

Super Weeds: Conceptual Frameworks and Integrated Management Systems

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ABSTRACT

Weeds are a major constraint in agricultural production, causing significant yield losses and economic damage worldwide. The continuous use of herbicides has brought about the development of weeds resistant to these herbicides, referred to as superweeds. Such weeds have spread throughout the world, including India, posing great problems in agricultural practices. Practices such as crop rotation, herbicide diversification, proper agronomic management and regular monitoring can help manage resistance effectively. Sustainable and diversified weed management strategies are therefore crucial to ensure long-term agricultural productivity and food security.

INTRODUCTION

Weeds are significant in agroecosystems; however, they have presented a great challenge to farming sustainability and productivity. Weeds have generally been regarded as plants that are growing where they are not intended, competing with farming operations and reducing agricultural yields. These invasive

plants consume nutrients, water and space needed by crops, thus reducing yield and quality. In recent times, the excessive use of herbicides to get rid of weeds in agriculture production has intensified their growth and development into more challenging and resistant weed populations. Such strong weed populations, known as superweeds, are a great

challenge in modern day agriculture. Superweeds are weeds with the ability to survive and thrive despite exposure to effective herbicides at the recommended dosage (Norsworthy *et al.* 2012). The evolution of superweeds is largely attributed to frequent applications of herbicides that have similar modes of action, creating a great selection pressure on weeds. This situation creates additional costs for weed management while making it difficult to manage these problematic plants. In recent times, much attention has been focused on herbicide resistance due to rapid evolution and its economic consequences. Therefore, there is need for a clear understanding of what superweeds are and how they can be controlled. This paper is meant to discuss superweeds comprehensively.

Impact of weeds on Agriculture

Weeds contribute significantly to agricultural loss, diminishing global potential crop yield by 34%, surpassing the 18% loss caused by pests and 16% from diseases (Junaid and Gokce, 2024). The effects differ among crops, with yield decreases noted up to 25–30% in cereals, 20–56% in pulses and 10–40% in oilseeds. In India, weed infestations lead to yield reductions of approximately 25–26% in Kharif crops and 18–25% in Rabi crops, emphasizing the seriousness of the issue across various agro-climatic settings (Gharde *et al.* 2018). These losses influence food security and diminish the overall effectiveness of agricultural production systems.

Besides lowering yields, weeds create a substantial financial strain on farmers and the agriculture industry. Worldwide, weeds lead to yearly losses surpassing USD 100 billion, comprising decreased crop yields and higher costs for management strategies. In India, the yearly economic loss caused by weeds is estimated to be approximately ₹92,000 crore (Gharde *et al.* 2018). Weeds negatively impact

soil health by changing nutrient balance and can lead to increased soil erosion. They also serve as additional hosts for different pests and pathogens, thus increasing the likelihood of diseases and insect invasions in crops. The escalating issue of herbicide resistance has added complexity to weed management, reducing the effectiveness and increasing the cost of control methods, ultimately jeopardizing the sustainability of contemporary agriculture (Norsworthy *et al.* 2012).

Concept of superweeds

Superweeds are types of weeds that have gained the capability to endure and reproduce despite the use of herbicides that were previously effective at prescribed levels (Nalia *et al.* 2019). Essentially, they are weeds resistant to herbicides that conventional chemical methods can no longer manage. The development of superweeds is mainly fuelled by the ongoing and repeated application of herbicides that operate in the same way, resulting in significant selection pressure that permits only resistant plants to endure and reproduce over time.

The swift rise of superweeds is additionally affected by the significant genetic diversity and adaptability of weed types, as well as inappropriate herbicide practices like under-application and absence of rotation. In certain situations, gene transfer from genetically engineered crops has also been proposed as an influencing element. With the rise of these resistant weed populations, managing them becomes more challenging and expensive, frequently necessitating greater doses of herbicides, combinations or different control strategies.

Herbicide resistance in weeds

The emergence of herbicide resistance is linked to various biological and biochemical alterations in the weed. These involve

modifications at the target site that lessen the herbicide's efficacy, in addition to non-target processes like increased degradation of herbicides, limited transport within the plant or compartmentalization. The issue is made worse by poor management techniques, such as frequent application of the same herbicide, incorrect amounts, and insufficient variety in cropping systems.

Global and Indian Scenario of Herbicide-Resistant Superweeds

The problem of superweeds resistant to herbicides is not confined to any specific area but has spread through major farming regions of the world and poses challenges for various crops. For instance, *Amaranthus palmeri* has evolved into a weed resistant to glyphosate in Georgia's cotton-farming lands. Similarly, *Lolium rigidum* of Western and South-Eastern Australia has become resistant to many herbicides including ACCase and ALS inhibitors making it one of the toughest weeds to eradicate from cereals. Another example is of *Echinochloa crusgalli* in rice-growing environments around the world which is now resistant to ALS and ACCase inhibiting herbicides.

Herbicide-resistant weeds have emerged as a threat to India in recent times and specifically in some of its most important cropping systems including rice and wheat. An example is that of *Phalaris minor*, which has developed resistance to isoproturon and then to ACCase inhibitor herbicides such as clodinafop-propargyl in Northern India's wheat fields. Also, *Rumex dentatus* in wheat-producing regions has become resistant to ALS-inhibiting herbicides. On the other hand, in Indian rice environments, *Echinochloa crusgalli* has become resistant to ALS and ACCase inhibiting herbicides whereas *Cyperus difformis* is known to be resistant to ALS-inhibiting herbicides.

Management of superweeds

There should not be a single strategy used to manage superweeds. They could become resistant to herbicides and other chemicals over time. Therefore, it becomes necessary to have an integrated strategy that would help minimize the selective pressure and provide sustainable weed management. Crop rotation would play a major role in disrupting the reproductive cycle of weeds. The application of different herbicides and their combination would help prevent the emergence of resistant weed species. Proper application of herbicides, including application at prescribed amounts and stages, would be key to preventing the emergence of resistance. Other cultural practices, such as proper planting dates, choice of competitive crops, plant density and fertilizers, enhance the competitiveness of crops and limit the spread of weeds. Physical weed management is accomplished with the use of mechanical tools, such as tillage, hoeing and manual weed removal. The use of cover crops and mulching would inhibit the formation of weeds. Other preventive measures include sterilizing farm implements and using certified seeds to prevent the spread of resistant weeds. Monitoring is key to identifying resistant biotypes and preventing their spread (Norsworthy *et al.* 2012).

CONCLUSION

Superweed infestation is one of the major threats facing agricultural productivity across the globe due to the rapid evolution of herbicide-resistant weeds through improper and frequent use of herbicides. The prevalence of these superweeds has contributed to significant losses in yields, increased costs of production, and low effectiveness of conventional weed control measures. Efficient superweed management calls for the integration of weed control measures that include chemical, cultural and mechanical weed control practices. The shift towards

diverse and scientifically based weed management approaches is fundamental in ensuring sustainability in agricultural productivity.

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