for ecological niches, yeasts can benefit biocontrol as well (17).

Furthermore, the use of agroindustrial wastes as substrate for yeast cultivation can help make biotechnological processes less environmental unfriendly or more sustainable (18).

Future Prospects and Research Directions

Industrial biotechnology within the field is continuing to evolve, and the use of yeasts in biological control and their impact on the environment will become more relevant. More effective and sustainable yeast based biocontrol formulations and novel antimicrobial compounds can be provided by future research in the field of use of this technology(10).

The use of yeasts in biological control has been demonstrated to be an attractive strategy for sustainable pest management as well as environmental remediation. Additional research and development will fully realize the potential of yeasts to be part of a healthier, more resilient ecosystem (19).

In order to be effective, biological control asts must be based on a thorough knowledge of the environmental impact. (3)(20).

Research has increased on genetic engineering of yeast metabolism to enable this orchestration in order to make yeast metabolic enhancement more effective as biocontrol agents by producing desired compounds, including antimicrobial agents and insecticidal toxins. (10).

As yeasts are capable of degrading such harmful substances as organic pollutants and heavy metals, and ological control can be used to reduce environment impact of such substances. Yeasts possess this property which can be applied for biological control to get rid of these contaminants from the target organisms as well as its surrounding ecosystems.(21)(4)

Future work should concentrate on the development of more successful and sustainable yeast based biocontrol formulations, the discovery of novel antimicrobial compounds, and the identification of ecological effects from their use. (22)

Together, these results indicate that yeasts have potential for use as biocontrol agents as a strategy for sustainable pest management and environmental remediation toward a healthier and more resilient ecosystem. (23)

Methods of using yeasts in biological control and their relationship to the environment

For years, yeasts have been considered as biological control agents and are a less environmentally threatening alternative to chemical pesticides. Recent progresses in industrial biotechnology have further widened the scope of yeast usage in this respect (24)(Sandhu et al., 2012)(Dara, 2019).

However, there is one of the major advantages to the use of yeasts in biological control due to their capacity to produce a great deal of antimicrobial substances, including killer toxins, enzymes and secondary metabolites, which can hamper the development or existence of rivals pests and parasites(24). This property can be especially advantageous in the context of postharvest disease management when yeasts have been demonstrated to reduce spoilage by fungi in the postharvest of fruits and vegetables. (24)

Also, the ability of yeasts to compete for resources and occupy ecological niches may assist in determining their value as a biocontrol agent. Yeast can displace harmful bacteria by outcompeting them for a limited number of available essential nutrients and space (20).

Nevertheless, biological control using yeasts requires a full understanding of their impacts on the environment so that use of them will not have indeliberate consequences on the fragile ecological balance. In addition, the production of yeast biomass for industrial applications generates vast amounts of waste streams which if they are not properly managed, they could result in environmental pollution (24) (25)

Continued evolution of the field of industrial biotechnology will increase demands for more strategic use of yeasts in biologic control and with heightened environmental implications. The continued exploration of the complex interactions between yeasts and their target organisms in their environment will allow more sustainable and effective biological control strategies(7).

Conclusion

The use of yeasts for biological control shows excellent potential in sustainable agriculture and brings benefits to the environment while facing future research obstacles. As scientists continue to research the topic they must learn how introducing yeasts to different environments impacts natural microbial populations and avoids unexpected side effects. Researchers need to evaluate all possible risks and advantages of using yeast to control pests. Researchers and environmental experts should work with government officials to create rules about yeast pest control so the methods benefit both pest suppression and ecosystem safety. The teamwork will improve our knowledge of yeast use and help set up methods that support eco-friendly agriculture. Our standard farming system becomes more sustainable by adding yeast control methods which protect nature and reduces pesticides while enhancing soil health. The combined use of yeast in farming benefits both ecological preservation and matches the rising need from customers for earth-friendly methods. Research needs to improve yeast strains' resistance against particular pests while studying their blending potential with alternative biocontrol options.

References:

1- Noguerol-Pato, R., Sieiro-Sampedro, T., González-Barreiro, C., Cancho-Grande, B., & Simal-Gándara, J. (2015). Evaluation of the effect of fenhexamid and mepanipyrim in the volatile composition of Tempranillo and Graciano wines. Food Research International, 71, 108-117.

2- Parapouli, M., Vasileiadis, A., Afendra, A. S., & Hatziloukas, E. (2020). Saccharomyces cerevisiae and its industrial applications. AIMS microbiology, 6(1), 1.

3- Halbfeld, C., Ebert, B. E., & Blank, L. M. (2014). Multi-capillary column-ion mobility spectrometry of volatile metabolites emitted by Saccharomyces cerevisiae. Metabolites, 4(3), 751-774.

4- Kutty, S. N., & Philip, R. (2008). Marine yeasts—a review. Yeast, 25(7), 465-483.

5- Aloui, C., Hammoudeh, S., & ben Hamida, H. (2015). Global factors driving structural changes in the co-movement between sharia stocks and sukuk in the Gulf Cooperation Council countries. The North American Journal of Economics and Finance, 31, 311-329.

