

# Integrated weed management in pulse crops

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*The article explores integrated weed management (IWM) strategies essential for optimising pulse crop production, which is vital for nutritional security and agricultural sustainability. Pulses, known for their high protein content and ability to enrich soil through nitrogen fixation, face significant yield losses due to weed competition, particularly in rainfed conditions. Weeds can cause yield reductions ranging from 30–80%, emphasising the need for effective management practices. It also highlights the importance of understanding weed dynamics, including species composition and growth behaviour, to devise targeted control measures. It advocates a holistic approach that combines manual, mechanical, and chemical methods tailored to specific crops and environmental contexts. Furthermore, the study underscores the necessity of continuous monitoring and adaptive strategies to mitigate weed impacts and enhance crop resilience. By focusing on IWM, pulse productivity can be improved, thereby addressing food security challenges and promoting sustainable agricultural practices in pulse cultivation.*

**Keywords:** Integrated weed management, Pulse crops, Weeds

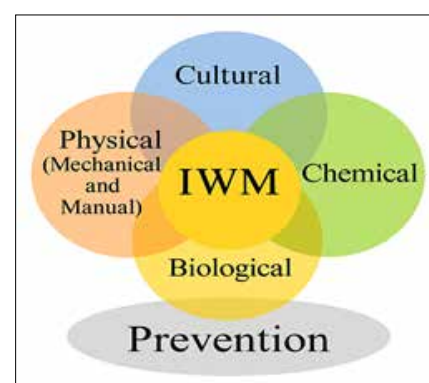
**P**ULSES are a vital source of plant-based protein and play a central role in food and nutritional security, particularly in developing countries where they contribute about 20–25% of total dietary protein intake. Important pulse crops include chickpea, pigeonpea, lentil, mungbean, etc. Nutritionally, pulses are rich in protein (18–25%) and carbohydrates (55–65%) and contain very low fat (1–4%), making them superior to cereals in supporting balanced diets. In addition to their nutritional value, pulses contribute significantly to sustainable and climate-resilient agriculture. Through symbiotic biological nitrogen fixation, pulse crops can fix 40–200 kg N/ha/season, reducing the dependence on synthetic nitrogen fertilisers in succeeding crops by 20–30%. Their well-developed tap root systems improve soil structure, porosity, and water infiltration, while diversified pulse-based cropping systems can increase soil organic carbon by 5–15% compared

with continuous cereal cultivation. Lower fertiliser use further helps in reducing greenhouse gas emissions.

Despite these benefits, pulse productivity remains low and unstable, largely due to severe weed infestation. Weeds rank among the top three biotic constraints in pulses, causing nearly 33% of agricultural production losses in India. Yield losses due to unchecked weeds range from 30–80% in *kharif* pulses and 18–80% in *rabi* and summer pulses. Pulses are especially vulnerable during the first 15–45 days after sowing (DAS) because of slow early growth and poor canopy development, during which weeds can remove up to 60% of available nutrients and moisture.

Weed pressure is particularly high in *kharif* and summer seasons, and overreliance on herbicides has led to weed flora shifts and resistance. Integrated weed management (IWM), combining preventive, cultural, mechanical, biological and chemical approaches with regular

monitoring, has therefore become essential. IWM can reduce weed density by 60–90%, increase yields by 20–50%, and reduce herbicide use by 25–40%, ensuring sustainable and profitable pulse production.



Integrated weed management

## Weed flora infesting pulse crops

Weed infestation in pulse crops varies widely with season, agroclimatic conditions and management practices. Weed pressure is generally higher in *kharif* and *rabi* pulses, while spring/summer

**Table 1.** Season-wise weed flora commonly found in pulse crops

Kharif weeds	Rabi weeds	Summer weeds
<i>Echinochloa colona</i>	<i>Chenopodium album</i>	<i>Echinochloa colona</i>
<i>Dactyloctenium aegyptium</i>	<i>Fumaria parviflora</i>	<i>Eleusine indica</i>
<i>Eleusine indica</i>	<i>Cirsium arvense</i>	<i>Cynodon dactylon</i>
<i>Digitaria sanguinalis</i>	<i>Rumex dentatus</i>	<i>Cyperus rotundus</i>
<i>Eragrostis</i> spp.	<i>Anagallis arvensis</i>	<i>Amaranthus viridis</i>
<i>Trianthema portulacastrum</i>	<i>Phalaris minor</i>	<i>Digitaria sanguinalis</i>
<i>Digera arvensis</i>	<i>Avena ludoviciana</i>	<i>Portulaca oleracea</i>
<i>Phyllanthus niruri</i>	<i>Poa annua</i>	<i>Commelina benghalensis</i>
<i>Cyperus rotundus</i>	<i>Polypogon monspeliensis</i>	<i>Trianthema portulacastrum</i>

