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Weed management in groundnut (*Arachis hypogaea* L.): A review

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Abstract
Groundnut is one of the most important oilseed and food legume crops cultivated worldwide, valued for its edible oil, protein rich kernels, and contribution to soil fertility through biological nitrogen fixation. However, weed infestation remains a major constraint in groundnut production, particularly during the early growth stages when the crop exhibits slow initial growth and poor canopy coverage. Uncontrolled weeds compete with crop for nutrients, moisture, light, and space, resulting in significant yield reduction and deterioration in pod quality. Effective weed management is therefore essential to achieve higher productivity and profitability in groundnut cultivation. This review summarizes the major weed flora associated with groundnut fields and discusses different weed management approaches. Mechanical methods like hand weeding remain effective but are often constrained by labour scarcity and increased production costs. Herbicide-based weed management, involving pre-emergence, and post-emergence herbicides, has gained importance due to its efficiency and timeliness. The review also highlights the role of integrated weed management (IWM), which combines multiple approaches for sustainable and eco-friendly weed control while minimizing herbicide resistance and environmental hazards.

Keywords: Groundnut, oilseed crop, food legume, biological nitrogen fixation, weed infestation, early growth stages, crop competition, yield reduction, pod quality

Introduction
Groundnut is an important oilseed and legume crop cultivated widely in tropical and subtropical regions for its edible oil, protein-rich seeds, and soil fertility improvement through biological nitrogen fixation. In India, it plays a significant role in rural economy. However, weed infestation is a major constraint affecting groundnut productivity, especially during the early growth stages due to slow initial growth and poor canopy development. Weeds compete with the crop for nutrients, moisture, light, and space, causing substantial yield losses. The critical period of weed competition in groundnut is generally between 15 and 45 days after sowing, during which effective weed control is essential. Traditional methods such as hand weeding and inter-cultivation are effective but labour-intensive and costly. Therefore, chemical weed control through herbicides has become increasingly important. Various weed management approaches including cultural, mechanical, chemical, and integrated weed management (IWM) practices are used to minimize weed infestation and improve crop productivity. Among these, IWM is considered a sustainable approach as it combines different methods for effective and eco-friendly weed control. This review highlights major weed management strategies for improving productivity and sustainability in groundnut cultivation.

Weed flora
Groundnut fields are infested with different types of weeds, including grasses, broad-leaved weeds, and sedges. Although grassy weeds are more predominant, broad-leaved weeds also compete strongly with the groundnut crop. Sharma *et al.* (2015) [31] found major weeds during *kharif* in the experimental field of groundnut are *Cynodon dactylon*, *Aeluropus villosus*, *Brachiaria* spp., *Indigofera glandulosa*, *Panicum colonum*, *Asphodelus tenuifolius*, *Digera arvensis* Forssk, *Euphorbia hirta*, *Amaranthus viridis*, *Leucas aspera*, *Boerhavia diffusa*, *Commelina benghalensis*, *Portulaca oleracea*, *Physalis minima*, *Parthenium hysterophorus* and *Cyperus rotundus*, on silt clay soils of Junagadh Agricultural University, Junagadh. In an experiment field during *rabi*, Divyamani *et al.* (2018) [6] stated that the major weeds in groundnut were *Cyperus rotundus*, *Digitaria sanguinalis*, *Commelina benghalensis*, *Phyllanthus niruri*, *Cleome viscosa*, *Boerhavia diffusa* and *Dactyloctenium aegyptium* on sandy loam soils at wetland farm of S.V. Agricultural college, Tirupati. Mehriya *et al.* (2020) [18] observed major weeds in the experimental field of groundnut were *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Cynodon dactylon*, *Setaria glauca*, *Cenchrus ciliaris*, *Eragrostis amabilis*, *Amaranthus* spp., *Digera arvensis*, *Corchorus olitorius*, *Phyllanthus niruri*, *Tribulus terrestris*, *Celosia argentea*, *Phyllanthus maderaspatensis*, *Boerhavia erecta*, *Commelina benghalensis*, *Cleome viscosa*, *Cucumis callosus* and *Cyperus rotundus* during *kharif* and *rabi* on sandy loam soils at ARS, Mandore, Jodhpur, Rajasthan.

