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BIOTECHNOLOGICAL WEED CONTROL METHODS IN FIELD CROPS (REVIEW)

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Abstract: Climate change alters weed dynamics in southern Romania, while herbicide-based control is limited by resistance and regulations. Biotechnological methods (cover crops, allelopathy, biological agents, bioinputs) reduce weed pressure through ecological mechanisms but depend on environmental conditions. Integrated, site-specific management is essential for sustainable and resilient agriculture.

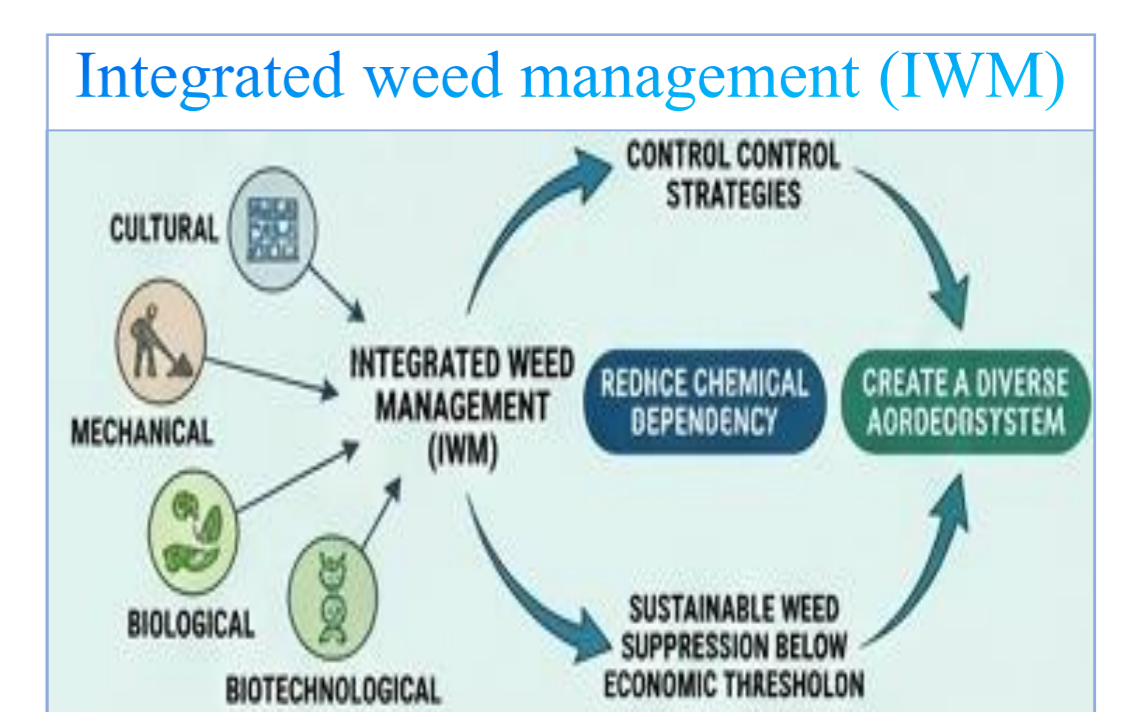
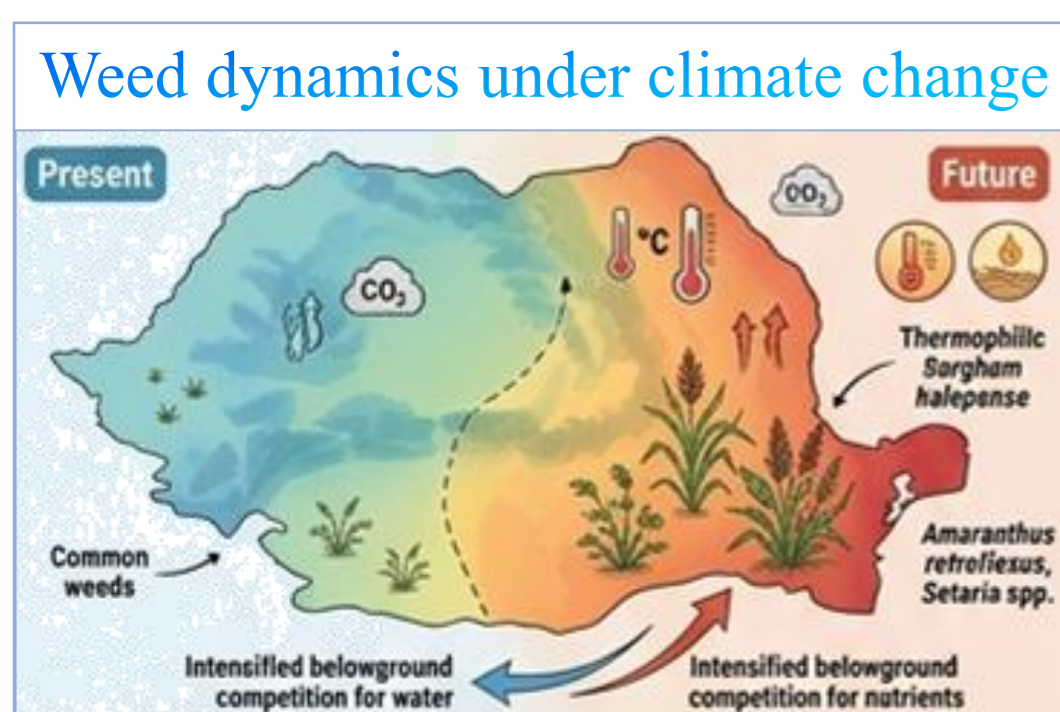
Material and method



A systematic literature review was conducted targeting studies published between 2015 and 2025, complemented by representative foundational works. The databases consulted included Scopus, PubMed, Web of Science, and Google Scholar. Both experimental studies and review articles were considered to ensure comprehensive coverage of current knowledge and methodological approaches in herbicide use and alternative weed management strategies.



