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Impact of sowing time and integrated weed management approaches on weed dynamics, crop growth and yield in dry-direct seeded rice

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Abstract

A field experiment was conducted at G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India, during the *Kharif* seasons of 2023 and 2024 to evaluate the impact of different sowing time and weed management approaches on weed flora and crop yield of dry direct-seeded rice. The experiment was laid out under split plot design with three main plots and five sub plots and replicated thrice. The treatments comprised of three sowing dates (1st June, 10th June, and 20th June) and five weed management treatments viz., W₁- Pendimethalin 38.7 CS 678 g/ha (PE) *fb* penoxsulum 1.02% w/w + cyhalofop-butyl (RM) 5.17 w/w OD 135 g/ha (PoE), W₂-Pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) 785 g/ha (PE) *fb* penoxsulum 21.7% SC 93.7 g/ha (PoE) *fb* one hand weeding at 40 DAS, W₃-Penoxsulum 1% + pendimethalin 24% (RM) 625 g/ha (PE) *fb* bispyribac sodium 10% EC 25 g/ha (PoE), W₄- Three manual hand weeding at 20, 40 and 60 DAS and W₅-Weedy check. The experimental results revealed that the least weed density, weed dry weight and highest weed control efficiency was observed at 60 DAS and at harvest stage, (92.03 and 87.27% in 2023; 91.44 and 90.32% in 2024), respectively, with sowing on 20th June as compared to earlier sowing dates on 1st June and 10th June. Among weed management strategies, integrated treatment consisting of pre-emergence application of pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) 785 g/ha followed by post-emergence penoxsulam 21.7% SC 93.7 g/ha followed by one hand weeding at 40 DAS recorded lowest total weed density and dry weight while achieved higher weed control efficiency (97.35 and 92.84% in 2023; 97.74 and 96.09% in 2024) at 60 DAS and harvest stage, respectively. Effective weed suppression under this combination of sowing time with integrated weed management treatment resulted in more tiller survival, higher panicle density and higher crop yield (5.41 t/ha in 2023 and 6.37 t/ha in 2024). The number of panicles per square meter was significantly higher under 20th June sowing combined with integrated weed management, while the weedy check recorded more than 60% reduction in panicle number due to severe weed competition. The study highlights that optimum sowing time coupled with integrated weed management is crucial for minimizing weed interference and improving productivity of dry direct-seeded rice under *Kharif* conditions.

Keywords: Dry-direct seeded rice, wet-direct seeded rice, sowing time, ready mix herbicides, integrated weed management

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops globally. It serves as the primary staple food for more than half of the world's population. It is cultivated across diverse agro-ecological regions and plays a vital role in food security, particularly in Asia. It is estimated that global rice production will reach about 541.66 million metric tons in 2024-25, grown on nearly 172.54 million hectares of land (USDA, 2026) [23]. Among all countries, India and China are the leading producers. Together, they contribute a major share of global production of rice. India is currently the largest rice producer in the world, producing around 150 million metric tons of rice from about 51.42 million hectares during 2024-25 (USDA, 2026) [24].

In India rice is typically cultivated by traditional puddled transplanted method, which involves raising a nursery from seeds and then planting the seedlings in the field. This rice cultivation system is increasingly challenged by rising labour costs, declining water availability and the need for improved resource use efficiency. As a result, direct-seeded rice (DSR) has gained

attention as water, labour and energy saving alternative that can shorten cropping cycles and reduce production costs (Phukan *et al.*, 2021) ^[15].

The DSR method can be further divided into the wet direct seeded rice method (WDS) where, pre-germinated seeds are sown into the soil using a drum-seeder and the dry direct seeded rice method (DDSR), where, dry or ungerminated seeds are sown directly using broadcast, drilled or dibbled method into dry and prepared soil (Fikriyyah *et al.*, 2019). Some research studies have shown that DDSR reduces weed infestation and increases yields by up to 75% (Shekhawat *et al.*, 2020) ^[19].

