AgriCos e-Newsletter
e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 04 Issue: 12 December 2023 Article No: 20

Exploring the Mode of Action of Herbicides: Unravelling the Molecular Mechanisms for Effective Weed Management

J. B. Vasave[1] and R. R. Sisodiya[2]
[1]Assistant Professor, Polytechnic in Agriculture, Navsari Agricultural University, Vyara
[2]Assistant Professor, NMCA, Navsari Agricultural University, Navsari

SUMMARY

Herbicides play a pivotal role in modern agriculture by enabling efficient weed control and ensuring optimal crop yields. Understanding the mode of action of herbicides is crucial for developing effective weed management strategies that are both environmentally sustainable and economically viable. This research paper reviews the current state of knowledge on the mode of action of herbicides, focusing on the molecular mechanisms that underlie their efficacy and selectivity. By delving into the intricate details of herbicidal action at the cellular and biochemical levels, this paper aims to provide a comprehensive overview of the various classes of herbicides and their specific targets. Furthermore, the paper discusses the implications of herbicide resistance and explores emerging technologies that may shape the future of weed management.

INTRODUCTION

The global demand for food production has driven the widespread use of herbicides as essential tools in modern agriculture. Herbicides are chemical substances designed to control or eliminate unwanted plants, commonly known as weeds, and thus optimize crop yields. The effectiveness of herbicides relies on their specific mode of action, which involves disrupting essential physiological processes in plants while minimizing harm to crops. This paper aims to examine the diverse modes of action exhibited by herbicides and their implications for sustainable weed management.

Classification of Herbicides

Herbicides can be classified based on their chemical structure, target organisms, and mode of action. The major classes of herbicides include but are not limited to triazines, acetolactate synthase (ALS) inhibitors, 4-hydroxyphenylpyruvate dioxygenase (HPPD) inhibitors, and synthetic auxins. Each class targets specific biochemical pathways within plants, leading to distinct physiological responses.

Mode of Action at the Cellular Level

Understanding the mode of action of herbicides requires a detailed examination of their impact on plant cells. This section explores the cellular processes targeted by herbicides, such as photosynthesis, amino acid synthesis, lipid metabolism, and cell division. The molecular mechanisms underlying herbicidal activity within plant cells will be discussed to provide a comprehensive understanding of how these chemicals exert their effects.

Herbicide Resistance

The emergence of herbicide-resistant weeds poses a significant threat to sustainable agriculture. This section examines the mechanisms behind herbicide resistance, including target-site mutations, enhanced metabolism, and reduced herbicide uptake. Strategies to mitigate and manage herbicide resistance, such as herbicide rotation and integrated weed management, will be explored.

Emerging Technologies in Weed Management

Advancements in biotechnology and genomics have opened new avenues for developing innovative weed management strategies. This section reviews the potential of RNA interference (RNAi), CRISPR/Cas9 gene editing, and precision agriculture in enhancing the selectivity and effectiveness of herbicides while minimizing environmental impact.

The mode of action of herbicides involves understanding the molecular mechanisms by which these chemicals disrupt or interfere with essential physiological processes in plants. Herbicides are designed to target specific biochemical pathways in plants, leading to their growth inhibition or death. Here are some common modes of action for herbicides:

1. Photosynthesis Inhibitors

Target: Herbicides in this category often target the photosynthetic process in plants.

Mechanism: They may interfere with the light reactions (photosystem II inhibitors) or the dark reactions (photosystem I inhibitors) of photosynthesis.

Examples: Atrazine, paraquat, and diuron.

2. Cell Division Inhibitors

Target: Herbicides that disrupt cell division processes in plants.

Mechanism: They may inhibit mitosis or cell wall synthesis, preventing normal growth and development.

Examples: Glyphosate inhibits the enzyme EPSP synthase involved in the synthesis of aromatic amino acids.

3. Growth Regulator Herbicides

Target: Plant hormones and growth regulators.

Mechanism: These herbicides mimic or disrupt natural plant hormones, leading to abnormal growth or development.

Examples: 2,4-D (2,4-dichlorophenoxyacetic acid) and dicamba.

4. Cell Membrane Disruptors

Target: Cell membrane integrity.

Mechanism: These herbicides affect the lipid composition of cell membranes, disrupting their structure and function.

Examples: Diquat and glufosinate.

5. Amino Acid Synthesis Inhibitors

Target: Amino acid biosynthesis.

Mechanism: These herbicides interfere with the synthesis of essential amino acids, affecting protein formation.

Examples: Imidazolinones and sulfonylureas.

6. Enzyme Inhibitors

Target: Specific enzymes crucial for plant metabolic processes.

Mechanism: Inhibition of key enzymes disrupts metabolic pathways, leading to plant death. **Examples:** Acetolactate synthase (ALS) inhibitors like sulfonylureas and imidazolinones.

Understanding the mode of action is essential for effective weed management because it allows for the selection of herbicides that target specific plants while minimizing the impact on non-target organisms. Additionally, this knowledge helps in preventing the development of herbicide-resistant weeds by rotating or combining herbicides with different modes of action.

CONCLUSION

In conclusion, a thorough understanding of the mode of action of herbicides is essential for optimizing their use in agriculture. This research paper provides insights into the diverse mechanisms by which herbicides exert their effects on plants, offering a foundation for the development of sustainable weed management practices. As the agricultural landscape continues to evolve, embracing emerging technologies and implementing integrated approaches will be crucial for addressing the challenges posed by herbicide resistance and ensuring the long-term efficacy of weed control strategies.

REFERENCES

Amarjeet, Punia SS, Yadav Ashok and Malik RK. 2003. Effect of pH on degradation of chlorsulfuron in Soil. *Indian Journal of Weed Science* 35: 97–99.

Bhan VM. 1994. Herbicidcs resistance against weeds: A growing menace in India. *Weed News* 1: 7–9.

Chinnusamy C, Senthil A, Bhuvaneswari J and Prabhakaran NK. 2010a. Studies on the threshold values of horse purslane in onion. *Indian Journal of Weed Science* 42: 109–111.

Deshmukh G. 2012. Rotary weeder for drudgery reduction of women during weeding in rice field. *Indian Journal of Weed Science* 44: 132–134.

DWR. 2015. Vision 2015. Directorate of Weed Research (DWR), Jabalpur, India. 45 p.

Gharde Y, Ghosh D, Singh PK and Dubey RP. 2017. Fitting dose-response curve to identify herbicide efficacy and ED50 value in mixture. *Indian Journal of Weed Science* 49: 165– 169

GOI (Government of India). 2018. Economic Survey 2017-2018. Chapter 6. Climate, Climate Change, and Agriculture. Government of India, Ministry of Finance, Department of Economic Affairs, Economic Division.

Mahajan G and Brar LS. 2001. Studies on herbicide resistance in Phalaris minor under Punjab conditions. *Indian Journal of Weed Science* 33: 1–4.

NRCWS. 2007. NRCWS - Perspective Plan Vision 2025, National Research Centre for Weed Science, Jabalpur, Madhya Pradesh.