AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 03, Issue: 08 (August, 2026)
Available online at http://www.agrimagazine.in

Herbicide-Based Weed Management in Groundnut: Challenges & Future Prospects

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Groundnut (*Arachis hypogaea* L.) is one of the most economically important oilseed crops cultivated in tropical and subtropical regions of the world. Owing to its high oil (40–56%) and protein (20–30%) content, it serves as an important source of edible oil, nutritional food, livestock feed, and industrial raw material. In India, groundnut occupies a prominent position among oilseed crops, contributing significantly to agricultural income, rural employment, and the country's edible oil economy. The productivity of groundnut is largely influenced by efficient crop management practices, among which weed management is considered one of the most crucial. Groundnut exhibits slow seedling growth, limited canopy development during the early stages, and a unique geocarpic habit in which pods develop beneath the soil surface. These characteristics make the crop highly vulnerable to weed infestation, particularly during the initial stages of growth. A wide range of grassy weeds, broad-leaved weeds, and sedges commonly infest groundnut fields. Weeds interfere with pegging and pod development, hinder harvesting operations, and may also serve as alternate hosts for insect pests and plant pathogens. The increasing complexity of weed problems and the need for efficient crop management have shifted weed control practices from conventional manual methods to herbicide-based approaches. The development of selective pre- and post-emergence herbicides has greatly improved weed control efficiency and crop productivity. However, concerns regarding herbicide resistance, environmental safety, and sustainable weed management have highlighted the need for integrated and judicious herbicide use.

Fig. Groundnut Crop. Source: Protect our livelihood

Need for Herbicide-Based Weed Management

Traditionally, weeds in groundnut are managed through hand weeding and intercultural operations. Although these methods are effective, they are becoming increasingly difficult because of labour scarcity, rising wages, untimely rainfall during the kharif season, and increased cultivation costs. Delayed weeding often results in irreversible crop losses because weeds dominate the crop during the most sensitive growth stages. Under such circumstances,

herbicides have emerged as an efficient, economical, and practical option for weed management. Herbicides provide: Timely weed control, reduce labour dependency, minimize crop-weed competition, and improve resource-use efficiency. Moreover, herbicide application allows farmers to maintain weed-free conditions during the critical growth period, thereby improving crop growth and yield (Jat et al., 2011).

Role of Herbicides in Groundnut Production

Groundnut is infested by a diverse weed flora comprising grasses, broad-leaved weeds and sedges, making effective control difficult with a single herbicide. Therefore, the use of pre-emergence (PE) followed by post-emergence (PoE) herbicides is an effective strategy for achieving prolonged weed suppression.

- **Pre-emergence herbicides** such as pendimethalin and diclosulam suppress the initial flush of weeds after sowing.
- **Post-emergence herbicides** such as quizalofop-p-ethyl and imazethapyr control weeds that emerge later or escape PE treatment.
- **Sequential application (PE → PoE)** provides broader and longer-lasting weed control than a single application. Mehriya and Choudhary (2023) also been reported improved weed suppression, crop productivity and economic returns with sequential herbicide application, highlighting its potential for effective weed management.
- **Rotation of herbicides with different modes of action** is important for reducing the risk of herbicide resistance and maintaining long-term efficacy.

Thus, **proper herbicide selection, dose, timing and application method**, along with integration with other weed management practices, are essential for sustainable groundnut production.

Fig. Fertilizer Requirement for Groundnut Crop Source: Wikifarmer

Fig. Herbicide Application on Groundnut Crop

Recent Research Developments in Herbicide Use

Field research over the past few years has continued to refine pre- and post-emergence herbicide use in groundnut, with a growing focus on efficacy, cost-effectiveness and compatibility with modern cropping systems:

- **Imazethapyr + Quizalofop combination:** Tripathi and Singh (2022) found that imazethapyr (100 g a.i./ha) combined with quizalofop (37.5 g a.i./ha) effectively controlled mixed weed flora in groundnut, achieving over 93% weed control efficiency along with higher pod yield and net returns.
- **Pendimethalin → Imazethapyr sequence:** Sequential application of pendimethalin as pre-emergence followed by imazethapyr as post-emergence has consistently improved growth attributes, pod yield and profitability of kharif groundnut compared with either herbicide applied alone (Mehriya and Choudhary, 2023).
- **Ready-mix formulations:** Pre-mixed products such as pendimethalin + imazethapyr and diclosulam-based formulations are gaining popularity for their convenience, broader weed-control spectrum, and fewer field operations, making them attractive options for resource-constrained farmers.

Challenges in Herbicide-Based Weed Management

Despite its clear benefits, herbicide-based weed management in groundnut faces several agronomic and environmental challenges that requires careful attention:

- **Herbicide resistance:** Repeated use of herbicides sharing the same mode of action, particularly ALS-inhibitors and dinitroaniline-group herbicides, has raised concern over the evolution of herbicide-resistant weed biotypes in groundnut-growing regions (Singh and Devkota, 2024).
- **Weed flora shift:** Continuous reliance on selective herbicides can shift the dominant weed spectrum toward more tolerant species, such as certain sedges and broad-leaved weeds, complicating the long-term management.
- **Crop phytotoxicity and seed safety:** Groundnut's geocarpic habit and shallow pegging zone make it particularly sensitive to herbicide overdose, drift, or poor timing, which can injure developing pegs and pods.
- **Environmental and non-target concerns:** Herbicide residues can persist in soil and affect succeeding crops in rotation, while off-target spray drift poses risks to neighbouring vegetation and water bodies.
- **Improper application practices:** Incorrect dose, poorly calibrated sprayers, wrong growth-stage timing, and limited farmer awareness often reduce herbicide efficacy and accelerate the risk of resistance development.

Future Prospects

Addressing these challenges calls for smarter, more integrated approaches to herbicide use in groundnut:

- **Precision and site-specific application:** Emerging technologies such as hyperspectral imaging combined with machine learning can accurately distinguish groundnut plants from weeds, paving the way for targeted, site-specific spraying that reduces overall chemical use (Bakhshipour and Ramezanpour, 2025).
- **New molecules and formulations:** Continued development of novel herbicide molecules and ready-mix formulations with differing modes of action will help diversify control options and delay the onset of resistance.
- **Integrated Weed Management (IWM):** Combining herbicides with cultural practices such as optimum plant geometry, mulching, and crop rotation can reduce reliance on chemical control while maintaining weed suppression efficacy.
- **Resistance management and farmer training:** Systematic herbicide rotation, tank-mixing different modes of action, and extension programmes on correct dose and timing will be key to preserving the long-term effectiveness of chemical weed control.

Conclusion

Herbicide-based weed management has transformed groundnut cultivation by offering a timely, economical and reliable alternative to labour-intensive manual weeding, particularly during the critical early crop-weed competition period. Sequential and combination herbicide strategies, backed by recent research, have consistently improved weed control efficiency, pod yield and farm profitability. Yet the long-term sustainability of this approach depends on addressing herbicide resistance, weed flora shifts and environmental safety through judicious, integrated use. Looking ahead, the convergence of precision application technologies, diversified herbicide chemistry and integrated weed management practices offers a promising path toward effective, economical and environmentally responsible weed control in groundnut production.

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