Despite these advantages, DSR is more vulnerable to weed infestation than flooded transplanted systems because aerobic soil conditions during crop establishment favour the germination of a diverse weed flora (grasses, sedges and broadleaves). Severe early-season weed competition in DSR can markedly reduce tiller survival, panicle formation and final grain yield; reported approximately 90% of crop yield losses under uncontrolled weed pressure in DSR (Ahmed, Salim, & Chauhan, 2014; Shekhawat *et al.*, 2020) ^[1, 19]. Therefore, effective weed management in DSR is crucial not only to reduce competition and protect crop growth, but also to achieve economic sustainability. Integrated methods combining manual, mechanical, and chemical control are a promising way to reduce weed density and increase crop productivity.

The date of sowing is a non-monetary, agronomic factor that strongly influences both crop performance and weed dynamics. Sowing time determines the environmental conditions (soil moisture, temperature and rainfall timing) during germination and early growth, which in turn affect weed emergence patterns and crop competitive ability. Early sowing may coincide with favourable conditions for weed germination and create a high initial weed flush, while an appropriately timed or slightly delayed sowing can reduce early weed pressure by avoiding peak flushes (Zhang *et al.*, 2023; Mir *et al.*, 2024) ^[26, 13]. Thus, optimizing sowing date is an important cultural measure for reducing weed interference and improving crop establishment in DSR.

However, use of herbicide mixtures that combine two or more active ingredients with different modes of action and can be applied sequential as pre-emergence followed by post emergence treatments throughout the growing seasons, reduces the seedbank of weeds and provide effective weed control against complex weed flora (Choudhary and Mishra, 2023; Sondhia *et al.*, 2024) ^[1, 20]. Consequently, integrated weed management (IWM) strategies that combine PE herbicides to suppress the initial flush, PoE herbicides to control escapes and at least one manual or mechanical weeding are recommended to achieve season-long weed control and sustain yields (Mir *et al.*, 2024) ^[13]. A recent study demonstrates that combining optimum sowing time with effective weed management strategies, reduce weed infestation, improves crop growth, yield and economic benefits in DDSR. Therefore, a study was undertaken to assess the combined effects of different sowing dates and weed management approaches on weed flora composition, weed density and dry weight, weed control efficiency and yield performance of dry-direct seeded rice under *Kharif* seasons in *Tarai* region of Uttarakhand. The objective was to identify optimum sowing date with weed management combinations that minimize weed competition, improve crop growth and maximize productivity of DDSR.

Materials and Methods

A field experiment was conducted during *Kharif* season at E-7

block of Norman E. Borlaug Crop Research Centre at G.B. Pant University of Agriculture and Technology, Pantnagar, Distt. Udham Singh Nagar (Uttarakhand) for two years 2023 and 2024. The research centre geographically located at an altitude of 243.84 m above mean sea level, 29° N latitude and 79.3° E longitudes. The texture of soil was sandy loam and slightly alkaline in pH i.e., 7.4 with the EC 0.21. The experiment was laid out in Split plot design, main plot comprises of three dates of sowing (D1-1st June, D2-10th June and D3-20th June) and sub-plot comprised of five weed management treatments such as W₁- Pendimethalin 38.7 CS 678 g/ha (PE) *fb* penoxsulum 1.02% w/w + cyhalofop-butyl (RM) 5.17 w/w OD 135 g/ha (PoE), W₂- Pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) 785 g/ha (PE) *fb* penoxsulum 21.7% SC 93.7 g/ha (PoE) *fb* one hand weeding at 40 DAS, W₃- Penoxsulum 1% + pendimethalin 24% (RM) 625 g/ha (PE) *fb* bispyribac sodium 10% EC 25 g/ha (PoE), W₄- Three manual hand weeding at 20, 40 and 60 DAS and W₅- Weedy check and replicated thrice.

The crop was grown as per recommended package of practices for DDSR. The sowing of Pant Dhan-18 rice variety was done in lines at 20cm apart with 50kg/ha seed rate. Between two sub-plots 1m space was maintained to avoid herbicide spray drift. The observations related to weeds were recorded at 60 and harvest stage for weed density and dry weight using a 0.5 x 0.5m quadrant at two random locations within each plot. Weed dry weight was recorded after sun drying the weed samples placed into the hot air oven at ±70°C temperature till constant weight gained. The data on weed density and dry weight were subjected to square root transformation $\sqrt{x} + 0.5$ before statistical analysis. Weed Control efficiency (WCE) was calculated based on data recorded at 60 DAS and at harvest stage in DDSR as per standard formula given by Mani *et al.* (1973) ^[12].