pulses usually face relatively lower infestation due to their shorter crop duration and better opportunities for land preparation and irrigation-based control. In *kharif* pulses, warm and humid conditions favour rapid growth of grassy and broadleaved weeds such as *Echinochloa*, *Digitaria*, *Dactyloctenium*, *Trianthema* and *Digera* species. *Rabi* pulses are mainly affected by winter annual weeds like *Chenopodium album*, *Fumaria parviflora*, *Rumex dentatus*, *Anagallis arvensis*, *Phalaris minor* and *Avena ludoviciana*, as slower crop emergence allows weeds to dominate. Weed problems in spring/summer pulses are increasing under irrigated systems, with species such as *Cyperus rotundus*, *Cynodon dactylon*, *Amaranthus viridis*, *Portulaca oleracea* and *Commelina benghalensis*. Parasitic weeds like *Orobanche* spp. pose severe threats in several pulse crops. Hence, regular weed surveys are essential for effective, site-specific weed management.

### Critical period of crop-weed competition

Pulses are highly sensitive to early weed competition, making timely weed control essential for optimal yield. The critical period of crop-weed competition refers to the stage in a crop's growth when weed interference can significantly reduce productivity. Weeds emerging before or after this window generally have minimal impact. The duration of this period varies with crop type and growth habits. For long-duration pulses like pigeonpea, soybean, chickpea, lentil, and pea, the first 30–60 days are crucial due to their bunch-type growth. In contrast, short-duration pulses

such as mungbean, urdbean, and cowpea require weed management within the initial 15–30 days, as they exhibit branching-type growth. Notably, cowpea also serves as a cover crop in widely spaced cereals like maize, helping suppress weed growth naturally. Understanding and managing this critical period is a key component of integrated weed management strategies in pulse cultivation.

**Table 2.** Critical period of crop-weed competition of major pulses

Pulse crop	Duration	Critical period (DAS)
Green gram	Short	15–30
Black gram	Short	15–30
Cowpea	Short	15–25
Lentil	Medium	30–45
Chickpea	Medium	30–45
Pea	Medium	30–45
Pigeon pea	Long	30–60
Soybean	Medium-long	20–45

DAS, Days after sowing.

### Weed management approaches

Effective weed management in pulse crops requires the adoption of individual or combined control measures to keep weed populations below the economic threshold level. Since no single method provides effective and long-term weed control, an integrated approach that combines preventive, cultural, physical, biological and chemical methods is essential.

Preventive methods form the first line of defence against weed infestation by preventing the introduction, establishment and spread of weeds. The principle that 'one year seeding makes seven years' weeding' emphasises the

importance of prevention. These measures aim to reduce weed seed banks and vegetative propagules such as tubers, rhizomes, etc. Farm hygiene plays a crucial role, as farm machinery, irrigation water and livestock often spread weed seeds. Weeds growing on bunds, irrigation channels, field borders and farm roads should be removed regularly to avoid reinfestation. The use of certified weedfree seed is essential, as contaminated seed lots commonly introduce new weed species. Physical seed cleaning using sieves, salt solution floatation or magnetic separation is especially important for parasitic weeds. Quarantine regulations also help prevent the spread of invasive weeds across regions. Collectively, preventive practices significantly reduce long-term weed pressure.

Cultural or ecological methods aim to enhance crop competitiveness while creating unfavourable conditions for weed growth. These practices are based on an understanding of weed biology and ecology. Crop rotation is one of the most effective cultural practices, as it disrupts weed life cycles and prevents dominance of species associated with monocropping. The use of competitive cultivars with rapid early growth, taller stature and dense canopy helps suppress weeds through shading. Practices such as intercropping, relay cropping and cover cropping reduce space and resource availability for weeds. Maintaining optimum plant population, timely sowing, proper row spacing and favourable planting geometry promote early canopy closure and facilitate mechanical weeding. Over time, effective cultural practices reduce weed density and reliance on herbicides.

Physical methods, including mechanical and manual control, involve direct removal or destruction of weeds. Tillage is one of the oldest practices, influencing weed seed placement and germination. Mechanical tools such as hand hoes, rotary weeders and inter-cultivation implements are effective during early crop stages, especially in linesown pulses. Although

labour-intensive, these methods are vital in smallholder systems. Techniques like the stale seedbed, soil solarisation and deep summer ploughing effectively suppress early flushes and perennial weeds, contributing to long-term weed management.



