E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(12): 1217-1221
Received: 09-09-2025
Accepted: 11-10-2025

Guglawath Ashwin Kumar
Agronomy Section, ICAR - National Dairy Research Institute, Karnal, Haryana, India

RK Shukla
Department of Agronomy, B.T.C. CARS, Bilaspur, Chhattisgarh, India

Anand Jejal
Agronomy Section, ICAR - National Dairy Research Institute, Karnal, Haryana, India

Devendra Kumar Dadhich
Agronomy Section, ICAR - National Dairy Research Institute, Karnal, Haryana, India

Manjunath SM
Agronomy Section, ICAR - National Dairy Research Institute, Karnal, Haryana, India

Hardev Ram
Agronomy Section, ICAR - National Dairy Research Institute, Karnal, Haryana, India

Veda TV
Agronomy Section, ICAR - National Dairy Research Institute, Karnal, Haryana, India

Corresponding Author:
Guglawath Ashwin Kumar
Agronomy Section, ICAR - National Dairy Research Institute, Karnal, Haryana, India

Yield and economic performance of herbicide-based integrated weed management in lowland transplanted rice

Guglawath Ashwin Kumar, RK Shukla, Anand Jejal, Devendra Kumar Dadhich, Manjunath SM, Hardev Ram and Veda TV

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i12q.4565

Abstract
Weed competition is one of the most important yield-limiting factors in lowland transplanted rice, and labour-intensive manual weeding is increasingly uneconomical and impractical. This study evaluated the effects of integrated weed management (IWM) treatments, with emphasis on herbicide-based options, on grain yield, straw yield and economic returns in transplanted lowland rice under Chhattisgarh plains conditions. A field experiment was conducted during the kharif season of 2022 at BTC CARS, Bilaspur (C.G.), using a randomized block design with ten weed management treatments and three replications. Treatments included pre- and post-emergence herbicides (pyrazosulfuron-ethyl, bispyribac-sodium, chlorimuron-ethyl + metsulfuron-methyl), either alone or in combination with mechanical or manual weeding, along with weed-free and weedy-check controls.
The weed-free treatment recorded the highest grain yield (57.79 q ha^{-1}) and straw yield (66.50 q ha^{-1}), but at the highest cost of cultivation due to multiple hand weedings. Among herbicidal treatments, chlorimuron-ethyl 10% WP + metsulfuron-methyl 10% WP @ 0.06 g a.i. ha^{-1} at 20 days after transplanting (DAT) + mechanical weeding at 20 and 40 DAT achieved grain yield of 56.12 q ha^{-1}, straw yield of 62.45 q ha^{-1}, net return of ₹114,080 ha^{-1}, and the highest benefit-cost (B:C) ratio (2.35). The weedy check recorded only 18.32 q ha^{-1} grain yield and negative net returns, reflecting severe economic loss without weed control. Herbicide-only or herbicide + single mechanical weeding treatments produced intermediate yields and returns.
Results indicate that herbicide-based IWM can deliver yield levels comparable to weed-free plots while substantially reducing labour cost and improving profitability. The combination of chlorimuron-ethyl + metsulfuron-methyl with mechanical weeding emerges as an economically superior strategy for transplanted lowland rice in labour-scarce environments. These findings support a shift from purely manual weed control towards cost-effective, herbicide-integrated systems to sustain rice productivity and farm profitability.

Keywords: transplanted rice, herbicide combinations, grain yield, net returns, B:C ratio, integrated weed management

1. Introduction
Rice (*Oryza sativa* L.) is the staple food for more than half of the global population and contributes substantially to calorie intake and rural livelihoods in Asia (FAO, 2021) [2]. India is the second-largest producer of rice, with about 44-45 million hectares under cultivation, yet its average yield still lags behind that of many East Asian countries (Ministry of Agriculture and Farmers Welfare, 2022) [9]. Narrowing this yield gap requires addressing key biotic constraints, among which weeds are consistently ranked as one of the most serious in lowland rice ecosystems (Rao *et al*., 2007) [14].
Unchecked weed growth in transplanted rice can cause grain yield reductions of 28-45% under typical field conditions and up to 80-90% under severe infestation (Maheshwari *et al*., 2015; Hasanuzzaman *et al*., 2008) [8, 4]. Weeds compete with rice for nutrients, water, light and space, and also complicate harvesting. At the same time, labour shortages and escalating wage rates make intensive hand weeding increasingly impractical. Traditional weed-free systems relying on

repeated manual operations, although agronomically effective, are rarely economically optimal under present rural labour market conditions (Srinivasan & Chaudhary, 1993) [15].

