



## Integrated Weed Management: Modern Approaches for Effective Control

\*Sarvesh Nanasaheb Shinde<sup>1</sup>, Dr. Jayesh Babu Dhangada<sup>2</sup> and Sanket Subhash Gajare<sup>2</sup>

<sup>1</sup>M.Sc. Scholar, Department of Agronomy, GD Goenka University, Gurugram, Haryana

<sup>2</sup>Assistant Professor, Department of Agronomy, College of Agriculture Maldad, MPKV Rahuri University, Maharashtra

\*Corresponding Author's email: [sanketgajare661@gmail.com](mailto:sanketgajare661@gmail.com)

Weeds are one of the most serious biological constraints to agricultural productivity, causing substantial yield losses by competing with crops for nutrients, water, light, and space. In India, yield reductions due to uncontrolled weeds range from 15 to 80 percent depending on crop type, weed flora, and agro-climatic conditions. Conventional dependence on chemical herbicides, although effective in the short term, has led to several challenges including herbicide resistance, environmental contamination, soil health deterioration, and increased production costs. Therefore, Integrated Weed Management (IWM) has emerged as a sustainable and eco-friendly strategy for effective weed control. IWM combines cultural, mechanical, biological, and chemical methods in a compatible and economically viable manner to suppress weed populations below economic threshold levels. Modern approaches in IWM include precision herbicide application, herbicide rotation, use of competitive crop cultivars, mulching, conservation agriculture practices, bio-herbicides, and digital weed detection technologies. These strategies aim not only to control weeds but also to enhance soil health, biodiversity, and long-term farm sustainability. ICAR recommends integrated approaches tailored to specific cropping systems and agro-ecological zones to minimize yield losses while ensuring environmental safety. Adoption of IWM practices reduces dependency on herbicides, delays resistance development, and improves resource-use efficiency. Thus, Integrated Weed Management represents a holistic and future-ready approach to sustainable crop production in India.

**Keywords:** Integrated weed management, Herbicide resistance, Cultural control, Precision agriculture, Sustainable farming.

### Introduction

Weeds are unwanted and undesirable plants that grow along with crops and interfere with agricultural production. They compete aggressively for essential resources such as nutrients, water, sunlight, and space, ultimately reducing crop growth and yield. According to ICAR reports, weeds cause greater yield losses than insects and diseases in many field crops of India. In crops like rice, wheat, soybean, cotton, and pulses, yield losses due to weeds may reach up to 30–70 percent if not managed properly. For many decades, chemical herbicides have been the primary tool for weed control due to their quick and effective action. However, continuous and indiscriminate use of the same herbicides has resulted in serious problems such as herbicide-resistant weed biotypes, shift in weed flora, environmental pollution, and residue accumulation in soil and water. These challenges have highlighted the need for sustainable alternatives. Integrated Weed Management (IWM) is a scientific approach that integrates multiple weed control methods based on ecological principles and economic feasibility. The objective is not complete eradication but maintaining weed populations below

the economic threshold level. IWM ensures long-term weed suppression while protecting environmental quality and improving soil health.

### Modern Approaches for Effective Weed Control:

**1. Cultural Methods:** Cultural practices form the foundation of IWM. These include crop rotation, optimum sowing time, proper seed rate, narrow row spacing, use of competitive crop varieties, and stale seedbed technique. Crop rotation helps break weed life cycles and reduces dominance of specific weed species. ICAR recommends inclusion of legumes and cover crops to suppress weeds naturally and improve soil fertility.

**2. Mechanical and Physical Control:** Mechanical methods such as hand weeding, hoeing, inter-cultivation, and mechanical weeders are effective, especially in row crops. Modern tools like power weeders and cono weeders in rice reduce labour dependency. Mulching with crop residues or plastic sheets suppresses weed emergence by blocking sunlight. Conservation agriculture practices such as zero tillage also help reduce weed seed germination when combined with residue retention.

**3. Chemical Control with Herbicide Stewardship :** Judicious use of herbicides remains an important component of IWM. Modern strategies include:

- Herbicide rotation with different modes of action
- Tank mixing and sequential application
- Site-specific herbicide application
- Use of pre- and post-emergence herbicides based on weed flora

**4. Biological Control:** Biological weed control involves the use of natural enemies such as insects, pathogens, and bio-herbicides. For example, *Zygotropha bicolorata* has been used against *Parthenium hysterophorus* in India. Bio-herbicides derived from fungi and bacteria are gaining attention as eco-friendly alternatives.

**5. Precision and Digital Technologies:** Recent advancements include drone-based herbicide spraying, AI-based weed detection, GPS-guided sprayers, and sensor-based site-specific weed management. These technologies reduce chemical use, minimize cost, and improve application efficiency. Smart farming tools support decision-making based on weed density and spatial distribution.

**6. Integrated Approach in Cropping Systems:** Effective IWM requires integration of all methods in a cropping system perspective. For example, in rice-wheat systems, stale seedbed + pre-emergence herbicide + mechanical weeding + crop residue retention provides sustainable weed suppression. Such integrated packages are recommended by ICAR institutes for different agro-climatic zones.

### Conclusion

Integrated Weed Management is a sustainable and scientifically sound strategy for long-term weed control. Sole reliance on herbicides is neither economically viable nor environmentally safe. Modern IWM approaches combine cultural, mechanical, biological, chemical, and precision technologies to manage weeds effectively while protecting soil and ecosystem health. Adoption of ICAR-recommended integrated practices can significantly reduce yield losses, delay herbicide resistance, and enhance farm profitability. Therefore, IWM should be promoted as a key component of climate-smart and sustainable agriculture in India.

### References

1. Chauhan, B. S., Mahajan, G., & Randhawa, R. K. (2020). Integrated weed management in dryland crops. *Agronomy*, 10(8), 1208. <https://doi.org/10.3390/agronomy10081208>
2. Bajwa, A. A., Chauhan, B. S., & Adkins, S. (2021). Weed management using crop competition: A review. *Crop Protection*, 142, 105519. <https://doi.org/10.1016/j.cropro.2020.105519>
3. Kumar, V., Jha, P., & Chauhan, B. S. (2021). Herbicide resistance in weeds and its management strategies. *Plants*, 10(8), 1613. <https://doi.org/10.3390/plants10081613>

4. ICAR-Indian Institute of Weed Science. (2022). *Integrated weed management for sustainable agriculture*. ICAR-IIWS, Jabalpur.
5. Meena, R. S., Kumar, S., & Yadav, G. S. (2023). Sustainable weed management approaches in conservation agriculture systems. *Indian Journal of Agronomy*, 68(2), 145–156.
6. Ministry of Agriculture & Farmers Welfare. (2023). *Package of practices for weed management in major crops*. Government of India.
7. Singh, R., Singh, A. K., & Kumar, P. (2024). Precision weed management using digital technologies in Indian agriculture. *Journal of Crop and Weed*, 20(1), 1–12.