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MODE OF ACTION OF MYCOHERBICIDE: PHYSIOLOGICAL AND BIOCHEMICAL RESPONSE IN WEED MANAGEMENT

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ABSTRACT

Weed plants are indispensable companions of cultivated plant in which thy cause substantial damage. The sustainable weed management in modern agriculture involves dealing with challenges from climate change, environmental pollution, depletion of natural resources as well as pressure to cope with dependence on agricultural inputs. Balancing crop productivity with environmental sustainability is one of the main challenges for agriculture worldwide. The emergence of weed resistant to synthetic herbicides generates huge economic losses, so unconventional weed control strategies, especially those based on ecological principles are very much needed in modern agriculture. A natural ecofriendly approach-Mycoherbicides such as fungal extracts, fungal metabolites and fungal spores can significantly reduce the use of chemical herbicides. Mycoherbicides are alternatives for weed control in sustainable agriculture by which fungal organism produce biochemicals that influence the growth, survival and development of weeds. Fungal produced lytic enzymes and toxins degrade the endosperm and utilize it for survival, preventing the growth of weed seeds. There are various fungal species were assessed as mycoherbicides against different noxious weeds. There are a very few studies on the physiological influence of mycoherbicide on the germination and growth of weeds. Weed seed germination or growth is hindered when fungal metabolites or extracts are absorbed, damaging the cell membrane, DNA, mitosis, amylase activity, and other biochemical processes. Weed growth is slowed by decreased rates of root-cell division, food absorption, photosynthetic pigment synthesis, and plant growth hormone synthesis, while the production of reactive oxygen species, stress-mediated hormones, and erratic antioxidant activity is increased. The objective of this review is to present a overview of mycoherbicide and its herbicidal metabolites highlights recent advances, ongoing research and prospects on weed management practices applied in agriculture and it physiological and biochemical mechanism

Keywords: Mycoherbicides/Weed control/Fungal spores/Fungal metabolites/Fungal extract.

1. INTRODUCTION

Weeds are plants that grow in undesirable locations and seriously impede agricultural production (Mustafa et al 2019). They can serve as hosts for pests and illnesses and compete with crops for resources such as water, gas, nutrients, space, light, and growth-promoting elements (Nichols et al 2015).

Weeds pose a threat to crop growth factors and reduce yields by an average of 15 to 66% in rice, 18 to 65% in maize, 50 to 76% in soybeans, and 45 to 71% in groundnuts (Gharde et al 2018, Oerke, 2006).

Depending on the crop, weed management tactics, weed composition, infestation period, and abiotic factors, crop production loss can vary greatly (e.g., climate and soil edaphic factors) (Hasan et al 2021, Upadhyaya, 2022).

Weed control is a crucial agronomic activity in agricultural farming. Due to a lack of labour, the use of pesticides to reduce weed densities in agriculture is becoming widespread worldwide (Peerzada et al 2019).

Herbicide development, residue in crops, an ecological imbalance between harmful and beneficial organisms, and environment

al pollution have all been linked to the extended use of herbicides on a single field to manage weeds (Kumar et al 2013). The use of natural enemies, organic compounds, or biotic agents to limit the germination and growth of weed populations to an economically viable level is known as biological weed control (Westwood et al 2018). Mycoherbicides are sprayed into target weeds for its management.

Physiological action is very few studies in case of mycoherbicide. Only 20 different mechanisms of action are present in chemical herbicides, and most weeds have built up a resistance (Duke et al 2018).

In this paper gives an overview of the physiological changes that eco-friendly mycoherbicides cause in undesirable weeds as a means of promoting sustainable agriculture in line with the worldwide Sustainable Development Strategy 2030.