Yield losses due to weeds
Weeds are one of the major biotic factors responsible for yield loss in groundnut. The loss caused by weeds depend on the type of weed flora, weed intensity and time of crop-weed competition. From a field experiment in groundnut on black soils of Junagadh, Jat *et al.* (2011) [12] revealed that weeds comprising diverse species including grasses, sedges,

broad leaf weeds and caused substantial yield losses from 15 to 75% and more in rainfed Spanish bunch type than in irrigated virgina type of groundnut. Priya *et al.* (2013) [27] carried out a field trial in groundnut and they witnessed substantial yield losses (15-75%) due to weeds which are more in bunch type than in Virginia type of groundnut in red loam soil at Tamilnadu Agricultural University, Coimbatore, Tamilnadu, India. Sharma *et al.* (2015) [31] revealed that uncontrolled growth of weeds during the crop growing period in *Rabi* groundnut reduced the pod yield by 70%. Thus, it can be concluded that the yield losses in groundnut due to weeds range from 15 to 90% under different soil and environmental conditions. A field experiment conducted by Prasad *et al.* (2020) [26] at Bikaner showed that kernel yield of groundnut was reduced by 55% in weedy check compared to two hand weedings.

Critical period of crop weed competition

On sandy clay loam soils at College of Postgraduate Studies, Central Agricultural University, Umiam, Meghalaya (Korav *et al.* 2020) [15] conducted a field trial during *kharif* and *rabi* of 2016 and 2017 and revealed that critical periods for weed competition under five percent yield loss during *kharif* was 16 to 66 DAE (Days after emergence) and *rabi* was 15 to 63 DAE, the estimated critical period for groundnut at 10 percent yield losses were 22 to 62 and 21 to 61 DAE in *kharif* and *rabi* respectively.

Weed management practices

Hand Weeding

Among the physical methods of weed control in groundnut, manual weeding was found effective, but it is time consuming and laborious. Manual weeding has been the oldest, simple and most direct method known to peanut growers. Adhikary *et al.* (2016) [1] observed that hand weeding twice resulted in lower weed density and weed biomass in groundnut during the summer seasons of 2012 and 2013 at the Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, on sandy loam soils. Goutham *et al.* (2016) [10] reported that hand weeding at 20 and 40 DAS recorded the highest weed control efficiency (87.1%) in *rabi* groundnut grown on sandy soils at Agricultural College Farm, Bapatla. This was found to be on par with pendimethalin followed by hand weeding at 40 DAS and pendimethalin followed by imazethapyr application. Srinivasan *et al.* (2024) [34] reported that hand weeding carried out at 20 and 40 DAS significantly increased dry matter production in groundnut, recording 2531.36, 4894.78 and 5972.57 kg ha^{-1} at 30 DAS, 60 DAS and harvest, respectively, in a field experiment conducted during January–April, 2023 at Annamalai University, Tamil Nadu.

Effect of herbicides on weed growth

Ahmed *et al.* (2008) [3] conducted a field trial at Ismailia Agricultural Research Station, Agriculture Research Centre, Egypt during 2004 and 2005. The results showed that with the pre-emergence application of pendimethalin @ 2023 g ha^{-1} reduce the weed population in groundnut and it was followed by PE application of pendimethalin @ 1111.5 g ha^{-1}. Honnali and Satihal (2022) [11] revealed that among the herbicides lower total weed density and weed dry weight was recorded in diclosulam 84% WDG @ 26 g a.i ha^{-1} in both the seasons followed by diclosulam 84% WDG @ 18 and 22 g a.i ha^{-1} and also pendimethalin and oxyfluorfen in groundnut at ARS, University of Agricultural sciences, Raichur. Mehriya *et al.* (2024) [14] carried out a field experiment in groundnut on sandy loam soils at Agricultural Research Station, Mandor during *kharif* of 2021 and 2022 and the succeeding *rabi* of 2021–22 and 2022–23. The study revealed that application of pendimethalin @ 1.0 kg ha^{-1} as pre-emergence followed by quizalofop-ethyl @ 50 g ha^{-1} as post-emergence significantly decreased weed dry weight by about 76.95% over the weedy check at 30 and 60 DAS.