Formula used for calculating WCE :-

$$WCE (\%) = \frac{WDTc - WDTt}{WDTc} \times 100$$

Where, WDTc = Weed dry weight in control plot (Weedy check)

WDTt = Weed dry weight in treated plot

Yield parameters (no. of panicles/ m² and grain yield in t/ha) were measured after harvesting of rice crop.

Results and Discussion

Effect on weed dynamics

The predominant weed flora observed in the experimental field during the *Kharif* season of 2023 and 2024, comprised grasses, broad-leaved weeds, and sedges. Major grassy weeds included *Echinochloa colona*, *E. crus-galli*, *Cynodon dactylon*, *Digitaria sanguinalis*, *Eleusine indica*, *Leptochloa chinensis* and *Paspalum distichum*; broad-leaved weeds such as *Alternanthera sessilis*, *Celosia argentea*, *Phyllanthus niruri*, *Eclipta alba*, *Caesulia axillaris*, *Ammannia baccifera* and *Mollugo pentaphylla*; whereas, sedges were represented by *Cyperus rotundus*, *C. iria*, *C. difformis* and *Fimbristylis miliacea*. Similar weed composition has also been reported by Mir *et al.* (2024) ^[13].

Date of sowing and weed management practices significantly affected total weed density, dry weight and weed control efficiency (WCE) at 60 DAS and harvest stage in both years of 2023 and 2024.

The lowest total weed density and dry weight at 60 DAS and at harvest were consistently recorded with D₃-20th June sowing i.e. 93.93 and 116.33/m² weed density in 2023; 82.67 and 88.77/m²

weed density in 2024 and the weed dry weight- 64.94 and 139.26 g/m² in 2023; 62.38 and 97.03 g/m² in 2024, respectively, at 60 DAS and harvest stages, while D₁ followed by D₂ recorded maximum total weed density and dry weight. Consequently, WCE was highest under D₃ (92.03 and 87.27% in 2023; 91.44 and 90.32% in 2024 at 60 DAS and harvest) and comparatively lower under D₁-1st June (90.01 and 83.27% in 2023; 86.72 and 85.10% in 2024). The reduced weed pressure under 20th June sowing may be attributed to better synchronization of crop emergence with monsoon rainfall, leading to rapid canopy development and reduced opportunities for successive weed flushes, whereas early sowing exposed the crop to pre-monsoon conditions favoring early and repeated weed emergence. These findings corroborate earlier reports of lower weed density and dry weight under mid-June sowing (Kumar *et al.*, 2012; Dwibedi *et al.*, 2016; Toppo *et al.*, 2023) [11, 5, 22].

All weed management treatments resulted in a significant reduction in weed density and dry weight compared with the weedy check (W₅), which consistently recorded the highest weed density (461.56 and 545.22/m² in 2023; 371.22 and 375.24/m² in 2024) and weed dry weight (307.98 and 552.23 g/m² in 2023; 260.10 and 387.84 g/m² in 2024) at 60 DAS and at harvest, resulting in lowest WCE. Among the different weed management treatments, W₂ (Pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) 785 g/ha as pre-emergence followed by penoxsulam 21.7% SC 93.7 g/ha and one hand weeding at 40 DAS) was the most effective herbicidal treatment. It recorded the lowest weed density during 2023 (19.44 and 37.22/m²) and 2024 (15.33 and 26.04/m²) at 60 DAS and at harvest, respectively. The performance of W₂ was statistically on a par with W₄ (three hand weeding at 20, 40 and 60 DAS), which recorded weed density of 13.22 and 33.56/m² in 2023 and 12.11 and 37.86/m² in 2024 at 60 DAS and harvest, respectively. A similar pattern was observed for weed dry weight, where W₄ followed by W₂ recorded the lowest values (8.50 and 40.66 g/m² in 2023; 6.12 and 15.72 g/m² in 2024 under W₂ at 60 DAS and harvest), indicating superior weed suppression. Correspondingly, highest WCE was recorded under W₂ (97.35 at 60 DAS and 92.84% at harvest in 2023), which was statistically comparable with W₄ (98.57% at 60 DAS and 89.22 at harvest stage in 2023). Similarly, in 2024 W₂ recorded the highest WCE (97.74 and 96.09%), which was remained on a par with W₄ (97.59 and 95.55%) at 60 DAS and at harvest.

