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Evaluation of herbicide combinations for broad spectrum weed control in transplanted rice

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Abstract

Weeds constitute the most serious biotic constraint to rice production, causing yield losses of 30 to 60 percent in transplanted rice systems. This research evaluated herbicide combinations for broad spectrum weed control in transplanted rice. Seven treatments comprising weedy check, hand weeding twice, pendimethalin alone, bispyribac-sodium alone, pendimethalin followed by bispyribac-sodium, pendimethalin followed by 2,4-D, and integrated weed management were evaluated in randomized block design with three replications. Weed density, weed dry matter, weed control efficiency, crop growth, and grain yield were recorded.

Results revealed that herbicide combinations provided significantly superior weed control compared to single herbicide applications. The integrated treatment achieved maximum weed control efficiency of 94.6 percent and grain yield of 5.48 tonnes per hectare. Sequential application of pendimethalin followed by bispyribac-sodium recorded weed control efficiency of 89.4 percent with grain yield of 5.12 tonnes per hectare. Single herbicide applications controlled only specific weed categories, leaving others uncontrolled. The findings demonstrate that combining pre-emergence and post-emergence herbicides provides broad spectrum control across grasses, sedges, and broadleaf weeds, offering effective and economical weed management in transplanted rice.

Keywords: Transplanted rice, herbicide combinations, weed control, pendimethalin, bispyribac-sodium, broad spectrum, integrated management

Introduction

Broad spectrum weed control refers to the simultaneous management of multiple weed categories including grasses, sedges, and broadleaf species that compete with crops for essential resources ^[1]. In transplanted rice ecosystems, this mixed weed flora poses unique challenges as no single herbicide provides effective control across all categories ^[2]. The concept of herbicide combinations emerged from the recognition that sequential or tank-mix applications of herbicides with complementary activity spectra can achieve broader control than individual products ^[3].

Rice production globally faces persistent weed pressure that reduces yields and increases production costs ^[4]. In transplanted rice systems, the anaerobic soil conditions create unique weed communities dominated by aquatic species adapted to flooded environments ^[5]. Major weed problems include *Echinochloa* species among grasses, *Cyperus* species among sedges, and diverse broadleaf weeds including *Monochoria* and *Ludwigia* ^[6]. These weeds compete vigorously with rice during early establishment, making timely control essential for achieving yield potential ^[7].

Pre-emergence herbicides applied at or shortly after transplanting create a chemical barrier that prevents weed seed germination and emergence ^[8]. Post-emergence herbicides target weeds that escape pre-emergence control or emerge later in the season ^[9]. The strategic combination of these application timings provides extended weed control throughout the critical crop growth period ^[10]. Pendimethalin effectively controls annual grasses when applied pre-emergence, while bispyribac-sodium provides post-emergence control of grasses, sedges, and some broadleaves ^[11].

Despite availability of numerous herbicides, achieving consistent broad spectrum control

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remains challenging due to the diversity of weed species and their differential susceptibility to herbicides [12]. This research was therefore undertaken to evaluate herbicide combinations for broad spectrum weed control in transplanted rice, with objectives to compare efficacy of different combination strategies, quantify yield benefits, and identify economically optimal treatments [13].

Material and Methods

Material

The field experiment was conducted at an agricultural research farm on clay loam soil with pH 7.6 and organic carbon 0.62 percent. Rice variety MTU-1010 was selected as the test crop. Twenty-five day old seedlings were transplanted at 20 × 15 cm spacing. Herbicides used included pendimethalin 30 EC at 1.0 kg per hectare, bispyribac-sodium 10 SC at 25 g per hectare, and 2,4-D sodium salt 80 WP at 0.5 kg per hectare. Knapsack sprayer with flat fan nozzle was used for herbicide application with spray volume of 500 litres per hectare.