Weed control efficiency

Patro *et al.* (2014) [25] reported that the highest weed control efficiency was recorded under the weed-free check, followed by PE application of pendimethalin 30 EC @ 1.0 kg a.i. ha^{-1} along with one hand weeding at 45 DAS, either alone or combined with PoE application of quizalofop-ethyl 5% EC @ 50 g a.i. ha^{-1} at 20 DAS during *kharif* groundnut cultivation at the breeder seed production farm of Orissa University of Agriculture and Technology. Divyamani *et al.* (2018) [6] conducted a field experiment during *rabi* in groundnut on sandy loam soils and observed that pre-emergence application of pendimethalin + imazethapyr (premix) @ 1000 g ha^{-1} resulted in the highest weed control efficiency at the wetland farm of S.V. Agricultural College, Tirupati. Nivetha *et al.* (2022) [24] carried out a field experiment in groundnut on sandy clay loam soils during the winter season at the Central Farm, Agricultural College and Research Institute, Madurai, Tamilnadu and reported that the highest weed control efficiency was observed under the weed-free treatment, followed by PE application of pendimethalin 30% + imazethapyr 2% EC (ready mix) @ 1.0 kg a.i. ha^{-1} followed by hand weeding at 40 DAS.

Weed index

Dixit *et al.* (2016) [7] conducted a field experiment in groundnut on clayey loam soils during *kharif* at research farm of Zonal Agricultural Research Station Khargone, JNKVV, Jabalpur and stated that highest weed index was recorded with the pre-emergence application of pendimethalin @ 1.0 kg ha^{-1}. Naik *et al.* (2022) [21] stated that PE application of pendimethalin 30 EC + imazethapyr 2 EC @ 1.0 kg ha^{-1} (ready mix) + manual weeding at 30 DAS recorded lowest weed index over pre-emergence application of pendimethalin 38.7 CS @ 1.0 kg ha^{-1} in the experimental field of groundnut on medium black soils during *kharif* at ZAHRS, Babbur farm, Hiriyur, Karnataka, India. Priyanka *et al.* (2023) [28] reported that the lowest weed index in groundnut was recorded with pre-emergence application of pendimethalin + imazethapyr @ 1.0 kg ha^{-1} along with one manual weeding at 30 DAS this was followed by pre-emergence application of pendimethalin @ 1.0 kg ha^{-1} combined with imazethapyr @ 75 g ha^{-1} at 20 DAS during *kharif* on sandy loam soils at Agricultural Research Station, Mandor, Agricultural University, Jodhpur.

Effect of Weed Management Practices on Growth Parameters

Goutham *et al.* (2016) [10] conducted a field experiment in groundnut and stated that hand weeding at 20 and 40 DAS recorded maximum crop dry weight. Pendimethalin *fb* imazethapyr, pendimethalin *fb* propaquizafop and pendimethalin *fb* hand weeding at 40 DAS were on par with hand weeding twice on sandy soil during *rabi* at

Agricultural College Farm, Bapatla. Nambi *et al.* (2019) [22] conducted a field experiment in groundnut during *kharif* on sandy clay loam soils at farmer's field, Tamilnadu and stated that maximum plant height was recorded with PE application of pendimethalin @ 1.0 kg ha^{-1} + hand weeding at 30 DAS which was followed by two hand weedings at 15 and 30 DAS. Ahirwal *et al.* (2020) [2] carried out a field experiment in groundnut during *kharif* on sandy loam soil at Research Farm, JNKVV, Jabalpur, Madhya Pradesh and stated that pre-emergence combine application of pyroxasulfone + pendimethalin 900 g ha^{-1} registered higher crop biomass followed by pyroxasulfone + pendimethalin @ 1125 and 675 g ha^{-1}. Timsina *et al.* (2020) [36] conducted field experiment during summer in groundnut on sandy loam soils at the research block of National Oilseed Research Program (NORP) and reported that flowering occurred earlier under weed-free conditions than in the control plot. Geethika and Subramanyam (2023) [9] carried out a field study during *rabi* in groundnut on sandy loam soils at the wetland farm of Sri Venkateswara Agricultural College and observed that pre-emergence application of pendimethalin @ 1.0 kg ha^{-1} followed by hand weeding at 40 DAS resulted in significantly greater dry matter production. Mukilan *et al.* (2023) [20] revealed that the highest plant height was observed with hand weeding at 20 and 45 DAS followed by pre-emergence application of diclosulam @ 0.025 kg a.i ha^{-1} *fb* hand weeding at 40 DAS in groundnut during *kharif* at Regional Agricultural Research Station, TNAU, Vriddhachalam.