The effectiveness of W₂ can be attributed to the complementary modes of action of the pre- and post-emergence herbicides combined with manual weeding, ensuring early suppression and season-long control of diverse weed flora. These findings are in close agreement with earlier reports (Kaur and Singh, 2015; Parthipan *et al.*, 2013; Yogananda *et al.*, 2021; Kashyap *et al.*, 2022) [9, 14, 25, 8], which emphasized that integrated weed management strategies provide sustained weed control comparable to repeated manual weeding in dry direct seeded rice. Overall sowing on 20th June combined with integrated herbicide application and timely hand weeding proved most effective in minimizing total weed density and weight and maximizing weed control efficiency under *Kharif* conditions.

Effect on yield attributes and grain yield

Number of panicles /m² was significantly influenced by sowing date during *Kharif* 2023 and 2024. The highest panicle density was recorded under D₃-20th June sowing (186.2 and 177.9

panicles/m²), which was superior to other sowing dates. The enhanced panicle number under mid-June sowing may be attributed to improved tiller survival and efficient assimilate partitioning toward reproductive sinks, supporting earlier findings of higher panicle density under optimum sowing windows (Shanta *et al.*, 2020) [18]. Weed management practices also exerted a significant effect on panicle number. Among treatments, W₂- pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) 785 g/ha *fb* penoxsulam 21.7% SC 93.7 g/ha *fb* one hand weeding at 40 DAS, produced the highest panicles/m² (218.7 and 207.2), which was statistically at par with W₄ (three hand weeding at 20, 40 and 60 DAS) (217.9 and 204.9). Both treatments were markedly superior to the weedy check (W₅), which recorded the lowest values (82.8 and 74.6 panicles/m² in 2023 and 2024, respectively). The increased production of fertile tillers under effective weed control indicates that minimizing early crop weed competition promotes vegetative vigor and reproductive sink development, in close agreement with Sanodiya and Singh (2017) [16]; Kaur *et al.* (2023) [10].

Sowing date significantly influenced grain yield of direct-seeded rice during both years. D₃-20th June sowing produced the highest grain yield (4.1 and 5.0 t/ha in 2023 and 2024), whereas D₁-1st June recorded the lowest yield (2.9 and 3.6 t/ha), followed by D₂-10th June (3.3 and 4.0 t/ha). These findings in close agreement with Kumar *et al.*, 2012 [11]. Weed management practices also exerted a significant effect on yield. Treatment W₂ [pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) 785 g/ha *fb* penoxsulam 21.7% SC 93.7 g/ha *fb* one hand weeding at 40 DAS] recorded the highest grain yield (4.6 and 5.7 t/ha), which was statistically comparable with W₄-three hand weeding at 20, 40 and 60 DAS, (4.5 and 5.6 t/ha) during 2023 and 2024. In contrast, the weedy check (W₅) produced the lowest grain yield (0.7 and 0.9 t/ha). The superiority of W₂ among herbicide-based treatments is attributable to its higher weed control efficiency and broad-spectrum suppression of weed flora, which agrees with previous reports emphasizing the benefits of integrated weed management in dry direct seeded rice (Bhurer *et al.*, 2013; Joshi *et al.*, 2015; Sanodiya and Singh, 2017) [2, 7, 16].

The superior grain yield under D₃-20th June sowing was associated with lower weed density and weight, which reduced competition for light, nutrients, water and space, thereby enhancing crop growth and productivity. Similar relationships between reduced weed pressure and improved yield performance have been documented by Sanodiya and Singh (2017) [16]; Swathi *et al.* (2024) [21].

The relationship between total weed dry weight at harvest stage and grain yield was examined using correlation and regression analysis based on the pooled data of two years. The results revealed a strong negative linear relationship between weed dry weight and grain yield, indicating that as weed dry weight increased, grain yield consistently decreased. The fitted regression equation ($y = -0.01x + 5.27$) indicates that for every unit increase in weed dry weight, grain yield decreased by approximately 0.01 t/ha. The R² value (0.93) suggests that about 93% of the variation in grain yield is explained by weed dry weight, indicating a very strong relationship between the two variables. Similar findings have been reported by Kaur *et al.* (2025) [10]; Sar *et al.* (2024) [17], who observed a significant negative correlation between weed dry matter and grain yield in direct-seeded rice and reported that higher weed dry weight resulted in reduced crop growth and yield due to severe competition throughout the crop growth period.

