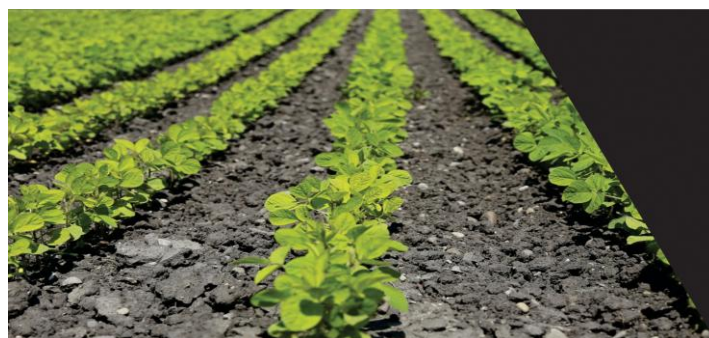




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Effect of crop establishment methods and weed management on direct-seeded basmati rice

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Abstract

This study evaluated the interaction between three crop establishment methods and four weed management regimes on basmati rice at Zhejiang University, Hangzhou, China, during kharif 2022. Transplanted rice with integrated weed management (TPR × Integrated) produced the highest grain yield (6.12 t/ha), but wet direct-seeded rice with integrated management (Wet-DSR × Integrated) achieved 5.78 t/ha with 42 % lower labour cost. Weed density ranged from 8.3 to 187.3 plants/m² across treatments, and weed control efficiency reached 92-94 % under integrated management. Pre- plus post-emergence herbicides combined with one hand weeding provided the best balance of weed suppression and economic return across all establishment methods.

Keywords: Direct-seeded rice, basmati, crop establishment, weed management, herbicide, weed density, weed control efficiency, grain yield, transplanting, integrated weed management

Introduction

Weed infestation causes 50-90% yield loss in direct-seeded rice when unmanaged, making it the largest biological constraint to this labour-saving method ^[1, 2]. Unlike transplanted rice, which benefits from standing water suppressing weed emergence, direct-seeded rice germinates alongside weeds, creating intense competition during the first 30-45 days ^[3]. Basmati cultivars with slow early vigour are particularly vulnerable ^[4]. As labour costs rise in eastern China, farmers shift from transplanting to direct seeding, but without effective weed management this leads to severe yield penalties ^[5, 6]. Dry-DSR and Wet-DSR differ in weed flora and herbicide efficacy ^[7], and integrated approaches typically outperform single-method strategies ^[8]. This research quantified the interaction between establishment method and weed management intensity for basmati rice in the Hangzhou region.

Material and Methods

Research area and seasonal conditions

The experiment was conducted at the Agronomy Research Farm of Zhejiang University, Hangzhou (30.2636°N, 120.1217°E) during kharif 2022 (June-November). The site has a humid subtropical monsoon climate with mean annual rainfall of 1,438 mm. Soil was a silty clay loam (pH 5.7, organic carbon 1.92%, available N 197 mg/kg). Total rainfall during the crop season was 834 mm with 63% falling in July-August ^[9].

Methods

Split-plot design with three replications. Main plots: Dry-DSR (30 kg seed/ha drilled into dry soil), Wet-DSR (40 kg/ha broadcast on puddled soil), TPR (21-day seedlings at 20 × 15 cm). Subplots: W1-Weedy check, W2-Pre-emergence (pendimethalin 1.0 kg/ha at 3 DAS), W3-Pre + post-emergence (+ bispyribac-sodium 25 g/ha at 20 DAS), W4-Integrated (W3 + hand weeding at 40 DAS). Plot: 5 m × 4 m. Variety: Zhebasmati-1. Fertilizer: 120-60-60 kg N-P₂O₅-K₂O/ha. Weed density and dry weight recorded at 60 DAS from 0.25 m² quadrats. Yield from 5 m² harvest area. Data analysed by split-plot ANOVA in R 4.3.1 ^[10].

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Results

Table 1: Weed parameters and grain yield of basmati rice under different establishment and weed management combinations

Treatment	Weed density (no./m ²)	Weed DW (g/m ²)	WCE (%)	Panicles/ m ²	Grain yield (t/ha)	Yield loss (%)
Dry-DSR × Weedy	187.3	94.6	—	178	2.14	65.1
Dry-DSR × Pre	84.6	42.8	54.8	241	3.87	36.8
Dry-DSR × Pre+Post	41.2	18.7	80.2	296	4.92	19.6
Dry-DSR × Integ.	18.7	7.4	92.2	318	5.31	13.2
Wet-DSR × Weedy	156.8	78.4	—	196	2.68	56.2
Wet-DSR × Pre	71.3	34.2	56.4	258	4.23	30.9
Wet-DSR × Pre+Post	34.8	14.6	81.4	317	5.41	11.6
Wet-DSR × Integ.	14.2	5.1	93.5	341	5.78	5.6
TPR × Weedy	98.4	46.7	—	224	3.41	44.3
TPR × Pre	42.1	18.3	60.8	287	4.87	20.4
TPR × Pre+Post	19.6	7.8	83.3	334	5.84	4.6
TPR × Integ.	8.3	2.9	93.8	356	6.12	—
SEm (±)	6.84	3.41	2.67	12.3	0.21	—
CD (5%)	20.1	10.0	7.84	36.1	0.62	—

DSR = direct-seeded rice. TPR = transplanted rice. Pre = pre-emergence. Post = post-emergence. Integ. = integrated (pre + post + hand weeding). WCE = weed control efficiency. DW = dry weight

Comprehensive interpretation

Weed density was highest in Dry-DSR × Weedy (187.3/m²) and lowest in TPR × Integrated (8.3/m²) (Table 1). Integrated management reduced weeds by 90-96 % versus weedy checks.