Effect of Weed Management Practices on Yield Parameters

Kalhapure *et al.* (2013) [14] carried out a field experiment in groundnut during two consecutive *kharif* in 2010 and 2011 at Rahuri and observed that the weed free treatment recorded a significantly higher number of kernels pod^{-1}. This was followed by pre-emergence application of pendimethalin @ 1.5 kg ha^{-1} combined + post-emergence application of imazethapyr @ 0.150 kg ha^{-1} + hand weeding at 40 DAS, whereas the lowest value was noticed with pre-emergence application of pendimethalin @ 1.5 kg ha^{-1} alone. Kumar *et al.* (2013) [16] stated that maximum pod weight $plant^{-1}$ was obtained with pre-emergence application of pendimethalin @ 1.0 kg a.i ha^{-1} + imazethapyr @ 50 g a.i ha^{-1} at 20 DAS + 1 HW at 45 DAS followed by preemergence application of pendimethalin @ 1.0 kg a.i ha^{-1} + post-emergence application of quizalofop ethyl @ 50 g a.i ha^{-1} at 20 DAS + 1HW at 45 DAS in groundnut on sandy loam soils during *kharif* at Research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur. Samant and Mishra (2014) [30] revealed that maximum no. of pods $plant^{-1}$ were recorded by PoE application of quizalofop-ethyl @ 1.0 kg ha^{-1} with one hand weeding which was on par with post-emergence application of quizalofop ethyl @ 0.75 kg ha^{-1} with one hand weeding in groundnut on sandy loam soils during *rabi* at Khuntanali village in Angul district of Odisha. Nambi *et al.* (2019) [22] conducted a field experiment in groundnut on sandy clay loam soils during *kharif* at farmer's field, Cuddalore district, Tamilnadu and stated that a greater number of pods $plant^{-1}$ were recorded with the pre-emergence application of pendimethalin @ 1.0 kg ha^{-1} + hand weeding at 30 DAS which was followed by two hand weedings at 15 and 30 DAS. Dolie and Nongmaithem (2020) [8] conducted a field experiment on sandy loam soils in groundnut at SASRD, Nagaland University and stated that maximum test weight was observed by pre-emergence application of pendimethalin *fb* one manual weeding at 45 DAS. Kundu *et al.* (2021) [17] stated that the maximum test weight was recorded with weed free treatment which was followed by hand weeding at 20 and 40 DAS in groundnut field experiment on sandy clay loam soils during three consecutive summer seasons of 2016-17, 2017–2018 and 2018-2019 at Research farm, Bidhan Chandra Krishi, Vishwavidhyalaya, West Bengal. Honnali and Satihal (2022) [11] revealed that among the herbicide treatments, PE application of diclosulam 84% WDG @ 26 g a.i ha^{-1} significantly recorded higher pod dry weight in groundnut compared with lower doses of diclosulam and all other herbicides during both the seasons at ARS, University of Agricultural sciences, Raichur. Mehriya *et al.* (2024) [19] carried out a field experiment in groundnut on sandy loam soils during two consecutive rainy seasons of 2021 and 2022 and subsequent *rabi* seasons of 2021-22 and 2022-23 at Agricultural Research Station, Mandor, Rajasthan, India and revealed that the shelling % increased by 14.7% with PE application of pendimethalin @ 1.0 kg ha^{-1} *fb* post-emergence application of quizalofop-ethyl 50 g ha^{-1} at 30 and 60 DAS.

Pod yield

Dixit *et al.* (2016) [7] conducted a field experiment in groundnut on clay loam soils during *kharif* at research farm of Zonal Agricultural Research Station, JNKVV, Jabalpur and stated that maximum pod yield was recorded with weed free treatment which was on par with pre-emergence application of pendimethalin @ 1.0 kg ha-1 + post-emergence application of imazethapyr @ 75 g ha-1 at 20 DAS. Subramanyam *et al.* (2020) [35] stated that pre-emergence application of diclosulam @ 20 g ha^{-1} + HW at 40 DAS recorded maximum pod yield which was at par with sequential application of diclosulam @ 20 g ha^{-1} + cycloxydim @ 100 g ha^{-1} at 20 DAS in groundnut during *rabi* on sandy loam soils at dryland farm of S.V. Agricultural College, Tirupati. Venkateshwara *et al.* (2020) [38] reported that the highest pod yield in groundnut was obtained with pre-emergence application of pendimethalin 30 EC + imazethapyr 2 EC (ready mix) @ 1.0 kg ha^{-1} followed by manual weeding at 30 DAS. In contrast, significantly lower pod yield was recorded with pre-emergence application of pendimethalin 38.7 CS @ 1.0 kg ha^{-1} alone during *kharif* at the Zonal Agricultural and Horticultural Research Station, Hiriyur, Chitradurga district, Karnataka. Regar *et al*. (2021) [29] revealed maximum pod yield was observed under weed free treatment followed by pre-emergence application of pendimethalin +imazethpyr (30+2) premix @ 800 g a.i ha^{-1} in groundnut on sandy loam soils during *kharif* at College of Agriculture, SKRAU, Bikaner, Rajasthan. Srinivasan *et al.* (2024) [34] revealed that maximum pod yield was recorded with pre-emergence application of pendimethalin 1.0 kg a.i ha^{-1} at 3 DAS followed by post-emergence application of quizalofop ethyl @ 100 g a.i ha^{-1} at 21 DAS in groundnut during January-April 2023 at Annamalai University, Annamalai Nagar of Chidambaram taluk, Cuddalore district, Tamilnadu.