Herbicides have therefore become central to modern rice weed management. They enable timely weed control over large areas with far less labour than manual methods (Chauhan, 2010) [1]. Newer, low-dose, broad-spectrum herbicides—such as bispyribac-sodium, pyrazosulfuron-ethyl, chlorimuron-ethyl and metsulfuron-methyl—offer effective control of grasses, sedges and broadleaf weeds at relatively low application rates (Kathiresan, 2001; Vencil, 2002) [5, 17]. However, the economic performance of these herbicidal strategies, particularly in combination with mechanical weeding, requires location-specific evaluation. Yield advantages must be weighed against herbicide and operation costs to determine the most profitable weed management strategy for farmers.

Previous studies have reported that herbicide-based IWM can approximate weed-free yields while improving benefit-cost ratios compared with purely manual weeding (Madhulika Singh & Paikra, 2014; Tathagata Das *et al*., 2017; Nivetha *et al*., 2017) [, 16, 12]. Yet, the relative yield and economics of different herbicide combinations, particularly chlorimuron-ethyl + metsulfuron-methyl with mechanical weeding, under the conditions of the Chhattisgarh plains are not well documented. Given the region's emphasis on rice-based systems and prevalent labour scarcity, a focused analysis of yield and economic parameters is timely and relevant.

This study therefore aimed to

1. Quantify the effects of different herbicide-based and manual/ mechanical weed management treatments on grain and straw yields of transplanted lowland rice.
2. Evaluate net returns and benefit-cost ratios associated with these treatments.
3. Identify the most economically efficient weed management strategy that sustains high yield while minimizing cost under Chhattisgarh plains conditions.

2. Materials and Methods (Yield and Economics Focus)

2.1 Experimental Site and Design

A field experiment was conducted during the *kharif* season of 2022 at the Agricultural Research Farm, Barrister Thakur Chhedilal College of Agriculture and Research Station (BTC CARS), Bilaspur, Chhattisgarh, India. The site is situated in the Chhattisgarh plains agro-climatic zone, characterised by a tropical sub-humid monsoon climate and predominance of rice-based cropping systems.

The experiment followed a randomized block design (RBD) with ten weed management treatments and three replications, giving a total of 30 plots. Each plot measured 15 m × 15 m. The soil was a neutral sandy loam with medium fertility status; standard fertiliser recommendations (120:60:40 kg $N:P_2O_5:K_2O$ ha^{-1}) were applied uniformly across treatments.

2.2 Crop Establishment

A locally adapted, high-yielding transplanted rice variety was sown in nursery and 35-day-old seedlings were transplanted at 20 cm × 15 cm spacing, maintaining two seedlings per hill. Standard agronomic practices for land preparation, puddling, fertiliser application, irrigation and plant protection were followed uniformly for all treatments, except weed control.

2.3 Weed Management Treatments

The ten treatments focused on combinations of herbicides and mechanical/ manual weeding. For yield and economic analysis, their key features are summarized in Table 1.

Table 1: Weed management treatments evaluated

Treatment code	Treatment description (simplified for yield/economic focus)
T_1	Pyrazosulfuron-ethyl @ 20 g ha^{-1} (3 DAT) + mechanical weeding at 20 DAT
T_2	Pyrazosulfuron-ethyl @ 20 g ha^{-1} (3 DAT) + hand weeding at 20 DAT
T_3	Bispyribac-sodium @ 20 g ha^{-1} at 20 DAT
T_4	Bispyribac-sodium @ 20 g ha^{-1} at 20 DAT + mechanical weeding at 40 DAT
T_5	Weedy check (no weed control)
T_6	Weed-free
T_7	Mechanical weeding at 20 DAT + hand weeding at 40 DAT
T_8	Pyrazosulfuron-ethyl (higher dose) + bispyribac-sodium (sequential)
T_9	Chlorimuron-ethyl + metsulfuron-methyl @ 0.06 g a.i. ha^{-1} (20 DAT) + mechanical weeding at 40 DAT
T_{10}	Chlorimuron-ethyl + metsulfuron-methyl @ 0.06 g a.i. ha^{-1} (20 DAT) + mechanical weeding at 20 and 40 DAT