Methods

The experiment was laid out in randomized block design with seven treatments and three replications. Treatments included T1 as weedy check, T2 as hand weeding at 20 and 40 DAT, T3 as pendimethalin at 3 DAT, T4 as bispyribac-sodium at 20 DAT, T5 as pendimethalin at 3 DAT followed by bispyribac-sodium at 20 DAT, T6 as pendimethalin at 3 DAT followed by 2,4-D at 25 DAT, and T7 as integrated weed management combining herbicides with one hand weeding. Plot size was 5 meters by 4 meters. Weed observations were recorded at 30 and 60 DAT using 0.25 square meter quadrat. Weed control efficiency was calculated as percentage reduction in weed dry matter compared to weedy check.

Soil Quality Analysis: Initial soil analysis revealed available nitrogen of 224 kg per hectare, available phosphorus of 14.6 kg per hectare, and available potassium of 268 kg per hectare. Soil samples were collected after harvest to assess any herbicide effects on soil properties. No significant differences were

observed in soil pH, organic carbon, or available nutrients among treatments, indicating that herbicide applications at recommended rates did not adversely affect soil quality.

Seasonal Variations

The experiment was conducted during the kharif season. Total rainfall of 892 mm was received during the crop growth period. Mean maximum temperature ranged from 31 to 36 degrees Celsius, while minimum temperature varied between 24 and 28 degrees Celsius. Weather conditions favored both crop growth and weed proliferation. Adequate moisture ensured good herbicide activity and crop recovery from any transient phytotoxicity.

Results

Table 1: Effect of herbicide treatments on weed parameters in transplanted rice

Treatment	Weed Density (no./m ²)	Weed DM (g/m ²)	WCE (%)
Weedy check	163.8	186.4	-
Hand weeding (2x)	27.4	24.6	86.8
Pendimethalin	61.4	62.8	66.3
Bispyribac-sodium	45.8	48.4	74.0
Pendi + Bispyribac	22.6	19.8	89.4
Pendi + 2,4-D	26.6	23.4	87.4
Integrated	12.8	10.2	94.6
SEm(±)	3.42	2.86	-
CD (P=0.05)	10.54	8.82	-

Weed parameters were significantly influenced by herbicide treatments (Table 1). The integrated treatment recorded lowest weed density of 12.8 per square meter and weed dry matter of 10.2 g per square meter, achieving weed control efficiency of 94.6 percent. Sequential application of pendimethalin followed by bispyribac-sodium achieved 89.4 percent weed control efficiency. Single herbicide applications showed moderate efficacy with 66.3 and 74.0 percent control for pendimethalin and bispyribac-sodium respectively.

