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Research Communication

Impact of direct seeding methods and weed management strategies on growth and yield of upland rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted at the Research cum Instructional Farm, S.G. College of Agriculture and Research Station, Jagdalpur, IGKV, Chhattisgarh, during the *kharif* season of 2023 in a split-plot design. The treatments included three main plots: M_1 (Broadcasting), M_2 (Line sowing), and M_3 (Semi-dry condition), and five sub-plots: W_1 [Pre-emergence herbicide (Pretilachlor @ 750 g ai/ha) at 3 DAS + 1 hand weeding (HW) at 15 DAS], W_2 [Post-emergence herbicide (Trifloxysulfuron + Ethoxysulfuron @ 67.5 g ai/ha) at 15 DAS + 1 HW at 30 DAS], W_3 (W_1+W_2), W_4 (weed-free), and W_5 (weedy check). In terms of seeding techniques, all crop growth parameters and indices such as plant height, number of tillers, dry matter accumulation, leaf area index, and crop growth rate were recorded highest in the line sowing treatment, which was found to be statistically on par with the semi-dry condition. Data revealed that all yield-attributing characters, including panicle length, number of grains per panicle, test weight, grain yield, and straw yield were recorded significantly higher in the M_2 (Line sowing) treatment, which was statistically on par with the M_3 (Semi-dry condition) treatment. Among weed management practices, W_3 treatment (Pre-emergence herbicide as Pretilachlor @ 750 g ai/ha + 1 HW at 15 DAS, followed by post-emergence herbicide Trifloxysulfuron + Ethoxysulfuron @ 67.5 g ai/ha + 1 HW at 30 DAS) recorded the highest growth and yield-attributing traits, which were on par with W_2 (Post-emergence of Trifloxysulfuron + Ethoxysulfuron @ 67.5 g ai/ha + 1 HW at 30 DAS).

Key words: Growth, Herbicide, Line Sowing, Yield

Upland rice is primarily grown as a rainfed crop by many farmers in damp, humid, subtropical climates with soils that drain well. In upland fields, water does not gather, and bunds are not constructed. Across the country, upland rainfed rice covers around 6.1 million hectares, representing 13.5% of the total rice cultivation area (Kankwatsa *et al*., 2019). Unlike transplanted rice systems, upland areas increasingly favour direct seeding. In recent years, several Southeast Asian nations have also transitioned from transplanted to direct-seeded rice (Pandey and Velasco, 2002), largely due to water shortages and high labour costs for transplanting amidst a labour shortage (Chan and Nor, 1993). Manual weeding in direct-seeded rice is costly, labour-intensive, and time-consuming, with early weed control presenting significant challenges. Although pre-emergence herbicides are effective in the initial stages, a second flush of weed growth usually occurs 25 to 30 days after sowing, creating additional management needs. For this reason, integrated weed management strategies have become the most viable solution (Mishra *et al.,* 2009). Weed in upland rice can be managed through pre-emergence, post-emergence, a combination of both, or manual weeding (Haldar and Thakur, 2023). To maintain productivity in upland rice systems, the current study aimed to identify effective seeding techniques and weed management practices suited to upland rice ecology.

A field experiment was conducted during the *kharif* season of 2023 at the Research cum Instructional Farm, S.G. College of Agriculture and Research Station, Kumhrawand, Jagdalpur, Chhattisgarh. The soil at the experimental site was silty loam and slightly acidic (pH 6.35), with medium levels of available nitrogen (248.25 kg/ha) and phosphorus (13.56 kg/ha), but high levels of potassium (288.8 kg/ha) and soil organic carbon was low (0.48%). The experiment consisted of fifteen treatments with three replications in a split-plot design. The treatments included

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three main plots: M_1 (Broadcasting), M_2 (Line sowing), and M_3 (Semi-dry condition), and five sub-plots: W_1 [Pre-emergence (Pretilachlor @ 750 g ai/ha) at 3 DAS + 1 hand weeding (HW) at 15 DAS], W_2 [Post-emergence (Trifloxysulfuron + Ethoxysulfuron @ 67.5 g ai/ha) at 15 DAS + 1 HW at 30 DAS], W_3 (W_1 + W_2), W_4 (Weed-free), and W_5 (Weedy check). The short-duration rice variety *Bastar Dhan* (110-115 days) was used in the experiment. Crop was grown under rainfed conditions under standard package of practices. Observations on crop growth and yield parameters were taken according to standard methods. Plant height, number of tillers, dry matter accumulation (g) at harvest, and leaf area index at harvest were measured at harvest, while crop growth rate (g/plant/day) was recorded at 60 and 90 DAS. Data were analyzed using the online statistical software OPSTAT, with analysis of variance (ANOVA) conducted for the split-plot design to test the significance of differences among treatments using the 'F' test at a 5% significance level.