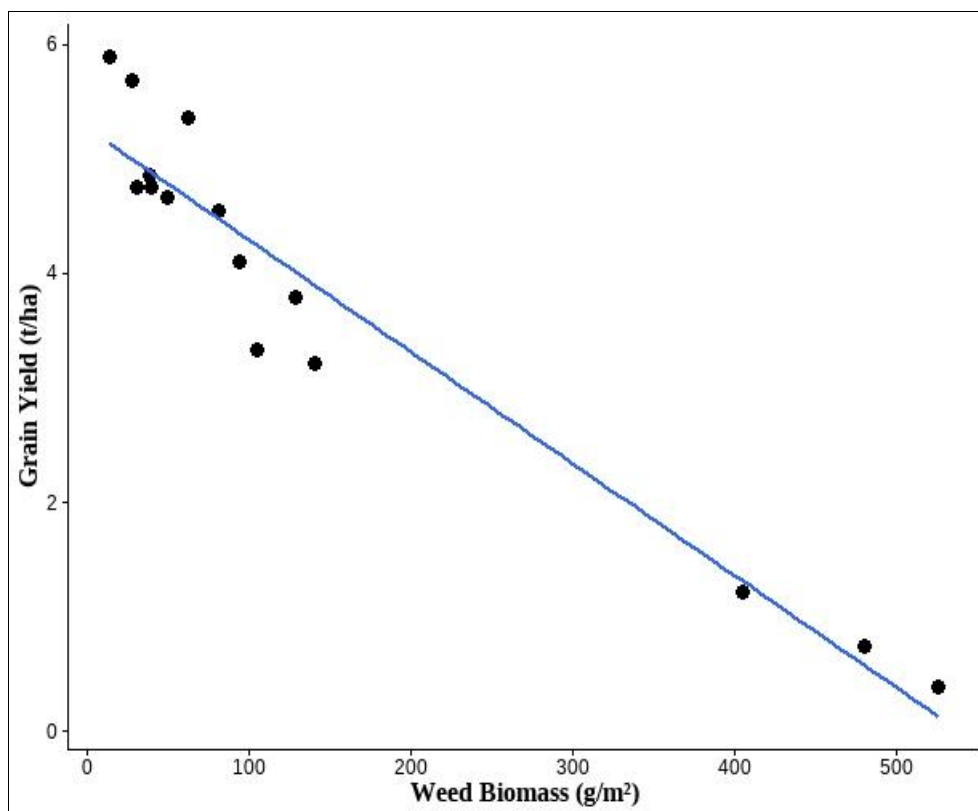


Fig 1: Relationship between weed dry weight at harvest and grain yield in dry direct-seeded rice (pooled data over two years)

Table 1: Effect of date of sowing and weed management practices on total weed density, total weed dry weight and weed control efficiency at 60 DAS and at harvest of direct seeded rice