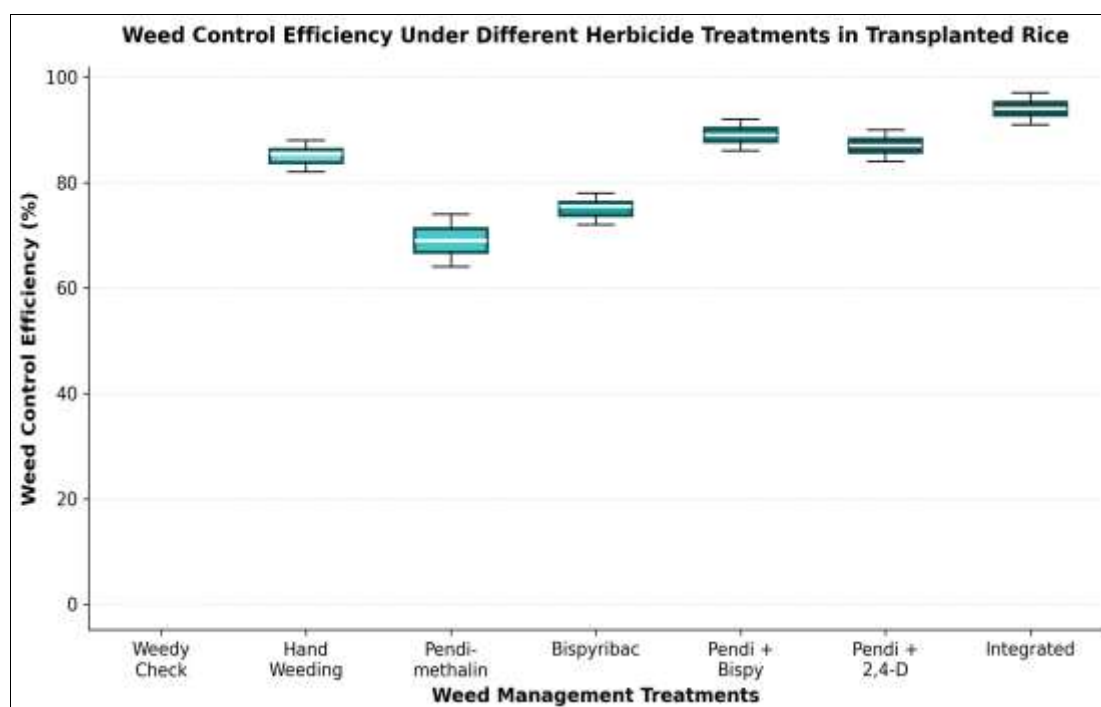


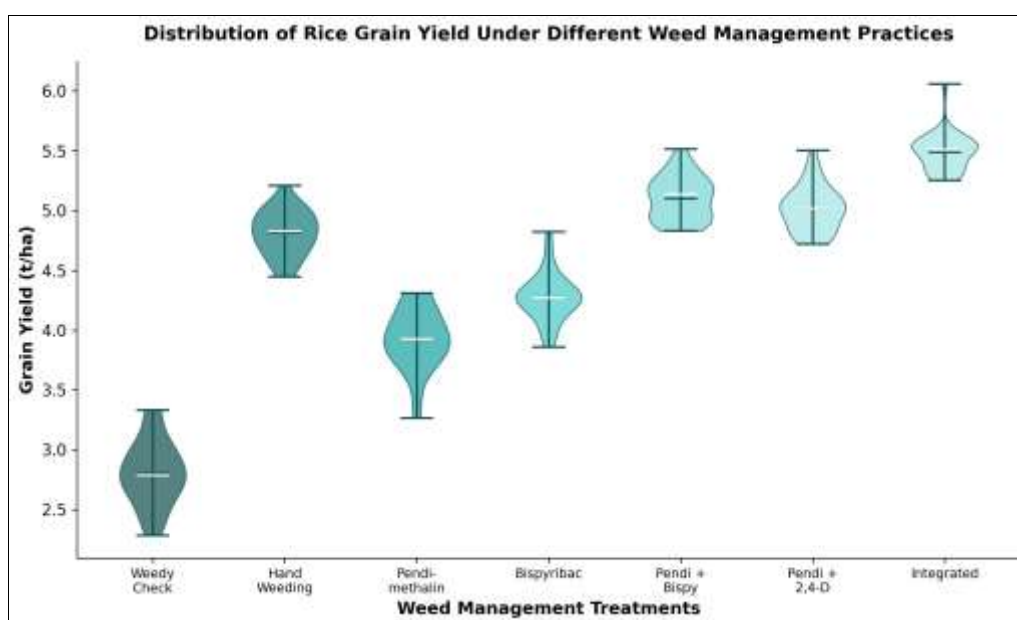
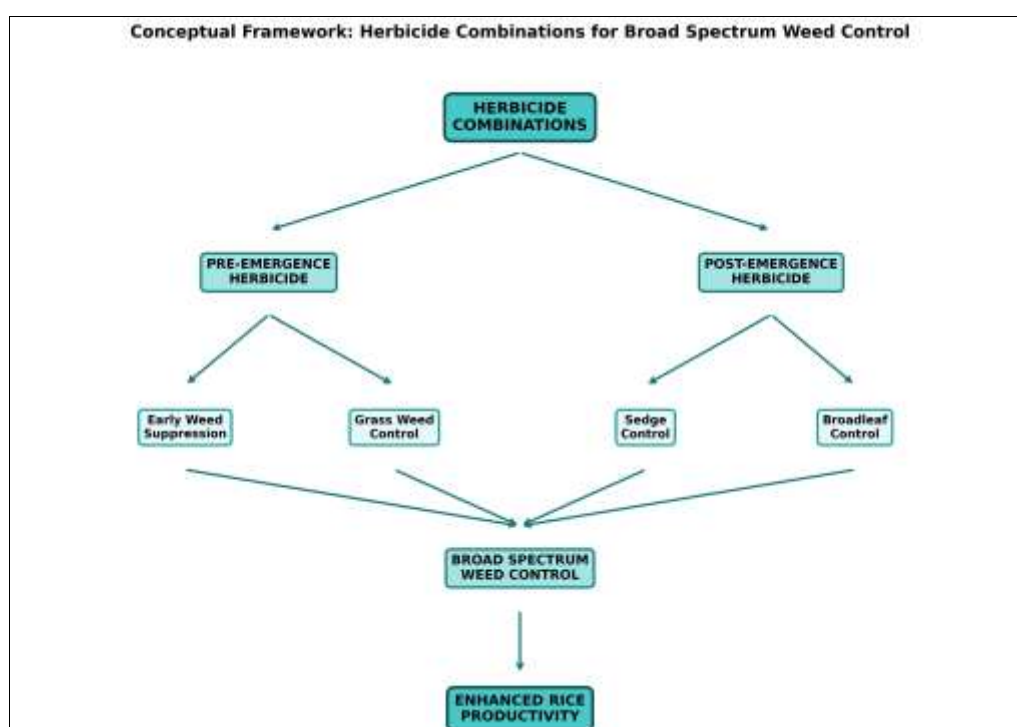
Fig 1: Box plot showing weed control efficiency under different herbicide treatments