Intercropping mungbean with maize



Manual weeding in pigeonpea

Chemical weed control plays a crucial role in modern agriculture, particularly in pulse crops, where rising labour costs and shortages limit manual weeding. Herbicides provide quick, efficient, and cost-effective weed management and also support conservation tillage systems. Herbicides are classified as selective or non-selective and are applied at different stages such as pre-plant, pre-emergence and post-emergence. Non-selective herbicides like glyphosate and paraquat are commonly used before sowing, especially in zero-till systems, while selective pre-emergence herbicides are applied within three days of sowing and post-emergence herbicides at 15–25 days after sowing. The effectiveness of herbicides depends on the compound, dose, timing, and method of application, and mixtures or sequential applications often improve control. However, excessive reliance on herbicides may cause weed flora shifts, resistance

**Table 3.** Crop-wise herbicide recommendations

Pulse crop	Herbicides
Greengram, Blackgram	Pendimethalin (PE) 750 g a.i./ha (controls annual grasses and some BLWs) Quizalofop ethyl (PoE) 40 g a.i./ha (excellent control of annual grasses) Imazethapyr (PoE) 75 g a.i./ha (controls BLWs and some grasses) Sodium acifluorfen + clodinafop propargyl ready-mix (PoE) 220–250 g a.i./ha (broad spectrum control of grasses and BLWs) Fomesafen + fluazifop-p-butyl ready-mix (PoE) 220–250 g a.i./ha (broad spectrum control of grasses and BLWs)
Pigeonpea	Pendimethalin (PE) 750 g a.i./ha (controls annual grasses and some BLWs) Quizalofop ethyl (PoE) 50 g a.i./ha (excellent control of annual grasses) Sodium acifluorfen + clodinafop propargyl ready-mix (PoE) 220–250 g a.i./ha (broad spectrum control of grasses and BLWs) Imazethapyr + Imazamox ready-mix (PoE) 100 g a.i./ha (broad spectrum control of grasses and BLWs)
Chickpea, lentil	Pendimethalin (PE) 750 g a.i./ha (controls annual grasses and some BLWs) Quizalofop ethyl (PoE) 40 g a.i./ha (excellent control of annual grasses) Clodinafop propargyl (PoE) 60 g a.i./ha (excellent control of annual grasses) Oxyfluorfen (PE) 150 g a.i./ha <i>fb</i> quizalofop-p-ethyl or propaquizafop (PoE) 100 g a.i./ha (broad spectrum control of grasses and BLWs)
Pea	Pendimethalin (PE) 750 g a.i./ha (controls annual grasses and some BLWs) Oxyfluorfen (PE) 250 g a.i./ha (controls annual grasses and some BLWs) Metribuzin (PE) 250 g a.i./ha (controls annual grasses and some BLWs) Quizalofop ethyl (PoE) 40 g a.i./ha (excellent control of annual grasses) Clodinafop propargyl (PoE) 60 g a.i./ha (excellent control of annual grasses) Imazethapyr (PoE) 100 g a.i./ha (controls BLWs and grasses)

BLW, Broadleaf weeds; PE, Pre-emergence; PoE, Post-emergence.

development, residue accumulation, and risks to human health and the environment.

Biological weed control through seed predation by granivorous insects, especially ants, is a promising ecological approach, particularly in zero-tillage systems where weed seeds remain on the soil surface. By retaining crop residues that provide food and shelter, seed predator activity can be enhanced, leading to reduced weed seed banks. Although effectiveness depends on predator presence and timing, integrating this approach into weed management programmes can improve sustainability and reduce reliance on herbicides, warranting further field-based research.

#### Integrated approaches

IWM aims to maintain weed populations at manageable levels, prevent shifts toward difficult to control and resistant species, and minimise crop-weed competition. IWM focuses on preventing weed establishment and reproduction by integrating cultural, agronomic, mechanical, biological and chemical practices rather than depending on a single method. Combining these tactics improves herbicide efficiency and crop competitiveness while reducing costs and environmental

risks. Practices such as zero tillage, stale seedbed, mulching, soil solarisation and timely operations reduce weed seed banks and herbicide load. Site-specific IWM enhances sustainability, farmer profitability and environmental protection.