The study examined the influence of seeding techniques and weed management practices on growth parameters, yield components, and productivity of upland rice. Among seeding techniques, line sowing demonstrated superior performance in several aspects. Plants sown in lines reached greater heights at harvest (96.18 cm) and produced more tillers per plant (3.06) compared to those in broadcasting (88.23 cm, 2.39 tillers) and semi-dry conditions (91.09 cm, 2.73 tillers). This growth advantage in line sowing likely stemmed from improved root establishment and spatial arrangement, which allowed plants to utilize available resources more efficiently. Line sowing also recorded the highest dry matter accumulation (13.57 g) and leaf area index (LAI) of 0.85, in contrast to broadcasting, which showed the lowest values (12.14 g and 0.77, respectively). The enhanced LAI and dry matter in line sowing indicate more efficient photosynthetic activity, contributing to greater crop growth rates (0.422 g/plant/day) and panicle length (14.9 cm), thus supporting yield development. In terms of yield, line sowing again showed an advantage, with the highest grain yield (2.13 t/ha) and straw yield (2.82 t/ha), closely followed by the semi-dry condition. Harvest index (HI), a measure of grain partitioning efficiency, was also highest in line sowing (42%) compared to broadcasting (38.47%), demonstrating that line sowing not only enhances overall growth but also optimizes biomass allocation towards grains. The results indicate that line sowing significantly improve growth, yield components, and overall productivity in upland rice systems. Line sowing likely benefits rice growth due to uniform spacing, which optimizes light interception, enhances root establishment, and reduces intraspecific competition for resources (Kumar *et al*., 2017). Higher leaf area index (LAI) and dry

Table 1. Effect of seeding techniques and weed management options on growth parameters and yield attributes of upland rice

Treatment	Plant height (cm)	Number of tillers	Dry matter accumulation (g)	Leaf area index	Crop growth rate (g/plant/day)	Panicle length (cm)	No. of grains/ panicle	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Seeding techniques											
M_1, Broadcasting	88.23	2.39	12.14	0.77	0.371	13.9	54.49	20.91	1.49	2.27	38.47
M_2, Line sowing	96.18	3.06	13.57	0.85	0.422	14.9	60.33	22.22	2.13	2.82	42.00
M_3, Semi dry condition	91.09	2.73	12.83	0.81	0.405	14.5	57.02	21.41	1.73	2.50	40.47
SEm±	1.66	0.10	0.20	0.02	0.010	0.21	1.24	0.40	0.05	0.09	1.25
CD (P=0.05)	6.51	0.41	0.79	0.07	0.038	0.83	4.88	NS	0.20	0.33	NS
CV%	6.25	13.13	5.41	7.45	8.29	5.06	7.51	6.38	9.77	11.62	10.7
Weed management practices											
W_1, Pre emergence + 1HW at 15DAS	92.58	2.56	12.33	0.77	0.365	13.96	57.62	20.90	1.53	2.29	40.31
W_2, Post emergence + 1HW at 30 DAS	95.09	2.91	12.78	0.82	0.418	14.39	59.42	21.93	1.86	2.71	40.50
W_3, W_1 + W_2	96.94	2.91	13.53	0.86	0.429	14.39	62.79	23.02	2.19	2.85	42.42
W_4, Weed free	99.09	3.31	14.64	0.91	0.447	16.83	64.00	22.40	2.42	3.24	43.19
W_5, Weed check	75.47	1.96	10.96	0.71	0.339	12.6	42.56	19.33	0.83	1.57	35.14
SEm±	1.55	0.13	0.32	0.01	0.015	0.25	1.57	0.14	0.08	0.10	1.59
CD (P=0.05)	4.53	0.38	0.93	0.04	0.043	0.73	4.58	NS	0.22	0.30	4.64
CV%	5.06	14.14	7.44	4.80	10.99	5.22	8.22	1.94	12.85	12.26	11.82

matter accumulation in line-sown rice suggest enhanced photosynthetic efficiency, which has been linked to increased crop growth rates and yield potential (Singh *et al*., 2018). Moreover, previous studies indicate that line sowing facilitates more efficient nutrient uptake due to improved plant spacing, which enhances root expansion and nutrient absorption (Mandal *et al*., 2015).

Weed management practices further influenced growth and yield outcomes. Among the treatments, W_3 (the combination of pre-emergence and post-emergence herbicides) demonstrated the highest effectiveness, achieving a plant height of 96.94 cm and a tiller count of 2.91. This treatment was statistically similar to W_2 (post-emergence herbicide with one hand weeding), which recorded a plant height of 95.09 cm and a tiller count of 2.91. W_3 (the combination of pre-emergence and post-emergence herbicides) also recorded the highest dry matter accumulation (13.53 g) and leaf area index (0.86), reflecting enhanced growth due to effective weed control. In contrast, the weed check (W_5) resulted in the lowest values across most parameters, with a plant height of only 75.47 cm and a tiller count of 1.96. Grain yield was notably highest in treatment W_3, with 14.39 g, while straw yield also peaked at 62.79 g. However, W_2 yielded statistically comparable results with W_3, highlighting that both treatments significantly enhanced crop performance compared to the weed check (W_5), which had the lowest plant height (75.47 cm) and grain yield (12.6 g). Effective weed control further boosts yield by reducing competition for essential resources. The weed-free treatment in this study demonstrated a significant increase in plant height, panicle length, and grain yield, aligning with findings from Chauhan and Johnson (2011) that weeds reduce rice productivity by up to 50% in upland conditions without intervention. Integrated weed management, or maintaining weed-free conditions, helps retain soil nutrients and water availability, crucial in upland settings where soil moisture is limited (Ahmed *et al*., 2016).