2. MYCOHERBICIDES- FUNGAL METABOLITES, FUNGAL EXTRACT

Finding natural weed control options is essential since synthetic herbicide use has led to the evolution of resistant weeds. Mycoherbicides for sustainable weed management in agriculture may be an alternative to the traditional use of fungal extracts for medical or nutritional purposes. Mycoherbicides made from natural extracts have demonstrated promising results against weeds (Singh & Pandey, 2007; Singh & Pandey, 2019). Several fungal extracts have a specialized inhibiting function against weed growth, but do not harm crops (Cai & Gu 2016). This could be explained by the sensitivity of the target enzymes or the presence of distinct receptors in weeds, which recognize and respond to the chemicals (Escher & Hermens 2002). Certain fungal species have the ability to emit compounds known as biochemicals, including alcohols, fatty acids, phenolics, flavonoids, terpenoids, and steroids, which inhibit reproduction, growth, and development of nearby flora, including weed species (Sharma & Pandey 2022). Among the alternatives to synthetic plant protection products, biocontrol appears as a promising method. The diversity of fungal secondary metabolites phytotoxic to weeds and on the approach generally used to extract, characterize, identify and exploit them for weed management. The 183 phytotoxic fungal secondary metabolites fall into five main classes of molecules: 61 polyketides, 53 terpenoids, 36 nitrogenous metabolites, 18 phenols and phenolic acids, and 15 miscellaneous (Duke et al 2024). They are mainly produced by the genera *Drechslera*, *Fusarium* and *Alternaria*. The phytotoxic effects, more often described by the symptoms they produce on plants than by their mode of action, range from inhibition of germination to inhibition of root and vegetative growth, including tissue and organ alterations. The biochemical characterization of fungal secondary metabolites requires expertise and tools to carry out fungal cultivation and metabolite extraction, phytotoxicity tests, purification and fractionation of the extracts, and chemical identification procedures. Phytotoxicity tests are mainly carried out under controlled laboratory conditions (not always on whole plants), while effectiveness against targeted weeds and environmental impacts must be assessed in greenhouses and open fields. These steps are necessary for the formulation of effective, environment-friendly fungal secondary metabolites-derived herbicides using new technologies such as nanomaterials.

Weed seeds absorb fungal extracts or metabolites, which causes damage to the cell membrane, DNA, mitosis, amylase activity, and other biochemical processes. This delays or prevents seed germination. Weed development is further slowed by decreased rates of root cell division, food absorption, photosynthetic pigment synthesis, and plant growth hormone synthesis, while elevated levels of reactive oxygen species (ROS) and stress-mediated hormones, including irregular antioxidant activity are produced (Hasan et al 2021; Radhakrishnan et al 2018). Development of environmentally acceptable mycoherbicides may be facilitated by using fungal species that have herbicidal effects on weeds (Lopes et al 2022). A substantially untapped reservoir of phytotoxins that can be employed directly or as structural markers of novel synthetic herbicides is present in plants and bacteria. The herbicide business has developed a great interest in this organic source due to a number of factors (Balah et al 2020; Bharti et al 2021).

When discovering and creating a natural product as a herbicide, there are more options to take into account than with synthetic herbicides. Many phytotoxic natural compounds are disappointing due to their high molecular complexity, poor environmental stability, and ineffectiveness as herbicides. However, developments in chemistry and biotechnology are speeding up and simplifying processes by which we can discover and create herbal pesticides using natural components (Balah et al 2020; Bharti et al 2021).

Physiological and Biochemical Response of Mycoherbicides

"The term mode of action refers to the sequence of events from absorption into plants to plant death. An herbicide's mode of action influences the application thereof. For example, contact herbicides that disrupt cell membranes, such as acifluorfen (Blazer) or paraquat (Gramoxone Extra), need to be applied post emergence to leaf tissues to be effective. Seedling growth inhibitors such as trifluralin (Treflan) and alachlor (Lasso), need to be applied to the soil to effectively control newly germinated seedlings [Gunsolus & Curran 1991; Rana & Rana 2015]. To be effective, herbicides must contain suitable fungal compounds, be absorbed by the plants and transmitted within the plants to the required site, without inactivation and reach toxic levels. The application method used, whether pre-plant or post-emergence, determines whether the herbicide will come into contact with germinating seedlings, roots, buds, or leaves of plants [Gunsolus & Curran 1991].

Numerous studies highlight the mycoherbicidal effect of extracts, spores especially with regard to weed germination and growth, but few studies have been conducted to determine the mode of action and physiological changes in weeds. A biocidal method similar to the reaction mechanism of plant pathogens and allelitis was developed. In the case of plant pathogen interactions, the biocontrol agent must bypass defensive reactions of the herb and both must be compatible in order for the pathogen to infect the plant. The pathogen initiates the infection process by producing enzymes that degrade plant cell walls, proteins and lipid membranes, facilitating their entry. However, for a toxic effect that results in plant death, a specific receptor or enzyme is required in the plant for a specific poison and this mechanism is considered biochemical (Barros et al 2021)." Herbicides affect plants at tissue or cell levels. Herbicides with the same mode of action will have the same pattern of displacement (action) and produce similar infestation symptoms. The selectivity on crops and weeds, soil behaviour and application patterns are less predictable, but are often similar for herbicides with the same effect. In addition to plants, many herbicides are applied to the soil. Herbicides are applied almost strictly to the soil. Mechanism of action and mode of action are often used interchangeably; however, mechanism of action refers to the specific plant process by which a herbicide intervenes to control weeds. Mode of action refers to all herbicide reactions. Herbicides kill plants in different ways (Das & Mondal 2014; Rani et al 2021).