Results and discussions



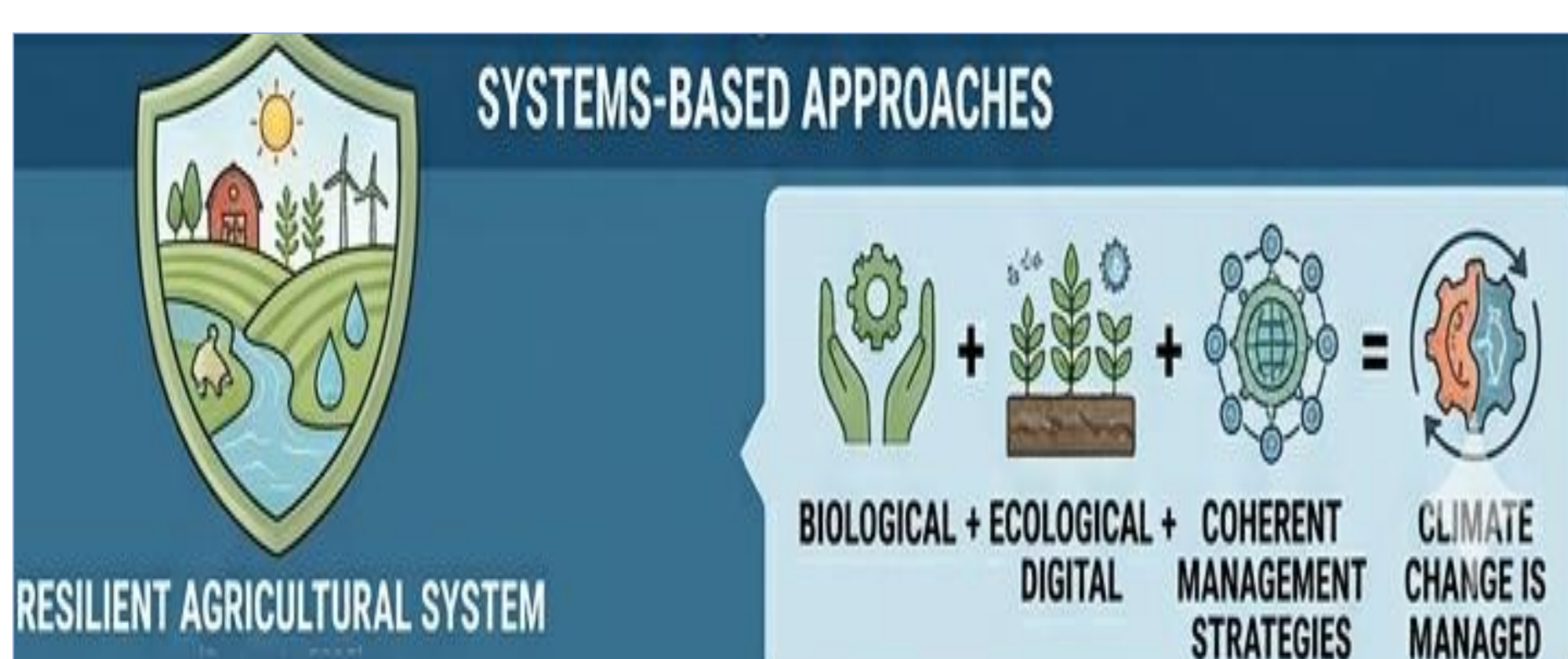
Biotechnological weed control methods

- Cover crops**
 - ▶ Suppress weeds through canopy closure, light interception, and competition for water and nutrients, while also modifying soil microclimate.
 - ▶ Their efficiency increases in intercropping/rotations and through mulch formation after termination.
 - ▶ Effectiveness depends on water availability, but long-term use reduces the soil seed bank.
- Allelopathy**
 - ▶ Allelopathy involves release of secondary metabolites that inhibit weed germination and growth.
 - ▶ It acts via root exudates, residues, and volatilization, but is strongly influenced by soil and climate conditions.
 - ▶ Integration in rotations enhances cumulative effects.
- Bioherbicides**
 - ▶ Bioherbicides (microbial or plant-derived) act through multiple physiological pathways, reducing resistance risk.
 - ▶ Limitations include low field stability and variable efficacy.
 - ▶ New formulations (nanoencapsulation, controlled release) improve persistence and performance.
- Microbial inoculants**
 - ▶ PGPR and mycorrhizae enhance crop growth and stress tolerance, indirectly suppressing weeds by increasing crop competitiveness.
 - ▶ Rhizosphere interactions regulate nutrient cycling and plant competition.
- Genetic strategies**
 - ▶ Competitive cultivars with early vigor, rapid canopy closure, and efficient resource use reduce weed establishment.
 - ▶ Genotype selection is critical, especially under climate stress and in intercropping systems.
- Bioinputs**
 - ▶ Improve soil fertility and crop performance, indirectly limiting weeds.
 - ▶ Their integration with other methods (cover crops, reduced tillage) creates synergistic, system-level weed suppression.

Practical implementation



Conclusions



- ▶ Biotechnological weed management shifts control from herbicides to integrated ecological and biological processes.
- ▶ Key components (cover crops, allelopathy, bioherbicides, microbes, competitive cultivars) act synergistically within agroecosystems.
- ▶ Weed suppression is driven by competition, biochemical interactions, and rhizosphere processes.
- ▶ Effectiveness is strongly influenced by environmental factors, especially temperature and water availability.
- ▶ Precision agriculture and advanced bioformulations enhance efficiency and field applicability.

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