6- Ferreira, D. (2010). Board diversity. Corporate governance: A synthesis of theory, research, and practice, 225-242.

7- Pandit, M. A., Kumar, J., Gulati, S., Bhandari, N., Mehta, P., Katyal, R., ... & Kaur, J. (2022). Major biological control strategies for plant pathogens. Pathogens, 11(2), 273.

8- He, Y., Degraeve, P., & Oulahal, N. (2024). Bioprotective yeasts: Potential to limit postharvest spoilage and to extend shelf life or improve microbial safety of processed foods. Heliyon, 10(3).

9- Pritsch, E. J., Schutz, D., de Oliveira, C. G., Camargo, A. F., Cabrera, L. C., dos Santos, A. A., ... & AlvesJr, S. L. (2024). A Two-Way Street: How Are Yeasts Impacted by Pesticides and How Can They Help Solve Agrochemical Contamination Problems?. Processes, 12(11), 2555.

10- Khan, A., Khan, B., Khan, S., Mabood, F., Rasool, A., Din, T. U., ... & Khan, M. (2024). Defending Crops Naturally: Biocontrol Agents in Action. SUSTAINABLE INNOVATIONS IN MICROBIOLOGY, 136.

11- Hollander, A. K. (2018). Environmental impacts of genetically engineered microbial and viral biocontrol agents. In Biotechnology for biological control of pests and vectors (pp. 251-266). CRC Press.

12- Gómez-Pastor, R., Pérez-Torrado, R., Garre, E., & Matallana, E. (2011). Recent advances in yeast biomass production. Biomass–Detection, Production and Usage, 201-222.

13- Noguerol-Pato, R., Sieiro-Sampredro, T., González-Barreiro, C., Cancho-Grande, B., & Simal-Gándara, J. (2014). Effect on the aroma profile of Graciano and Tempranillo red wines of the application of two antifungal treatments onto vines. Molecules, 19(8), 12173-12193.

14- Valero, C. E., & Bakošová, M. (2021, June). Classic Methodologies in Control of a Yeast Fermentation Bioreactor. In 2021 23rd International Conference on Process Control (PC) (pp. 200-205). IEEE.

15- Zhang, X., Li, B., Zhang, Z., Chen, Y., & Tian, S. (2020). Antagonistic yeasts: A promising alternative to chemical fungicides for controlling postharvest decay of fruit. Journal of fungi, 6(3), 158

16- Aliko, V., Multisanti, C. R., Turani, B., & Faggio, C. (2022). Get rid of marine pollution: bioremediation an innovative, attractive, and successful cleaning strategy. Sustainability, 14(18), 11784.

17- He, T., Yang, M., Du, H., Du, R., He, Y., Wang, S., ... & Du, F. (2024). Biocontrol agents transform the stability and functional characteristics of the grape phyllosphere microenvironment. Frontiers in Plant Science, 15, 1439776.

18- Martins, M. B., & de Oliveira, T. G. (Eds.). (2011). Amazônia maranhense: diversidade e conservação (p. 328). Belém: Museu Paraense Emílio Goeldi.

19- Rosa, C. A., Lachance, M. A., Limtong, S., Santos, A. R., Landell, M. F., Gombert, A. K., ... & Hallwachs, W. (2023). Yeasts from tropical forests: Biodiversity, ecological interactions, and as sources of bioinnovation. Yeast, 40(11), 511-539.

20- Zaky, A. S., Tucker, G. A., Daw, Z. Y., & Du, C. (2014). Marine yeast isolation and industrial application. FEMS yeast research, 14(6), 813-825.

21- Mitjà, O., Alemany, A., Marks, M., Mora, J. I. L., Rodríguez-Aldama, J. C., Silva, M. S. T., ... & Paredes, M. T. (2023). Mpox in people with advanced HIV infection: a global case series. The Lancet, 401(10380), 939-949.

22- Palmieri, D., Ianiri, G., Del Grosso, C., Barone, G., De Curtis, F., Castoria, R., & Lima, G. (2022). Advances and perspectives in the use of biocontrol agents against fungal plant diseases. Horticulturae, 8(7), 577.

23- Lucas, C., & Cássio, F. (2023). Yeasts as New Powerful: Bio-tools for Sustainable Agriculture Biocontrol of Plant Fungal Diseases and Ecological Implications. In Biofungicides: Eco-Safety and Future Trends (pp. 94-143). CRC Press.

24- Galván-Román, J. M., Rodríguez-García, S. C., Roy-Vallejo, E., Marcos-Jiménez, A., Sánchez-Alonso, S., Fernández-Díaz, C., ... & Montes, N. (2021). IL-6 serum levels predict severity and response to tocilizumab in COVID-19: An observational study. Journal of Allergy and Clinical Immunology, 147(1), 72-80.

25- Lam, S. M., Zhang, C., Wang, Z., Ni, Z., Zhang, S., Yang, S., ... & Shui, G. (2021). A multi-omics investigation of the composition and function of extracellular vesicles along the temporal trajectory of COVID-19. Nature metabolism, 3(7), 909-922.