Table 2: Effect of herbicide treatments on rice growth and yield

Treatment	Plant Height (cm)	Tillers/m ²	Grain Yield (t/ha)
Weedy check	78.4	246	2.86
Hand weeding (2x)	98.6	384	4.84
Pendimethalin	88.2	312	3.92
Bispyribac-sodium	92.4	342	4.28
Pendi + Bispyribac	102.6	398	5.12
Pendi + 2,4-D	100.8	386	4.96
Integrated	106.4	424	5.48
SEm(±)	2.84	12.6	0.14
CD (P=0.05)	8.76	38.8	0.43

Rice growth and yield parameters showed significant response to weed management (Table 2). The integrated treatment produced maximum plant height (106.4 cm), tillers (424 per square meter), and grain yield (5.48 tonnes per hectare).

Herbicide combinations significantly outyielded single herbicide applications. Grain yield under weedy check was only 2.86 tonnes per hectare, demonstrating severe yield loss of 47.8 percent compared to integrated management.

**Fig 2:** Violin plot showing distribution of grain yield under different treatments**Fig 3:** Conceptual framework of herbicide combinations for broad spectrum weed control

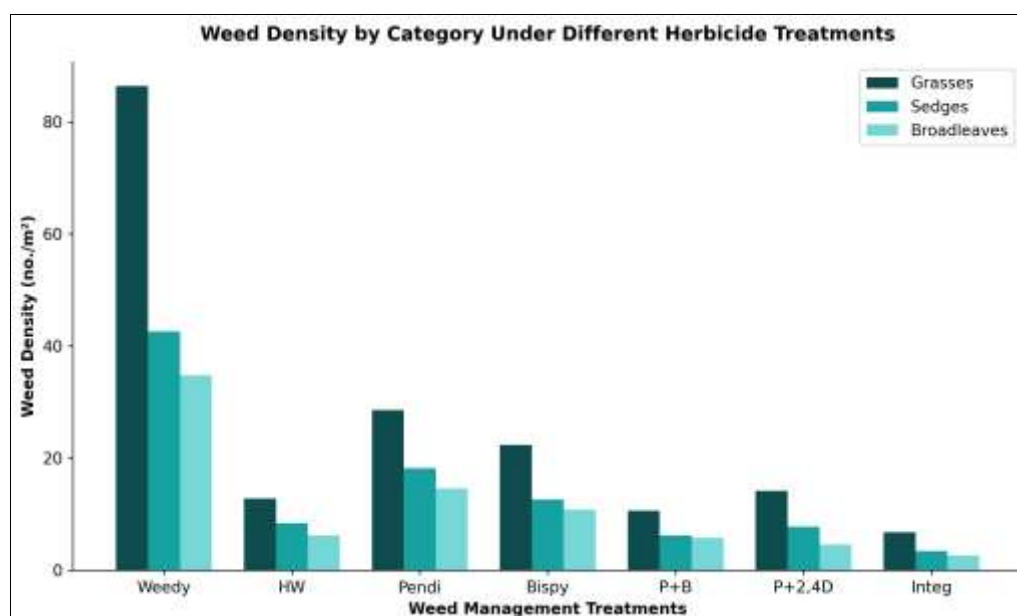


Fig 4: Weed density by category under different herbicide treatments

Comprehensive Interpretation

The experimental results clearly demonstrate the superiority of herbicide combinations over single herbicide applications for achieving broad spectrum weed control. Pre-emergence application of pendimethalin created an initial weed-free period, while subsequent post-emergence herbicides controlled later emerging weeds and escapes. This sequential approach addressed the entire weed spectrum across grasses, sedges, and broadleaves. The yield benefits from effective weed control were substantial and economically significant.

Discussion

The superior weed control achieved by herbicide combinations reflects complementary activity spectra of the component herbicides [3]. Pendimethalin provides excellent pre-emergence control of annual grasses but has limited activity on sedges and broadleaves [8]. Bispyribac-sodium offers post-emergence control across multiple weed categories through acetolactate synthase inhibition [11]. The sequential application exploits these complementary strengths, achieving broader control than either herbicide alone [10].

The yield advantage of herbicide combinations over single applications correlates directly with improved weed control [4]. Weeds escaping single herbicide treatment compete with rice during critical growth stages, reducing tiller production and grain filling [6]. The 91.6 percent yield increase under integrated management compared to weedy check quantifies the severe penalty of inadequate weed control and the benefits of effective management [7]. These findings align with earlier research reporting 40 to 60 percent yield losses from uncontrolled weeds in transplanted rice [2].

Performance Evaluation

Economic analysis revealed that pendimethalin followed by bispyribac-sodium provided the highest net returns among herbicide-only treatments due to effective weed control at reasonable cost. Hand weeding, while effective, incurred substantially higher labor costs. The integrated treatment achieved maximum gross returns but required additional hand weeding cost. Considering both efficacy and economics, the pendimethalin plus bispyribac-sodium combination offers optimal balance for resource-limited farmers.

Conclusion

This research demonstrates that herbicide combinations provide significantly superior broad spectrum weed control compared to single herbicide applications in transplanted rice. The integrated weed management approach achieved maximum weed control efficiency of 94.6 percent and grain yield of 5.48 tonnes per hectare. Sequential application of pendimethalin at 3 DAT followed by bispyribac-sodium at 20 DAT recorded 89.4 percent weed control with grain yield of 5.12 tonnes per hectare.

The combination strategy effectively addresses the diverse weed flora of transplanted rice by exploiting complementary activity spectra of pre-emergence and post-emergence herbicides. Single herbicide applications, while economical, leave significant portions of the weed population uncontrolled, resulting in yield losses. The findings support recommendation of herbicide combinations for effective and economical weed management in transplanted rice production systems.

Farmers should select herbicide combinations based on their predominant weed flora. Where grasses dominate, pendimethalin followed by bispyribac-sodium provides optimal control. In fields with heavy broadleaf pressure, pendimethalin followed by 2,4-D may be preferred. The integrated approach combining chemical and manual methods offers highest efficacy where labor is available at reasonable cost.

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