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Study of weed management options under conservation agriculture

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Abstract

Weed management is a critical component of conservation agriculture (CA) to ensure sustainable crop production. The reduced soil disturbance and residue retention in CA systems create a different weed dynamics compared to conventional agriculture. This review explores various weed management strategies under CA, including cultural, mechanical, chemical, and biological approaches. Integrating these methods can enhance weed suppression, reduce herbicide dependency, and improve overall system sustainability. Weed management in conservation agriculture requires an integrated approach that aligns with the principles of minimal soil disturbance, soil cover, and crop rotation. By leveraging diverse weed control strategies, farmers can effectively manage weeds while preserving soil health and reducing environmental impact. Future research should focus on enhancing the efficacy of biological weed control and developing herbicide-resistant management practices to support CA systems.

Keywords: Weed management, conservation agriculture, ecology

Introduction

Conservation agriculture (CA) is based on three core principles: minimal soil disturbance, permanent soil cover, and crop rotation. While CA enhances soil health and productivity, it also alters weed ecology, necessitating adaptive weed management strategies. This review discusses the different approaches to weed control within CA systems (Singh and Sharma, 2016b, Singh *et al.* 2017, Singh *et al.*, 2014h) ^[19, 20, 13]. Pearl millet is a key part of local livelihoods and culture in the study areas. In the perception of farmers, millet has many different functions. The introduced millet varieties scored higher than the local landraces for all of these attributes (Singh and Sharma, 2015, Singh and Sharma, 2015a, Singh and Sharma, 2015b, Singh and Sharma, 2016, Singh and Sharma, 2016a) ^[14, 15, 16, 17, 18]. Hamirpur District, situated in the Bundelkhand region of Uttar Pradesh, experiences a semi-arid climate with erratic rainfall patterns, extreme temperatures, and periodic drought conditions. These climatic factors pose significant challenges to rice cultivation, necessitating efficient weed management strategies to optimize productivity. This paper reviews various weed management practices tailored to the region's specific agro-climatic conditions (Singh and Sharma, 2017b, Singh *et al.* 2017c, Singh and Sharma, 2017d, Singh *et al.* 2018, Singh, G. 2019) ^[22, 23, 24, 25, 26]. The productive improvements among dairy animals can be made through proper management, feeding, handling, etc., which may influence the expression of productive characters as per their heritability nature (Singh *et al.* 2024e) ^[35]. The production and use of animal products in the use of human diet is receiving tremendous attention (Singh *et al.* 2025 and Singh *et al.* 2025c) ^[36, 39].

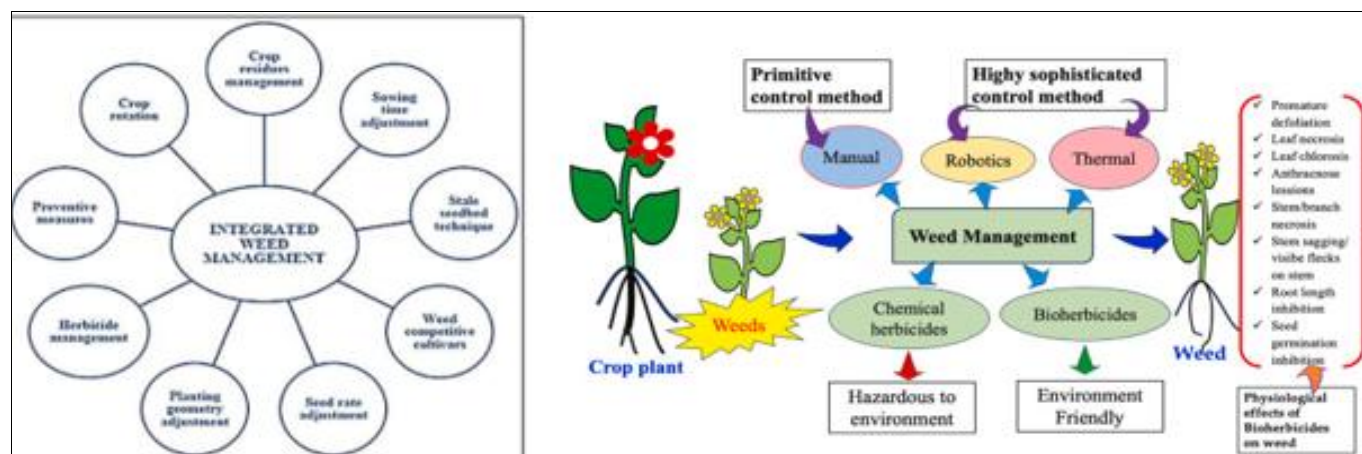


Fig 1: Weed Management

Weed Management Strategies under Conservation Agriculture

1. Cultural Methods

- **Crop Rotation and Diversification:** Rotating crops with different growth habits disrupts weed cycles and reduces weed pressure.
- **Cover Crops and Mulching:** Cover crops suppress weed emergence by shading and allelopathic effects, while mulch acts as a physical barrier to weed growth (Singh *et al.*, 2013, Singh and Sharma, 2013a, Singh *et al.*, 2012, Singh *et al.* 2017a) [2, 3, 1, 21].

2. Mechanical Methods

It is one of the oldest weed management methods. It requires the removal of weeds by mechanical equipment before planting the main crops. One of the most important factors in mechanical control of weeds is the management of soil cultivation practices (Singh, G., 2019a and Singh *et al.* 2025bm, Singh and Singh, 2020) [27, 38, 28].

- **Residue Retention:** Surface retention of crop residues suppresses weed germination by limiting light penetration.
- **Intercropping:** Growing different crops together can enhance ground cover and outcompete weeds for nutrients and space.

3. Chemical Methods

This part of weeding included four steps: (i) pre-emergence only, (ii) post-emergence only, (iii) pre- and post-emergence applications, (iv) no application (Singh and Somvanshi, 2020a, Singh, G., 2024) [29, 30].

- **Herbicide Use:** Selective and pre-emergence herbicides play a crucial role in early weed suppression.
- **Herbicide Resistance Management:** Rotating herbicide modes of action helps mitigate the risk of resistant weed populations.

4. Biological Methods

This methodology includes biological techniques such as cover crop roller crimping, mechanical weeding and thermal weed control (Singh *et al.*, 2024a, Singh *et al.* 2024b and Singh *et al.* 2025a) [31, 32, 37].

- **Allelopathy:** Certain plant species release biochemicals that inhibit weed growth.
- **Use of Bioherbicides:** Naturally occurring microorganisms can be employed to target specific weed species.

5. Integrated Weed Management (IWM)

Integrated Weed Management (IWM) is a comprehensive method to control and mitigate infestation in fields incorporating diverse techniques. The oldest way to tackle the problem is manual pulling. Yet, it is labor and time consuming due to vast areas and short staff.

Nowadays, most farmers rely on herbicides. However, sustainable agriculture and organic farming require a profound reconsideration of the approach as chemical residues harm both humans and nature, and many herbs develop resistance to chemical substances. In this regard, alternative and integral weed management plans are the most beneficial option with a thought of the future. Combining cultural, mechanical, chemical, and biological methods creates a more sustainable and effective weed management system under CA (Singh *et al.* 2024c, Singh *et al.* 2024d) [33, 34].

Conclusion

Weed management in conservation agriculture requires an integrated approach that aligns with the principles of minimal soil disturbance, soil cover, and crop rotation. By leveraging diverse weed control strategies, farmers can effectively manage weeds while preserving soil health and reducing environmental impact. Future research should focus on enhancing the efficacy of biological weed control and developing herbicide-resistant management practices to support CA systems.

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