Haulm yield

Patro *et al.* (2014) [25] stated that weed free treatment recorded maximum haulm yield, this was followed by pre-

emergence application of pendimethalin 30 EC @ 1.0 kg a.i ha^{-1} + one HW at 45 DAS alone or in combination with post emergence application of quizalofop ethyl 5% EC @ 50 g a.i ha^{-1} at 20 DAS in groundnut for consecutive three rainy seasons in 2010, 2011 and 2012 at Breeder seed production farm of Orissa University of Agriculture and Technology, Bhubaneswar, Odisha. Aruna and sagar (2018) [4] revealed that highest haulm yield was registered with weed free treatment which was significantly superior over pre-emergence application of pendimethalin @ 1.5 kg ha^{-1} followed by post-emergence application of quizalofop-ethyl @ 50 g ha^{-1} at 18-20 DAS and weedy check in groundnut during *rabi* of 2016 and 2017 on sandy clay loam soils at Agricultural Research Station, Utukur, Kadapa. Jopale *et al.* (2024) [13] stated that the highest haulm yield was recorded under weed free treatment which was statistically on par with the preemergence application of diclosulam 84% WDG @ 25 g ha^{-1} fb hand weeding at 20 and 40 DAS in groundnut field experiment during summer on sandy clay loam soils at AICRP, Mahatma Phule Krishi Vidhyapeet, Rahuri.

Harvest index

Chaitanya *et al.* (2013) [5] conducted a field experiment in groundnut on red sandy loam soils at University of Agricultural Sciences, Bangalore and revealed that pre-emergence application of pendimethalin @ 1.0 kg ha^{-1} along with post-emergence application of quizalofop ethyl @ 50 g ha^{-1} at 25 DAS recorded maximum harvest index as compared to unweeded check. Narwal *et al.* (2024) [23] stated that pre-emergence application of pendimethalin 30% EC @ 1.5 kg ha^{-1} followed by one hand weeding at 25 DAS recorded significantly higher harvest index in groundnut at ARS Kumta, UAS Dharwad.

Effect of Weed Management Practices on Economics

Shwetha *et al.* (2016) [32] stated that highest net returns and benefit cost ratio was recorded with pre-emergence application of pendimethalin @ 700 g ha^{-1} *fb* post-emergence application of imazethapyr @ 100 g ha^{-1} in groundnut field experiments on red sandy loam soils at Agricultural Research Station, Kawadimatti, Karnataka. Sridhar *et al.* (2021) [33] carried out a field experiment in groundnut during *kharif* at Department of Agronomy, SASRD, Nagaland University, Medziphema campus and stated that net returns and B:C ratio were maximum with pre-emergence application of diclosulam @ 27 g ha^{-1} *fb* hand weeding at 50 DAS due to higher pod and haulm yields. Tripathi *et al.* (2022) [37] observed that the application of post-emergence application of imazethapyr + quizalofop ethyl at 20 DAS was effective in controlling both grassy and broad-leaved weeds and produced the maximum yield with higher monetary returns in the field experiment of groundnut at the Institutional Farm of Krishi Vigyan Kendra, Chhatarpur, Madhya Pradesh.

Conclusion

Effective weed management is essential for improving growth, yield and profitability of groundnut. The reviewed studies showed that integrated weed management practices involving herbicides along with manual weeding were more effective than individual methods alone. Although hand weeding effectively reduced weed density and improved crop growth, its labour requirement limits large-scale adoption. Among herbicides, pre-emergence application of pendimethalin, diclosulam, pendimethalin and imazethapyr effectively controlled weeds and improved weed control efficiency. Sequential application of pre and post-emergence herbicides along with one hand weeding at 30–45 DAS recorded better growth, yield attributes, pod yield and economic returns. Overall, integrated weed management combining chemical and cultural methods was found to be the most effective and sustainable approach for reducing weed competition and enhancing productivity in groundnut cultivation.

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