Treatments	Total weed density (No./m ²)				Total weed dry weight (g/m ²)				WCE (%)			
	2023		2024		2023		2024		2023		2024	
	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest
Date of Sowing												
D ₁ - June 01	10.20 (151.87)	12.58 (203.00)	9.52 (125.33)	10.76 (142.98)	8.30 (104.61)	12.95 (208.32)	8.02 (89.60)	10.09 (135.33)	90.01	83.27	86.72	85.10
D ₂ - June 10	8.83 (119.40)	10.80 (161.40)	8.61 (104.93)	9.68 (119.77)	7.33 (82.79)	12.32 (189.89)	7.27 (76.50)	9.30 (118.75)	90.87	83.44	87.41	86.77
D ₃ - June 20	7.49 (93.93)	8.77 (116.33)	6.80 (82.67)	8.00 (88.77)	6.34 (64.94)	10.21 (139.26)	6.14 (62.38)	8.04 (97.03)	92.03	87.27	91.44	90.32
SEm (±)	0.25	0.32	0.26	0.28	0.20	0.31	0.22	0.35	0.37	0.81	0.89	0.76
LSD (P=0.05)	0.96	1.26	1.01	1.09	0.78	1.22	0.86	1.37	1.46	3.16	3.50	2.97
Weed Management												
W ₁	8.11 (67.78)	10.51 (113.56)	8.45 (73.89)	8.84 (80.19)	7.32 (53.87)	11.87 (143.46)	7.75 (60.80)	9.43 (89.92)	82.58	74.42	76.84	76.97
W ₂	4.32 (19.44)	5.95 (37.22)	3.92 (15.33)	5.05 (26.04)	2.93 (8.50)	6.25 (40.66)	2.49 (6.12)	3.89 (15.72)	97.35	92.84	97.74	96.09
W ₃	6.69 (46.67)	8.24 (71.67)	6.89 (49.00)	8.09 (66.53)	6.69 (45.72)	9.90 (99.31)	6.86 (47.28)	8.58 (74.45)	85.38	82.14	81.91	80.97
W ₄	3.65 (13.22)	5.61 (33.56)	3.06 (12.11)	6.12 (37.86)	2.18 (4.51)	7.68 (60.11)	2.51 (6.50)	4.17 (17.24)	98.57	89.22	97.59	95.55
W ₅	21.42 (461.56)	23.27 (545.22)	19.24 (371.22)	19.29 (375.24)	17.49 (307.98)	23.45 (552.23)	16.10 (260.10)	19.65 (387.84)	-	-	-	-
SEm (±)	0.28	0.36	0.27	0.27	0.17	0.30	0.17	0.22	0.42	0.94	0.67	0.57
LSD (P=0.05)	0.81	1.04	0.79	0.80	0.50	0.88	0.50	0.65	1.24	2.78	2.00	1.70

Value in the parenthesis was original and transformed to $[\sqrt{(x + 0.5)}]$ for statistical analysis.

W₁- Pendimethalin 38.7 CS 678 g/ha (PE) *fb* penoxsulum 1.02% w/w + cyhalofop-butyl (RM) 5.17 w/w OD 135 g/ha (PoE),

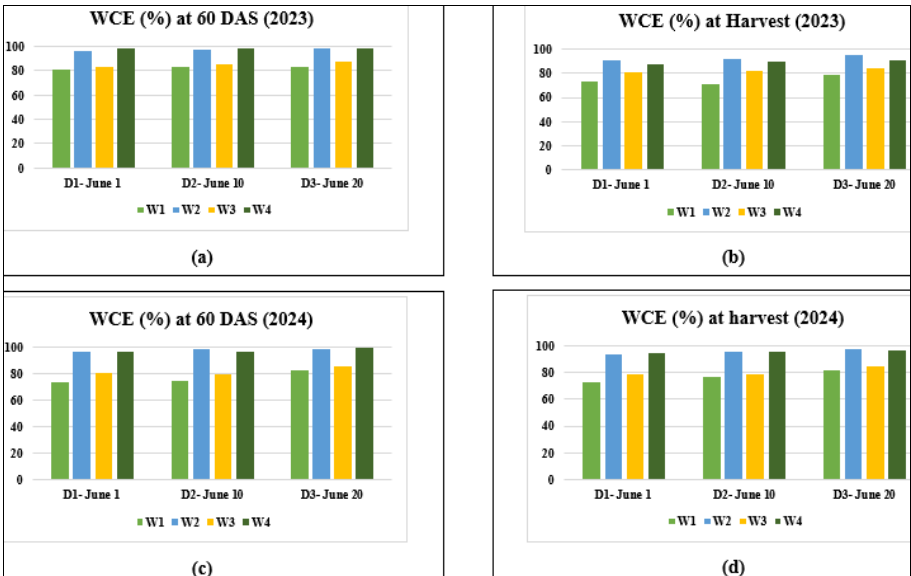
W₂- Pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) 785 g/ha (PE) *fb* penoxsulum 21.7% SC 93.7 g/ha (PoE) *fb* one hand weeding at 40 DAS,

W₃- Penoxsulum 1% + pendimethalin 24% (RM) 625 g/ha (PE) *fb* bispyribac sodium 10% EC 25 g/ha (PoE),