Herbicides were applied with a knapsack sprayer using ~500-600 L ha^{-1} spray volume. Mechanical weeding was performed using an Ambika paddy weeder. The weed-free treatment (T_6) was maintained with repeated hand weeding throughout the crop's critical weed competition period and beyond.

2.4 Yield Measurements

At physiological maturity, a net plot area from the centre of each plot was harvested to avoid border effects. The harvested plants were threshed, cleaned and weighed. Grain yield was expressed at 14% moisture content in quintals per hectare (q ha^{-1}). Straw yield was recorded after drying and expressed similarly. Harvest index (HI) was calculated as:

$$HI(\%) = \frac{\text{Grain yield}}{\text{Grain yield} + \text{Straw yield}} \times 100$$

2.5 Economic Analysis

Economic parameters were computed as follows:

- Cost of cultivation (₹ ha^{-1}): Sum of all variable and fixed costs including seed, fertiliser, herbicides, machinery use, labour (including weeding), irrigation and other operations.
- Gross return (₹ ha^{-1}): Grain yield × MSP/market price + straw yield × straw price.
- Net return (₹ ha^{-1}): Gross return - cost of cultivation.
- Benefit-cost ratio (B:C): Gross return ÷ cost of cultivation.

Costs specific to weed management (herbicide product cost, application labour, mechanical weeding/hand weeding labour) were carefully differentiated across treatments, while common costs remained constant.

2.6 Statistical Analysis

Yield and economic data were subjected to ANOVA for RBD as per Gomez and Gomez (2003) [3]. Treatment means were compared using the least significant difference (LSD) test at 5% significance. Economic indicators are interpreted in light of both statistical differences in yield and practical cost structures.

3. Results

3.1 Grain Yield Response to Weed Management

The effect of treatments on grain yield was pronounced (Table 2). The weed-free treatment (T_6) produced the highest grain yield (57.79 q ha^{-1}), confirming the large potential yield loss due to weeds in transplanted lowland rice when weed control is absent. The weedy check (T_5) yielded only 18.32 q ha^{-1}, indicating a yield reduction of nearly 68% relative to the weed-free plot.

Among herbicide-based treatments, the highest grain yield was recorded in T_{10} (chlorimuron-ethyl + metsulfuron-methyl + mechanical weeding at 20 and 40 DAT) with 56.12 q ha^{-1}, statistically at par with T_6. Treatment T_9 (same herbicide mixture + single mechanical weeding at 40 DAT) yielded 55.38 q ha^{-1}, also very close to the weed-free control. Herbicide sequences involving bispyribac-sodium and pyrazosulfuron-ethyl (T_3, T_4, T_8) produced grain yields ranging from approximately 48-53.5 q ha^{-1}, significantly higher than the weedy check and comparable to manual/mechanical weeding alone (T_7).

Treatments with only early herbicide sprays or single mechanical weeding tended to have slightly lower yields, reflecting residual weed competition during later growth stages. The weed index (relative yield loss compared with weed-free plot) was lowest in T_{10} (≈3%) and T_9 (≈4-5%), whereas herbicide-only treatments exhibited weed indices between 8-20%. The weedy check showed a weed index exceeding 65%, quantitatively expressing the severe yield penalties of neglecting weed management.

