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Weed management in wheat: A review

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Abstract
In India and around the world, wheat is the main staple crop. In order to feed the expanding population in the near future, output must be increased. Weed infestation is one of the main causes of yield reduction, while there are other contributing aspects as well. Weeds prevent the primary crop plant from growing correctly and producing a healthy yield by competing with the crops for a variety of vital resources. Eliminating it from the field is crucial if farmers want to increase their yield. Weeds are controlled using a variety of weed management strategies, including chemical, cultural, and mechanical approaches. Due to its low input costs, the chemical approach of weed control is growing in popularity and effectiveness. Depending on the type of target weed or the time of treatment, several herbicides are employed to control mixed flora of weeds in wheat crops. Therefore, choosing an efficient weed management strategy is crucial for increasing crop output.

Keywords: Weed management, chemical weed control, resistant, weeding, herbicides

Introduction
Increased weed invasion has been made possible by these high-yielding dwarf types' high fertilizer and water requirements as well as their less competitive nature. About one-third of all pest-related losses are attributed to weeds, which are thought to be the most significant limiting factor in crop output (Liliane and Charles, 2020) [15]. In the early phases of crop growth, weeds create competition for nutrients, sunlight, and water. Their relative density also significantly lowers crop output (Qasem and Foy, 2001) [25]. Serious yield decline is caused by high weed density and their long-term competition with wheat crops (Reddy, 2004) [30]. Among all the various variables that reduce wheat yield, such as nematodes, insects, pests, etc., weeds are one of the most well-known and commercially significant (Savary *et al.*, 1997; Gupta, 2004) [32, 9]. According to Rao (2000) [28], weeds significantly lower wheat yields compared to pests and illnesses.
Regarding the various weed control methods, manual eradication has proven to be more effective than all of them at controlling weeds. However, wheat growers have not adopted this technique because it is costly, time-consuming, labor-intensive, and frequently impracticable due to labor shortages during periods of high labor demand (Mohammadi, 2013; Shrestha *et al.*, 2019; Monteiro and Santos, 2022) [21, 33, 22]. Since timely weeding is crucial to reducing crop losses, chemical weed management is the only available effective method in these situations (Beiermann *et al.*, 2022) [3]. Chemical fertilizers are being used more often in modern agriculture due to their effectiveness in eliminating weeds (Kumar and Singh, 2010) [12]. Chemical weed management has also been found to be as successful as manual weed eradication in a variety of crops, adding to the advantages of reducing labor expenses associated with physical weed removal. Numerous pre- and post-emergence herbicides have already been included in wheat cultivation packages to manage weeds. However, over time, weeds may develop herbicidal resistance if certain herbicides are used continuously (Kaur *et al.*, 2018) [11]. In order to effectively control wheat, it is imperative that the effectiveness of herbicidal weed management alternatives be evaluated in light of the aforementioned facts.

Chemical weed control
Herbicides are frequently used by Indian farmers since traditional methods like hoeing and manual weeding are too expensive for them to implement (Lee and Thierfelder, 2017) [13].

Applying herbicides at the right time and dose using the right technique can increase their effectiveness. Lowering carrier volumes, which concentrate the herbicide per volume of the spray solutions, can increase the effectiveness of foliar active herbicides. Due to their higher translocation and numerical coverage, little droplets of herbicide are more hazardous than large ones (Petroczi *et al.*, 2002) [24].

Weeds were shown to be significantly controlled when isoproturon was applied 35 days after seeding, but as the number of days increased, its effectiveness continued to decline (Balyan *et al.*, 1988) [2]. When isoproturon was administered 25 days rather than 35 days after sowing, wild oats were more effectively controlled (Malik *et al.*, 1984) [19]. Additionally, the effectiveness of foliar spray herbicides can be enhanced by reducing the amount of herbicide used in each spray because smaller droplets have better coverage and faster translocation than bigger droplets. However, using herbicides in the form of extremely small droplets is riskier (Loddo *et al.*, 2021) [16].

Tralkoxydim, sulfosulfuron, atlantis, clodinafop, pinoxaden, and fenoxaprop are herbicides that work well against *P. minor* that is resistant to isoproturon (Jaiswal *et al.*, 2020) [10]. While tralkoxydim, clodinafop, and fenoxaprop can only manage narrow weeds, atlantis, sulfosulfuron, and pendimethalin can control grassy and broad-leafed weeds. Metsulfuron, 2,4-D, and carfentrazone are useful for managing wide leaf weeds (Chhokar *et al.*, 2007) [6-7]. Although 2,4-D has been used for a long period to manage broad leaves weed, its treatment at the wrong time can reduce wheat yield due to malformation (Chhokar *et al.*, 2007) [6-7].