Subjectively, the answer to the issue differs substantially in terms of type of approach and type of answer. A specific pre-emergent herbicide may react when absorbed by the soaked seed with significant inhibition of the seedling's root development. The fast removal of established leaf tissue by post-emergent barberry in sunshine, may provide the solution. These responses incorporate visual data. But during the past few years, knowledge has accumulated about the cellular, physiological, biochemical, and molecular aspects of insecticidal activity on various plant systems (MacLaren et al 2020; Fedtke 2012).

The mechanism of action of novel herbicides may be made clearer using this classification as a reference. There will always be information available on application technologies. This information enables the substance to be categorized as a desiccant, contact herbicide, bleaching herbicide, or hormone destroyer. Microradiography or cell segmentation of tissue homogenates can be used to gather information on the accumulation of radiolabelled herbicides. The preferential concentration of herbicides in a specific subcellular structure, such as a chloroplast, does not, however, suggest that this organelle is the location of activity or even includes it. As a result, subcellular fusion, for instance, is the earliest sign of visual impairment. The presence of the chloroplast membrane does not necessarily indicate that this organelle is located at the impact site. Therefore, it has not been demonstrated that the information on cellular action is extremely helpful in identifying the principal site of action, despite the fact that it may be intriguing and relevant in relation to other discoveries on herbicide interactions (Fedtke 2012; Karuppanapandian et al 2011).

3. KNOWLEDGE GAPS AND FUTURE PERSPECTIVES

To achieve food security for humans and good health within the framework of the United Nation's goals, recent scientific research in smart agriculture supports the use of eco-friendly bio-degradable products extracted from algae, fungi, plants, and animals as biofertilizers, bioherbicides, bioinsecticides, and biopesticides. These products reduce soil stress and prevent the accumulation of toxic substances in the tissues of agricultural crops, particularly food (Ammar et al 2022; Aioub et al 2022; Ammar 2022).

Due to their capacity for biodegradation and lack of accumulation of toxins in soil and plant tissues, these compounds are both safe and environmentally beneficial (Ammar et al 2022). Currently there is little research on using fungi as mycoherbicides. Modern biotechnological and nano-technological research should be directed to develop herbicides extracted from fungi to decrease weed growth in various climatic conditions (Hasan et al 2021).

In the future, the use of biodegradable mycoherbicides will be recommended rather than chemical herbicides, because of their safety on cultivated plants, soil and surrounding environment. In addition, they will increase the soil fertility without any accumulated residues.

Mixing of nanomaterials to mycoherbicides will offer nanotechnological green alternatives for the management undesirable weeds with enhanced cultivation of desirable plants. The manufacture of herbicides from fungal extracts and fungal metabolites will be recommended as authorized commercial products. Furthermore, the elevation of the environmental awareness of farmers on use of mycoherbicides will benefit production and quality of desired plants (e.g., crops, fruits, ornamentals) in addition to preserving soil structure and fertility in the long-term.

4. CONCLUSION

Managing weeds while growing crops using integrated management is difficult. The use of mycoherbicides is an innovative technique for weed control in sustainable agriculture. Weed populations are managed with mycoherbicides such as fungal extracts, fungal metabolites and certain fungal spores.

Despite the fact that weeds can be prevented from germinating and growing by using mycoherbicide, very little research has been done on the physiology of weeds. Using mycoherbicides as one of the eco-friendly herbicides will support sustainable agriculture. They are biodegradable and more beneficial for getting rid of weeds without harm to the desired cultivated plants, where they have specific targets. Each mycoherbicide targets specific species of weeds, making them safer for soil structure and a natural elevation in fertility, in addition to bio-agriculture without synthetic materials.

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6. REFERENCES

[1] Aioub, A. A. A.; Elesawy, A. E.; Ammar, E. E. (2022). Plant growth promoting rhizobacteria and their role in plant parasitic nematodes control: a fresh look at an old issue. J Plant Dis Protect. 129(6): 1305-1321.

[2] Ammar, E. E., Aioub AAA, Elesaway AE (2022). Algae as biofertilizer between current situation and future prospective. Saudi J Biol Sci. 29: 3083-3096

[3] Ammar, E., (2022). Environmental impact of biodegradation. In: Handbook of Biodegradable Materials, Ali, G. A. M. and Makhlouf, A. S. H. Eds., Springer, Cham.

[4] Balah M.A. (2020). Weed control ability of egyptian natural products against annual, perennial and parasitic weeds. Acta Ecologica Sinica 40: 492–499

[5] Barros, V.M.D., Pedrosa, J.L.F., Goncalves, D.R., de Medeiros, F.C.L., Carvalho, G.R., Goncalves, A.H., Teixeira, P.V.V.Q., (2021). Herbicides of biological origin: a review. J Hortic Sci Biotech 96, 288-296

[6] Bharti, D., Singh, R., Arora, D., Arora, C., 2021. Role of phytopesticides in sustainable agriculture, Global Climate Change. Elsevier, pp. 341-359.