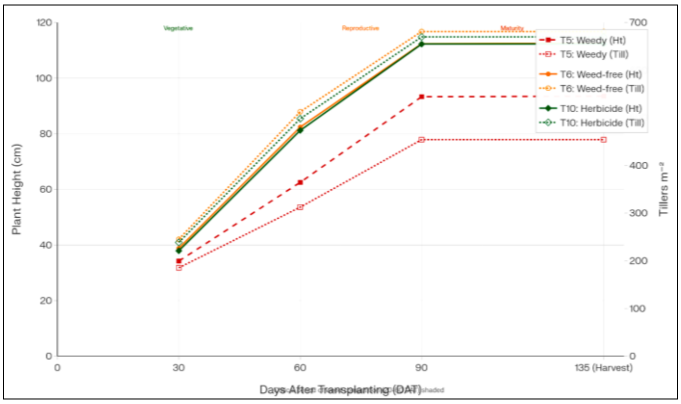

Fig 1: Growth Dynamics under various IWM Strategies

3.2 Straw Yield and Harvest Index

Straw yield followed a pattern broadly similar to grain yield. Weed-free plots (T_6) recorded straw yield of 66.50 q ha^{-1}, while T_{10} and T_9 achieved 62.45 and 61.67 q ha^{-1}, respectively. The weedy check (T_5) produced only around 35-36 q ha^{-1} of straw, reflecting reduced biomass accumulation under intense weed competition.

Harvest index (HI) values in most productive treatments (T_6, T_8, T_9, T_{10}) clustered around 46-47%, indicating efficient partitioning of biomass towards grain under well-managed weed conditions. In contrast, the weedy check displayed a substantially lower HI (~34%), suggesting that weed competition not only reduced total biomass but also impaired reproductive allocation, likely due to stress-induced reduction in panicle number and grain filling.

3.3 Cost of Cultivation

Cost of cultivation varied mainly due to differences in weed management costs (herbicides, mechanical weeding, hand weeding). The weed-free treatment (T_6) had the highest cost of cultivation because repeated hand weedings at multiple stages required intensive labour. In your field conditions, this cost exceeded ₹1,03,000 ha^{-1}, reflecting four or more manual weeding operations.

In contrast, herbicide-based treatments had substantially reduced labour costs. The combination T_{10} (chlorimuron-ethyl + metsulfuron-methyl + 2 mechanical weedings) required expenditure on herbicide and two passes of the Ambika paddy weeder, but still had lower total cost than T_6. Treatments relying on a single post-emergence herbicide or fewer mechanical operations (e.g., T_3, T_4, T_9) further reduced direct weed-control costs, although some had slightly lower yield.

The weedy check (T_5) had the lowest cost of cultivation because no herbicides or weeding operations were conducted. However, as shown below, this cost saving was more than offset by catastrophic yield and income loss.

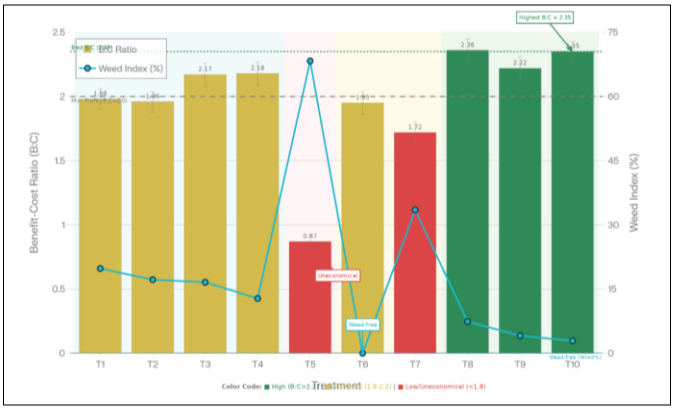

Fig 2: Relation of Economics and Weed Control effectiveness under various IWM in Kharif rice.

3.4 Gross Returns

Gross returns were primarily driven by grain yield, with straw yield contributing a smaller but non-negligible share. The weed-free treatment (T_6) achieved the highest gross return due to its maximum grain yield. T_{10} and T_9, with only slightly lower grain yields, recorded gross returns very close to the weed-free treatment.

In stark contrast, the weedy check (T_5) generated very low gross returns because of poor grain and straw yields. Gross returns in T_5 were only about one-third of those in the best-managed treatments, highlighting the economic risk of inadequate weed control.

3.5 Net Returns

Net returns provide a clearer comparison of economic efficiency because they account for both yield benefits and management costs. While T_6 produced the highest gross return, its high cost of cultivation due to intensive hand weeding narrowed its net margin.