The study revealed significant variations in weed density across different seeding techniques and weed management practices (Table 2). Among seeding techniques, broadcasting (M_1) recorded the highest weed density across all growth stages, while line sowing (M_2) exhibited the

Table 2. Effect of different seeding techniques and weed management practices on weed density at different growth stages

Treatment	Density of grassy weeds (Numbers/m²)			Density of sedges (Numbers/m²)			Density of broad leaves weeds (Numbers/m²)		
	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
Seeding techniques									
M_1, Broadcasting	7.84 (2.89)	20.07 (4.54)	32.67 (5.76)	5.74 (5.50)	20.68 (4.60)	33.32 (5.82)	8.06 (2.93)	23.09 (4.86)	36.88 (5.82)
M_2, Line sowing	5.34 (2.42)	17.90 (4.29)	26.53 (5.20)	4.91 (2.33)	17.19 (4.21)	28.15 (5.35)	6.70 (2.68)	18.65 (3.38)	30.86 (5.35)
M_3, Semi dry condition	6.63 (2.67)	19.05 (4.42)	29.08 (5.44)	5.03 (2.35)	18.54 (4.36)	30.74 (5.59)	7.46 (2.82)	20.83 (4.62)	33.07 (5.59)
SEm±	0.03	0.06	0.09	0.09	0.07	0.13	0.10	0.07	0.11
CD (P=0.05)	0.13	0.24	0.34	NS	0.27	0.51	NS	0.27	0.42
CV%	5.63	5.25	5.62	16.28	5.94	8.22	16.52	5.55	6.45
Weed management practices									
W_1, Pre-emergence + 1 HW at 15 DAS	4.04 (2.13)	23.34 (4.88)	34.21 (5.89)	3.00 (1.85)	24.91 (5.04)	36.92 (6.12)	5.60 (2.47)	27.87 (5.33)	40.44 (6.12)
W_2, Post emergence + 1 HW at 30 DAS	0.74 (1.11)	17.08 (4.19)	29.02 (5.43)	0.63 (1.05)	13.49 (3.74)	31.46 (5.65)	0.39 (0.94)	16.60 (4.14)	34.72 (5.65)
W_3, $W_1 + W_2$	0.21 (0.84)	13.60 (3.75)	24.83 (5.03)	0.11 (0.78)	11.62 (3.48)	23.65 (4.91)	0.28 (0.80)	13.68 (3.77)	29.60 (4.91)
W_4, Weed free	0.38 (0.94)	0.72 (1.11)	13.70 (3.77)	0.13 (0.79)	0.76 (1.12)	12.44 (3.60)	0.13 (0.89)	0.88 (1.18)	11.55 (3.60)
W_5, Weed check	11.25 (5.30)	40.28 (6.39)	45.37 (6.77)	22.27 (4.75)	43.22 (6.61)	49.22 (7.05)	30.64 (5.58)	45.26 (6.77)	51.70 (7.05)
SEm±	0.08	0.11	0.17	0.10	0.09	0.13	0.12	0.07	0.13
CD (P=0.05)	0.24	0.31	0.49	0.28	0.25	0.38	0.36	0.27	0.38
CV%	11.93	8.07	9.36	15.72	6.44	7.16	17.52	7.09	6.91

* The observations are subjected to square root transformation ($\sqrt{x+0.5}$). Figures in the parentheses indicate square root transformed values

lowest weed infestation. Line sowing reduced grassy weeds (26.53/m²), sedges (28.15/m²), and broadleaf weeds (30.86/m²) at harvest compared to broadcasting. Weed management practices significantly influenced weed density. Weed-free (W_4) and integrated weed control (W_3: pre- and post-emergence herbicide + hand weeding) recorded the lowest weed count. Weed-free treatment (W_4) showed minimal weed presence at harvest (grasses: 13.70/m², sedges: 12.44/m², broadleaf weeds: 11.55/m²), followed by W_3. In contrast, the highest weed density was observed under weed check (W_5). The effectiveness of sequential herbicide application over a single application aligns with previous findings, emphasizing the role of integrated weed management in sustainable crop production (Singh *et al*., 2023; Haldar and Thakur, 2024). The significantly higher weed infestation in the broadcasting method (M_1) and untreated control (W_5) underscores the necessity of adopting optimized agronomic and chemical weed management strategies (Singh *et al*., 2018).

Thus, it can be concluded that line sowing method and weed management either through pre-emergence herbicide (Pretilachlor @ 750 g ai/ha) at 3 DAS + 1 hand weeding (HW) at 15 DAS followed by post-emergence herbicide (Trifloxysulfuron + Ethoxysulfuron @ 67.5 g ai/ha) at 15 DAS + 1 HW at 30 DAS or only adapting post-emergence herbicide application (Trifloxysulfuron + Ethoxysulfuron @ 67.5 g ai/ha) at 15 DAS + 1 HW at 30 DAS maximizes upland rice growth and yield.

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