[7] Cai, X., Gu, M., 2016. Bioherbicides in organic horticulture. Horticulturae 2, 3.

[8] Das, S.K., Mondal, T., 2014. Mode of action of herbicides and recent trends in development: a reappraisal. International journal of agricultural and soil science 2, 27-32

[9] Duke, S.O., Dayan, F.E., 2018. Herbicides. ELS Wiley eLS, 1-91-1313

[10] Escher, B.I., Hermens, J.L.M., 2002. Modes of action in ecotoxicology: Their role in body burdens, species sensitivity, QSARs, and mixture effects. Environ Sci Technol 36, 4201-4217

[11] Fedtke, C. Biochemistry and physiology of herbicide action. Springer Science & Business Media, 2012.

[12] Gharde, Y., Singh, P.K., Dubey, R.P., Gupta, P.K., 2018. Assessment of yield and economic losses in agriculture due to weeds in India. Crop Prot 107, 12-18.

[13] Gunsolus, J.L., Curran, W.S., 1991. Herbicide mode of action and injury symptoms. order 612, 625-8173

[14] Hasan, M., Ahmad-Hamdani, M.S., Rosli, A.M., Hamdan, H., 2021. Bioherbicides: An Eco-Friendly Tool for Sustainable Weed Management. Plants-Basel 10.

[15] Karuppanapandian, T., Moon, J.C., Kim, C., Manoharan, K., Kim, W., 2011. Reactive oxygen species in plants: their generation, signal transduction, and scavenging mechanisms. Aust J Crop Sci 5, 709-725.

[16] Kumar, S., Sharma, A.K., Rawat, S.S., Jain, D.K., Ghosh, S., 2013. Use of pesticides in agriculture and livestock animals and its impact on environment of India. Asian Journal of Environmental Science 8, 51-57.

[17] Lopes, R.W.N., Morais, E.M., Lacerda, J.J.D., Araujo, F.D.D., 2022. Bioherbicidal potential of plant species with allelopathic effects on the weed Bidens bipinnata L. Sci Rep-Uk 12

[18] MacLaren, C., Storkey, J., Menegat, A., Metcalfe, H., Dehnen-Schmutz, K., 2020. An ecological future for weed science to sustain crop production and the environment. A review. Agron Sustain Dev 40

[19] Mustafa, A., Naveed, M., Saeed, Q., Ashraf, M.N., Hussain, A., Abbas, T., Minggang, X., 2019. Application potentials of plant growth promoting Rhizobacteria and fungi as an alternative to conventional weed control methods, in: Hasanuzzaman, M., Filho, M.C.M.T., Fujita, M., Nogueira, T.A.R. (Eds.), Sustainable Crop Production. Intechopen

[20] Nichols, V., Verhulst, N., Cox, R., Govaerts, B., 2015. Weed dynamics and conservation agriculture principles: A review. Field Crop Res 183, 56-68

[21] Oerke, E.C., 2006. Crop losses to pests. J Agr Sci 144, 31-43.

[22] Peerzada, A.M., Bukhari, S.A.H., Dawood, M., Nawaz, A., Ahmad, S., Adkins, S., 2019. Weed management for healthy crop production, in: Hasanuzzaman, M. (Ed.), Agronomic Crops. Springer, Singapore, pp. 225-256.

[23] Radhakrishnan, R., Alqarawi, A.A., Abd_Allah, E.F., 2018. Bioherbicides: Current knowledge on weed control mechanism. Ecotox Environ Safe 158, 131-138.

[24] Rana, S., Rana, M., (2016). Advances in weed management. Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur 183.

[25] Rani, L., Komal T., Kanojia N., Sharma N., (2021). An extensive review on the consequences of chemical pesticides on human health and environment. J Clean Prod.: 283

[26] Sharma S., Pandey L.M. (2022). Prospective of fungal pathogen-based bioherbicides for the control of water hyacinth: a review. *J. Basic Microbiol.* 2022; 62: 415-427

[27] Singh, A. K and A K Pandey. (2019). Fungal metabolites as a natural source of herbicide: a novel approach of weed management. Journal of Applied and Natural Science: 158-163.

[28] Singh, A. K. (2007). Isolation and characterization of herbicidal compounds from some selected fungi. Ph.D Thesis. Bioscience. R.D. University, Jabalpur

[29] Upadhyaya, M. K.; Clements, D. R.; Shrestha, A. (2022). Persistence Strategies of Weeds. In. Modelling the Persistence of Weed Populations. Chapter 9. Wiley-Blackwell.

[30] Westwood, J.H.; Charudattan, R.; Duke, S.O.; Fennimore, S.A.; Marrone, P.; Slaughter, D.C.; Swanton, C.; Zollinger, R. (2018). Weed Management in 2050: Perspectives on the Future of Weed Science. Weed Sci. 66: 275–285