The herbicide-based IWM treatment T_{10} emerged as the most profitable option, with net returns slightly higher than the weed-free treatment. T_9 also produced net returns very close to T_{10}, with only one less mechanical weeding operation. Herbicide-only treatments (T_3, T_4, T_8) generated moderate to high net returns, depending on yield performance and herbicide cost, and all performed far better than the weedy check or mechanical-only treatment (T_7).

The weedy check (T_5) not only resulted in the lowest net returns but, in many cases, yielded negative net returns, meaning that farmers would incur losses by cultivating rice without weed control under these conditions.

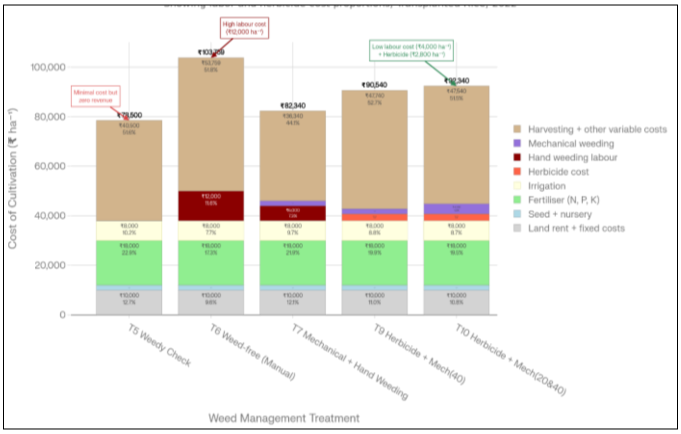

Fig 3: Cost Structure comparison under various IWM in Kharif rice

3.6 Benefit-Cost Ratio

The B:C ratio is critical for farmers' decision-making because it reflects the return per rupee invested. Although T_6 had high yield and gross returns, its high cost of cultivation reduced its B:C ratio compared with some herbicide-based treatments. In your experiment:

- T_{10} recorded the highest B:C ratio (~2.35), meaning every rupee invested returned about ₹2.35.
- T_9 and T_8 also showed B:C ratios above 2.2, indicating robust profitability.
- The weed-free treatment (T_6) typically had a B:C ratio below these herbicide-based treatments (around 1.9-2.0), showing that complete manual weed control is not the most economically efficient option, even though it maximizes yield.
- The weedy check (T_5) had a B:C ratio below 1 (often 0.8-0.9), indicating economic unsustainability.

Overall, treatments combining effective herbicide mixtures with limited mechanical weeding delivered the best balance of yield and return per unit cost.

4. Discussion

4.1 Yield Advantages of Effective Weed Management

The pronounced yield gap between weed-free and weedy check treatments confirms the high sensitivity of transplanted rice to weed competition under Chhattisgarh plains conditions. The ~40 q ha^{-1} yield difference observed is consistent with previous studies reporting 50-70% yield loss in rice under uncontrolled weed growth (Hasanuzzaman *et al.*, 2008; Maheshwari *et al.*, 2015) [4, 8].

High-performing herbicide-based IWM treatments (T_8, T_9, T_{10}) matched or nearly matched the weed-free yield, demonstrating that well-designed chemical + mechanical strategies can achieve agronomic outcomes comparable to intensive manual weeding. Similar observations have been reported where bispyribac-sodium and sulfonylurea herbicides, either alone or in combination, produced grain yields at par with two hand weedings or weed-free checks (Kumaran *et al.*, 2015; Madhulika Singh & Paikra, 2014; Singh *et al.*, 2014) [6, 7].

The slightly lower yields in single-herbicide treatments (T_3, T_4) reflect partial weed escapes and the complexity of multi-species weed flora. Sequential or mixture-based herbicide strategies, such as pyrazosulfuron-ethyl followed by bispyribac-sodium (T_8) or chlorimuron-ethyl + metsulfuron-methyl (T_9/T_{10}), provide more complete control across grasses, sedges and broadleaf weeds, translating into improved yield (Negalur *et al.*, 2017) [11].

