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Editorial: Herbicide efficacy

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Editorial on the Research Topic
Herbicide efficacy

Herbicides are chemicals used to manage unwanted plants (terrestrial or aquatic) called weeds. Over a long period, there has been a continuous effort to develop more selective herbicide compounds. However, the introduction of new herbicides with either a new mode of action or novel chemical classes has slowed in the last 30 years. For example, relatively few herbicides with new modes of action (MOAs) have been discovered in the past two decades (Qu et al., 2021). Farmers prefer chemical herbicides as they are the most effective and practical way to control weeds due to their high efficacy, specific mode of action, affordable cost, and better profitability (Abouziena and Haggag, 2016). Herbicides can enter a plant through roots, shoots, stems, foliage, or buds. To be effective, contact herbicides must adequately contact plants; systemic herbicides, meanwhile, are absorbed by plants and must move within them to the site of action without being deactivated and reach the site of action at toxic levels. Herbicide selectivity is based on differential absorption, translocation, and metabolism of herbicides in plants. Overall, herbicide performance largely depends on its application rate, environmental impacts, and spray technology.

In the wake of climate change, rising CO_2 could alter yield losses due to competition from weeds, and weed control will be crucial in realizing any potential increase in the yield of C_3 crops (Kaur et al., 2020). Climate variability also directly affects herbicide efficacy by altering the absorption and translocation of herbicides within the plant. Climate change leading to altered environmental conditions increases the risk for metabolism-based reduction in herbicide efficacy for weed control. A distinct variation in the efficacy of 2,4-D was found in Palmer amaranth (*Amaranthus palmeri* S. Watson) grown at high temperature versus low temperature; enhanced 2,4-D metabolism at high temperatures resulted in reduced amounts of herbicide to control the resistant *A. palmeri* population (Rudell et al., 2023). In addition to the physicochemical properties of herbicides, environmental factors such as temperature, humidity, wind speed, and soil physicochemical properties may significantly impact the performance of herbicides. Knowledge of soil phase characteristics and the mechanisms involved in herbicide transformation can help in understanding the fate of herbicides in soil. Therefore, the current Research Topic was initiated for this purpose and includes five research papers on application timing, herbicide rotation, integrated use of herbicides with non-chemical measures, and evaluation of herbicide efficacy.

Annual/rigid ryegrass (*Lolium rigidum* Gaudin) has evolved resistance to herbicides of multiple modes of action groups in many parts of the world (Heap, 2024); the worst-case scenario is probably the one taking place in many cropping regions in Australia. Dose-response studies are helpful in evaluating herbicide efficacy for weed control, crop safety, putative herbicide resistance, and herbicide persistence in soil (Price et al., 2012). The first article by Pritchard et al. published in this Research Topic explores the use of a dose-response experiment to differentiate susceptible and resistant *Poa annua* collections from a golf course in the southeastern United States; these collections were then screened for putative indaziflam resistance. Similarly, in the fourth article, a dose-response study conducted by Mahajan and Chauhan demonstrated the use of pendimethalin for effective control of late cohorts of *L. rigidum* while ensuring crop safety. The novel post-emergence use of pendimethalin, typically used as a pre-emergence herbicide, can diversify herbicide programs and delay resistance evolution in *L. rigidum*.

Plant age affects herbicide absorption as well as its translocation and activity in the plant. Herbicide efficacy is affected by spray technology, including spray volume, timing of herbicide application, and adjuvants added (Kaur et al., Brankov et al., 2023). The third article, by Kaur et al., demonstrated the effect of POST herbicides applied at two heights (10-15 cm and 20-30 cm) for multiple herbicide-resistant Palmer amaranth control and seed production. Further, the excessive and non-sustainable use of herbicides may result in low agricultural production, environmental pollution, and health hazards. The repeated use of a similar mode of action may help in the faster evolution of herbicide resistance in weeds. The results from the fifth article, authored by Vulchi et al., indicated the necessity for rotating herbicides during alternate cropping seasons and emphasized integrating non-chemical strategies for barnyard grass (*Echinochloa* spp.) control in Californian (USA) rice production. Innovative and feasible integrated weed management systems, including herbicide programs with residual herbicides and crop rotations, may be designed for diverse production situations that can reduce weed infestations and environmental impacts and prolong the use of herbicides (Kaur et al.). Another manuscript by Vulchi et al. corroborates the above statements. This manuscript highlights that, when crop rotations were integrated with dicamba-based herbicide programs and residual herbicides, it helped in effective management of Palmer amaranth across tillage types and environments.