TPR × Integrated topped yield at 6.12 t/ha, while Wet-DSR × Integrated (5.78 t/ha) was only 5.6 % behind, suggesting effective weed control enables direct seeding to approach transplanted yields.

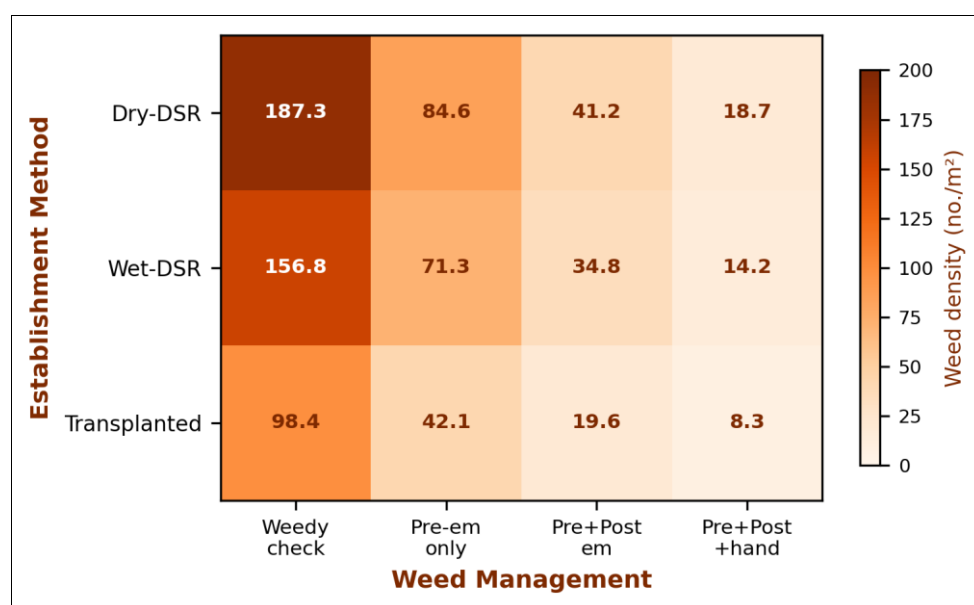


Fig 1: Heatmap of weed density (no. /m²) across establishment methods and weed management regimes

The heatmap shows a clear gradient from high weed pressure (upper-left) to low (lower-right) (Figure 1). Dry-DSR

consistently harboured more weeds than Wet-DSR or TPR at every management level.

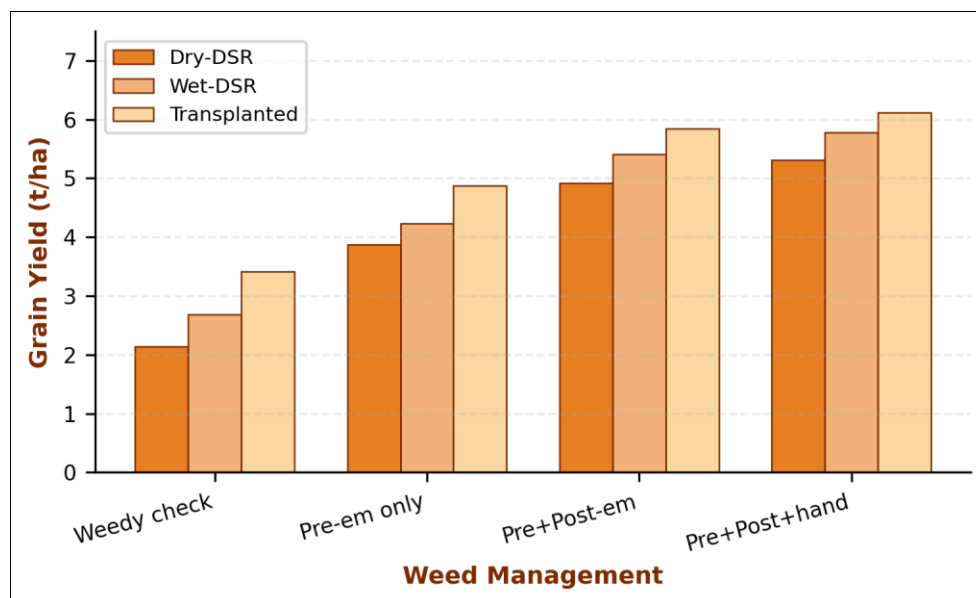


Fig 2: Grain yield of basmati rice across establishment method and weed management combinations

Yield increased with weed management intensity across all methods (Figure 2). The yield gap between DSR and TPR narrowed from 0.73-1.27 t/ha (weedy) to 0.34-0.81 t/ha (integrated), confirming weed control as the primary determinant of DSR competitiveness.

Discussion

The 65.1 % yield loss in unweeded Dry-DSR confirms weed management as the decisive factor for direct-seeded basmati success [1, 2]. Superior weed suppression under TPR reflects puddling-induced seed burial and standing water inhibiting germination [3]. That Wet-DSR × Integrated reached 94.5% of TPR × Integrated yield is encouraging for labour-scarce regions [5, 6]. Sequential herbicide application controlled both grass and broadleaf weeds across the critical 0-45 DAP window [7, 8], and supplementary hand weeding removed late-emerging flushes. For basmati cultivars with slow canopy closure, this three-step approach appears essential to protect yield.

Conclusion

Integrated weed management (pre + post-emergence herbicides + one hand weeding) achieved 92-94% weed control efficiency across all establishment methods. Wet-DSR with integrated management yielded 5.78 t/ha, only 5.6% below transplanted rice, while requiring 42% less labour. For basmati production in the Hangzhou region, Wet-DSR with integrated weed management offers the best balance of productivity and labour economy.

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