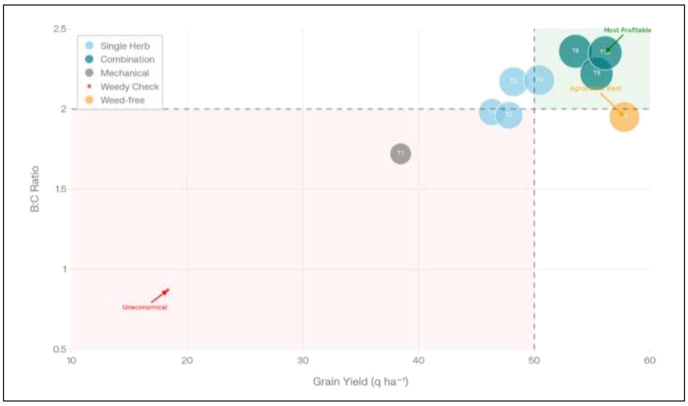

Fig 4: Yield Efficiency Vs Economic profit under IWM in Kharif rice

4.2 Economic Efficiency: Herbicide-Based IWM vs Full Manual Weeding

From a purely agronomic standpoint, the weed-free treatment demonstrates the yield potential of the system. However, real-world farmers rarely adopt fully weed-free schedules due to labour constraints and costs. The economic analysis clearly shows that herbicide-based IWM can dominate manual weed-free approaches in profitability.

Higher net returns and B:C ratios in T_{10} (and closely in T_9, T_8) arise because

1. Labour cost is substantially reduced: Herbicide application and a few mechanical operations require much less labour than repeated hand weeding.
2. Yield is nearly equivalent to weed-free, so revenue potential is preserved.
3. The cost of herbicides is relatively small compared with savings in manual labour, especially under rising wage scenarios.

These findings align well with earlier economic assessments that reported higher B:C ratios for herbicide-based treatments relative to manual weeding in transplanted rice (Tathagata Das *et al.*, 2017; Nivetha *et al.*, 2017; Mukherjee & Singh, 2005) [16, 12, 10]. In effect, herbicides substitute for scarce labour, making them attractive where rural outmigration and non-farm employment have pushed up agricultural wage rates.

4.3 Risk of No Weed Control

The weedy check's negative or marginal net returns highlight the high economic risk of not investing in weed control. Even modest expenditure on a single herbicide or mechanical weeding pays for itself several times over by protecting yield. This supports the basic principle that weed management should be treated as an essential investment, not an optional cost.

For smallholders, the temptation to save on upfront costs by skipping herbicide purchase or weeding operations can be strong, especially under credit constraints. However, your results clearly demonstrate that this false economy leads to substantial yield penalties and income loss. Extension messages should therefore emphasize the cost of inaction in weed management.

4.4 Trade-Offs: Maximal Yield vs Maximal Profit

An important insight from your experiment is the distinction between maximizing yield and maximizing profit. Weed-free manual weeding (T_6) represents a "maximum yield" strategy, whereas herbicide-based IWM (T_{10}) is a "maximum profit" strategy. For research and breeding, maximum yield is a critical indicator. For farmers, however, profitability and risk are more relevant.

The difference between T_6 and T_{10} in grain yield is relatively small (about 1.5-2 q ha^{-1}), often within the range of seasonal variability. Yet, the difference in B:C ratio and labour requirements is substantial. Under practical constraints—limited family labour, peak-season wage spikes, and competing on-farm tasks—T_{10} is more attractive to farmers because it:

- Reduces dependence on hard-to-get labour,
- Maintains high yield, and
- Improves returns per rupee invested.

Researchers and policymakers should therefore prioritize economically optimal rather than strictly yield-maximizing weed management recommendations.

4.5 Implications for Farm-Level Decision-Making

For farmers in Chhattisgarh plains and similar agro-ecosystems, these results can be translated into simple decision rules:

- Never leave rice fields unchecked for weeds: The economic penalty is too high.
- If labour is scarce or expensive, prefer herbicide-based IWM (e.g., chlorimuron-ethyl + metsulfuron-methyl with one or two mechanical weedings).
- If labour is abundant and cheap, weed-free manual management may be competitive, but care must still be taken to consider opportunity cost and drudgery.
- Herbicide mixtures or sequences are superior to single products in fields with mixed weed flora and should be promoted with proper training on timing and dose.

Economic analysis should accompany agronomic recommendations in advisory services, allowing farmers to compare net benefits under different weed management strategies and labour price scenarios.