In conclusion, this special Research Topic on herbicide efficacy explored the relevant aspects for sustainable weed management with herbicides. Creating a novel herbicide is a significant challenge for the industry; therefore, good stewardship practices must be maintained to increase herbicide life. The high costs, regulatory hurdles, and eventual resistance make new discoveries daunting. Recently, herbicide-tolerant crops (and genetically modified organisms in general) have been considered an agro-business opportunity, potentially allowing the use of one and the same herbicide across many crops. The increasing world population seems to be a major driver for the need to increase food production output per area. The high impact of weed competition on yields makes weed control mandatory. To secure crop yields, herbicides for weed management will continue to be the preferred choice for the foreseeable future. However, herbicides should persist long enough to check weeds until the end of the critical period of weed competition but should not persist beyond the crop harvest. Moreover, the physicochemical properties of herbicides affect their behavior in soil and regulate their interaction mechanisms with organic and inorganic soil phases. Predicting herbicide movement and fate in soils is an important strategy in limiting their environmental impact. The non-sustainable use of pesticides, low efficacy, faster evolution of resistance in weeds, pollution, and biomagnification of pesticides in agroecosystems and food chains are questioning the success of chemical weed control. As one of the future trends, these adverse effects of herbicides would be addressed with the novel developments in nanotechnology. However, the road to finally accepting nanoherbicides in current cropping systems is not a short one; several obstacles need to be overcome, including the regulating framework for their approval.

Author contributions

SK: Conceptualization, Supervision, Writing – original draft, Writing – review & editing. KM: Conceptualization, Supervision, Writing – review & editing. FE: Conceptualization, Supervision,Writing – review & editing. DC: Conceptualization, Supervision, Writing – review & editing. BC: Conceptualization, Supervision, Validation, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Qu, R. Y., He, B., Yang, J. F., Lin, H. Y., Yang, W. C., Wu, Q. U., et al. (2021). Where are the new herbicides? *Pest Manage. Sci.* 77, 2620–2625. doi: 10.1002/ps.6285

Abouziena, H. F., and Haggag, W. M. (2016). Weed control in clean agriculture: A review. *Planta Daninha* 34, 377–392. doi: 10.1590/S0100-83582016340200019

Brankov, M., Simi´c, M., Ulber, L., Tolimir, M., Chachalis, D., and Dragičevi´c, V. (2023). Effects of nozzle type and adjuvant selection on common lambsquarters (*Chenopodium album*) and johnsongrass (*Sorghum halepense*) control using nicosulfuron in corn. *Weed Technol.* 37, 156–164. doi: 10.1017/wet.2023.16

Heap, I. (2024). *The International Herbicide-Resistant Weed Database*. Available online at: www.weedscience.org (Accessed September 29, 2024).

Kaur, S., Jabran, K., Florentine, S., and Chauhan, B. S. (2020). "Assuring crop protection in the face of climate change through an understanding of herbicide metabolisms and enhanced weed control strategies," in *Crop Protection under Changing Climate*. Eds. K. Jabran, S. Florentine and B. S. Chauhan (Springer Nature, Switzerland AG), 17–56.

Price, W. J., Shafii, B., and Seefeldt, S. S. (2012). Estimation of dose-response models for discrete and continuous data in weed science. *Weed Technol.* 26, 587–601. doi: 10.1614/WT-D-11-00101.1

Rudell, E. C., Aarthy, T., Shyam, C., Borgato, E. A., Kaur, S., and Jugulam, M. (2023). High temperature increases 2,4-D metabolism in resistant *Amaranthus palmeri*. *Weed Sci.* 71, 217–223. doi: 10.1017/wsc.2023.26