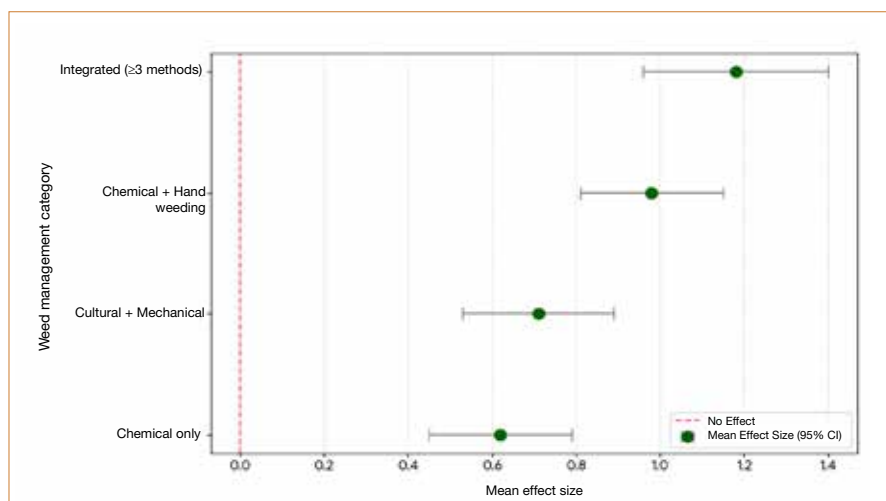
#### Moderator analysis for effect of various weed management practices

The moderator analysis indicates a clear hierarchy in weed control effectiveness, showing that pulse crop productivity increases with greater diversity of management tactics. The chemical-only approach showed the lowest effect size (0.62), reflecting limited efficiency due to risks of resistance and environmental pollution. Cultural and mechanical methods improve outcomes moderately (0.71) by enhancing crop vigour. Adding hand weeding after chemical control markedly increases effectiveness (0.98) by removing surviving weeds. The highest productivity gain was achieved under IWM (effect size 1.18), combining chemical, cultural, and physical practices. This confirms that a multipronged, integrated strategy is the most reliable and sustainable option for managing weeds in pulse crops, which are inherently weak competitors.

**Table 4.** Recommended IWM options for pulses

Pulse crop	Integrated weed management
Greengram	Pendimethalin (PE) 0.75 kg a.i./ha <i>fb</i> hand weeding at 30 DAS Pendimethalin (PE) 1 kg a.i./ha <i>fb</i> hand weeding at 45 DAS
Blackgram	Pendimethalin (PE) 0.75 kg a.i./ha <i>fb</i> hand weeding at 25 DAS
Pigeonpea	Trifluralin (PPI) 1 kg a.i./ha <i>fb</i> hand weeding at 60 DAS Pendimethalin (PE) 0.75 kg a.i./ha <i>fb</i> hand weeding at 30 DAS Pendimethalin (PE) 1 kg a.i./ha <i>fb</i> hand weeding at 45 DAS
Cowpea	Pendimethalin (PE) 0.75 kg a.i./ha <i>fb</i> hoeing at 20–25 DAS Pendimethalin (PE) 0.75 kg a.i./ha <i>fb</i> hand weeding at 30 DAS
Horsegram	Hand weeding at 20 DAS
Chickpea	Pendimethalin (PE) 0.75 kg a.i./ha <i>fb</i> hand weeding
Lentil	Pendimethalin (PE) 0.75 kg a.i./ha <i>fb</i> hand weeding
Pea	Pendimethalin (PE) 1 kg a.i./ha <i>fb</i> hand weeding Metribuzin (PE) 0.25 kg a.i./ha <i>fb</i> hand weeding Oxyfluorfen (PE) 0.25 kg a.i./ha <i>fb</i> hand weeding
Rajmash	Pendimethalin (PE) 1 kg a.i./ha <i>fb</i> hand weeding
Lathyrus	Trifluralin (PPI) 0.75 kg a.i./ha <i>fb</i> hand weeding

PE, Pre-emergence; PPI, Pre-plant incorporation; DAS, Days after sowing.



Moderator analysis of different weed management practices

## SUMMARY

Integrated weed management (IWM) is a cornerstone of sustainable pulse production, as weeds remain one of the most yield-limiting biotic constraints. Although cultural practices such as crop rotation, timely sowing, optimum plant population and use of competitive cultivars provide an ecological foundation for weed control, they are often insufficient under conditions of high weed pressure, labour scarcity and favourable climates for weed growth. In such situations, timely and judicious application of herbicides, especially during critical crop-weed competition periods, becomes essential to minimise yield losses. Research showed that integrating pre- and post-emergence herbicides with mechanical and manual weeding enhances weed control efficiency, crop competitiveness and resource-use efficiency. However, IWM effectiveness varies across regions due to differences in weed flora, soil type, rainfall and soil management practices. Continuous use of similar methods may also alter weed composition and increase herbicide resistance. Therefore, crop- and location-specific IWM modules, supported by monitoring, innovation and farmer awareness, are vital for environmentally sound and economically viable pulse production.

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