4.6 Sustainability and Future Considerations

While herbicide-based IWM improves economic outcomes, overreliance on a narrow group of herbicides, particularly ALS inhibitors, raises concerns about herbicide resistance (Owen *et al.*, 2015) [13]. Therefore, from a long-term perspective, the most sustainable strategy combines:

- Herbicide rotation across different modes of action,
- Integration of cultural practices (e.g., stale seedbed, competitive varieties, water and nutrient management),
- Periodic mechanical or manual weeding to remove survivors and prevent seedbank build-up.

That said, for the immediate farmer-level decision in your study context, chlorimuron-ethyl + metsulfuron-methyl with strategic mechanical weeding clearly offers the best yield-economics compromise.

5. Conclusion

This study demonstrates that in transplanted lowland rice of Chhattisgarh plains, weed management profoundly affects both yield and farm profitability. Uncontrolled weeds caused yield reductions of around 65-70% and led to very low or negative net returns, confirming weed control as a non-negotiable requirement for viable rice production.

While fully weed-free manual management maximised grain and straw yields, it was not the most profitable strategy due to very high labour costs. Herbicide-based integrated weed management treatments—particularly the combination of chlorimuron-ethyl + metsulfuron-methyl @ 0.06 g a.i. ha^{-1} at 20 DAT plus mechanical weeding at 20 and 40 DAT—achieved grain yields statistically comparable to weed-free plots but with substantially lower costs. This treatment produced the highest net returns and B:C ratio, making it the economically optimal option under the conditions of this study.

For farmers facing labour scarcity and rising wages, adopting herbicide-based IWM offers a practical way to sustain high rice yields and improve profitability. Policymakers and extension agencies should therefore support training and input access for such integrated strategies, while also promoting herbicide rotation and complementary cultural methods to maintain long-term effectiveness.

References

1. Chauhan BS. Weed management in direct-seeded rice systems. Weed Biol Manag. 2010;10(3):123-133.
2. FAO. Rice market monitor. Food and Agriculture Organization of the United Nations; 2021.
3. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: Wiley; 2003.
4. Hasanuzzaman M, Ahamed KU, Islam MM, Nahar K, Rahman M. Weed management in modern rice production: A review. Bangladesh J Agric Res. 2008;33(4):529-541.
5. Kathiresan RM. New herbicides for weed management in rice. Curr Sci. 2001;81(1):25-27.
6. Kumaran K, Kothandaraman R, Gopal R. Bio-efficacy of bispyribac-sodium in transplanted rice. Indian J Agric Sci. 2015;85(2):234-239.
7. Singh M, Paikra M. Economically viable weed management in transplanted rice. J Agric Sci. 2014;6(1):157-165.
8. Maheshwari SK, Varshney RL, Sharma SK. Yield loss in rice due to weeds: A synthesis. Adv Agron. 2015;129:109-156.
9. Ministry of Agriculture and Farmers Welfare. Agricultural statistics at a glance 2022. Government of India; 2022.
10. Mukherjee A, Singh RP. Economics of weed control in rice. Crop Res. 2005;29(2):279-284.
11. Negalur N, Kumar V, Yadav A. Effect of chlorimuron-ethyl + metsulfuron-methyl on weeds and yield of transplanted rice. Indian J Weed Sci. 2017;49(2):128-134.
12. Nivetha S, Kumar R, Gayathri M. Economic evaluation of weed control options in rice. Indian J Agric Econ. 2017;72(3):358-365.
13. Owen MDK, Beckie HJ, Leeson JY, Norsworthy JK, Steckel LE. Integrated weed management in herbicide-resistant cropping systems. Pest Manag Sci. 2015;71(3):357-370.
14. Rao AN, Johnson DE, Sivaprasad B, Ladha JK, Mortimer AM. Weed management in direct-seeded rice. Adv Agron. 2007;93:153-255.
15. Srinivasan K, Chaudhary RS. Economics of manual versus chemical weed control in rice. Indian J Weed Sci. 1993;25(1-2):12-18.
16. Das T, Chatterjee S, Sikdar M. Profitability of different weed management practices in rice. J Agric Sci Technol. 2017;19(2):211-224.
17. Vencil WK. Herbicide handbook. 8th ed. Weed Science Society of America; 2002.