The results indicate that the use of 2,4-D butyl ester frequently causes damage to adjacent broad leaf crops due to its drifting and volatilization (Li *et al.*, 2002) [14]. Because of its quick impact, recent research has suggested using carfentrazone to manage wide leaf weeds (Bhardwaj *et al.*, 2022) [4]. Sometimes a pesticide works well against some weeds but poorly against others. *Malva parviflora* and *S. nigigrum* have been found to be resistant to 2,4-D and metsulfuron (Chhokar *et al.*, 2007; Mukherjee *et al.*, 2011) [6-7, 23, 37]. Several additional broad-leaf weeds include *Medicago denticulata*, *Anagallis arvensis*, and *Melilotus indica* (Singh *et al.*, 2002) [34]. Isoproturon-resistant weeds include *Rumex* spp., *Vicia sativa*, *Anagalis arvensis*, *Circium arvensis*, and Convolvulus arvensisis (Malik and Singh, 1993; Debangshi and Ghosh, 2022) [17, 8]. the application time and are economical.

Compared to using metsulfuron and carfentrazone separately, it was found that combining them in a tank effectively controlled *R. spinosus*. This combination was beneficial because no 2,4-D formulation could completely eradicate *R. spinosus* (Singh *et al.*, 2011) [37]. In certain situations, combining herbicides was preferable to applying them separately since it saves time and money. Herbicide mixtures were particularly effective in controlling a very complex weed flora. Combining wide leaf herbicides with grassy herbicides decreased their effectiveness (Chhokar *et al.*, 2013) [5]. Herbicides that belong to the same chemical group, such as sulfosulfuron + metsulfuron, exhibit a synergistic action (Chhokar *et al.*, 2007) [6-7].

However, when certain herbicides like pinoxaden, fenoxaprop, clodinafop, and tralkoxydim are used in a sprayer with metsulfuron or 2,4-D, an antagonistic impact has been observed (Singh *et al.*, 2011) [37]. This issue can be resolved by administering wide leaf and grassy weed herbicides in a consecutive manner or by altering the schedule of their application.

Weeds' resistance to herbicides

Isoproturon was advised in the late 1980s, which significantly reduced wheat yield losses caused by *Phalaris minor*. However, if isoproturon was used continuously for ten to fifteen years, resistance to the herbicide developed in rice wheat cropping systems. It turned out to be the world's most severe instance of herbicide resistance (Malik and Singh, 1995) [18, 20, 36]. In Northwest India, the total area exhibiting herbicide resistance ranged from 0.8 to 1 million hectares, primarily in Punjab and Haryana.

When it comes to irrigated wheat crops in our nation, *Phalaris minor* is the most harmful wintertime weed (Rao and Chauhan, 2015) [26]. It was not an issue before, but as our nation embraced the green revolution, it became a major issue for all of our farmers. The key features of India's green revolution were high-yielding dwarf wheat varieties, as well as advancements in irrigation systems and fertilizer techniques. These high-yielding, dwarf wheat types are unable to compete with this plant. This weed flourished and took over fields thanks to additional variables like better irrigation and fertilization techniques (Balyan and Malik, 1989) [1].

According to the studies, burning rice straw in the field increases the adsorption of herbicides, which lowers their effectiveness. These elements also contributed to *Phalaris minor's* dominance and isoproturon's decreased effectiveness. As herbicide adsorption occurs in thick soils, herbicide efficiency decreases (Rasool *et al.*, 2022) [29]. Rather than combining pesticide with sand, it works better when sprayed (Singh *et al.*, 1995) [36]. All of these elements contributed to the development of metabolic resistance in *Phalaris minor* and reduced the effectiveness of isoproturon (Malik *et al.*, 1995) [18, 20].

Integrated weed management (IWM)

Integrated weed management (IWM) addresses environmental data, weed control technology, and the biology and ecology of weeds while lowering environmental and human health risks (Sanyal, 2008) [31]. To suppress weeds, IWM employs a variety of management techniques, including both chemical and non-chemical approaches. Chemical herbicides were found to be an efficient method of controlling weeds when combined with other biological agents (Subramanian and Martin, 2006) [38]. However, when a rice/wheat cropping system was combined with intercropping of either green gram or sesbania, a decrease in the population of sedges and grasses was noted without the need of chemical treatments (Singh *et al.*, 2008) [35]. Introducing highly efficient, environmentally friendly, and financially sound IWM systems that can be applied to our existing and future farming methods is the current problem facing agricultural scientists (Rao and Nagamani, 2010) [27].

Conclusion

One of the primary biotic and abiotic factors limiting wheat yield and productivity is weed infestation. Numerous weeds, such as broad-leaved, sedges, and grasses, have an impact on wheat. Because chemical herbicides are more efficient and less expensive than manual and other cultural approaches, the majority of wheat producers use them to

manage weeds. However, in order to minimize the yield losses caused by weeds, an efficient and environmentally sound strategy must be adopted due to the growing risk associated with the ongoing use of chemical herbicides and the higher expense of alternative approaches. Some essential elements of IWM that can be successful include adopting the proper sowing technique, sowing time, seed rate, crop variety selection, applying fertilizers and herbicides in the right amount, at the right time, and in the right location, choosing the right fertilizers and herbicides, sowing weed-free seeds and farm tools, crop rotations, etc.

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