W₄- Three manual hand weeding at 20, 40 and 60 DAS and

W₅-Weedy check *DAS- Days after sowing, *WCE- Weed control efficiency

*RM- Ready mix



W₁- Pendimethalin 38.7 CS 678 g/ha (PE) fb penoxsulum 1.02% w/w + cyhalofop-butyl (RM) 5.17 w/w OD 135 g/ha (PoE),
W₂ - Pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) 785 g/ha (PE) fb penoxsulum 21.7% SC 93.7 g/ha (PoE) fb one hand weeding at 40 DAS,
W₃- Penoxsulum 1% + pendimethalin 24% (RM) 625 g/ha (PE) fb bispyribac sodium 10% EC 25 g/ha (PoE),
W₄- Three manual hand weeding at 20, 40 and 60 DAS
*DAS- Days after sowing, *WCE- Weed control efficiency, *RM- Ready mix

Fig 2: Graphical representation of weed control efficiency (%) affected by date of sowing and weed management practices at 60 DAS and at harvest in 2023 and 2024

Table 2: Effect of date of sowing and weed management practices on no. of panicles and grain yield of dry direct seeded rice during kharif season of 2023 and 2024

Treatments	No. of panicles (m ²)		Grain yield (t/ha)	
	2023	2024	2023	2024
Date of Sowing				
D ₁ - June 01	166.5	158.5	2.9	3.6
D ₂ - June 10	177.6	165.4	3.3	4.0
D ₃ - June 20	186.2	177.9	4.1	5.0
S.Em (±)	3.52	6.40	0.11	0.13
LSD (P=0.05)	13.81	25.14	0.44	0.53
Weed Management				
W ₁ - Pendimethalin 38.7 CS (PE) fb penoxsulum 1.02% w/w + cyhalofop-butyl (RM) 5.17 w/w OD (PoE)	174.1	174.2	3.4	4.3
W ₂ - Pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) (PE)fb penoxsulum 21.7% SC (PoE)fb one hand weeding at 40 DAS	218.7	207.2	4.6	5.7
W ₃ - Penoxsulum 1% + pendimethalin 24% (RM) (PE) fb bispyribac sodium 10% EC (PoE)	190.4	175.3	3.9	4.6
W ₄ - Three manual hand weeding at 20, 40 and 60 DAS	217.9	204.9	4.5	5.6
W ₅ - Weedy check	82.8	74.6	0.7	0.9
S.Em (±)	7.73	7.71	0.13	0.14
LSD (P=0.05)	22.57	22.50	0.37	0.41

Conclusion

The findings of the present study indicated that the optimum sowing time with integrated weed management strategies plays a crucial role in regulating weed dynamics and improving crop productivity in dry direct seeded rice. The experiment concluded that sowing on 20th June, combined with an integrated sequential application of pre-emergence (PE) treatment of pendimethalin 38.4% + pyrazosulfuron 0.85% (RM) at 785 g/ha, followed by a post-emergence (PoE) application of penoxsulum 21.7% SC at 93.7 g/ha and supplemented with one hand weeding at 40 DAS, found to be the most effective treatment combination to supressing mixed weed flora. This approach resulted in reduced total weed density and dry weight, higher weed control efficiency, improved crop growth and more tiller survival and more panicle formation which ultimately resulted in higher grain

yield under dry direct seeded rice condition. Thus, timely sowing along with integrated sequential herbicide application supplemented with manual weeding can be recommended as an efficient and sustainable weed management strategy for improving productivity in dry-direct seeded rice during the *Kharif* season.

References

1. Ahmed S, Salim M, Chauhan BS. Effect of weed management and seed rate on crop growth under direct dry seeded rice systems in Bangladesh. PLoS ONE. 2014;9(6):e101919.
2. Bhurer KP, Yadav DN, Ladha JK, Thapa RB, Pandey K. Effect of integrated weed management practices on performance of dry direct seeded rice (*Oryza sativa* L.).

- Agronomy Journal of Nepal. 2013;3:53-63.
3. Chaudhary VK, Mishra JS. Herbicides resistance in weeds: emerging challenges and management strategies. *Indian Journal of Agronomy*. 2023;68:S120-S131.
 4. Chauhan BS. Weed ecology and weed management strategies for dry-seeded rice in Asia. *Weed Technology*. 2012;26:1-13.
 5. Dwibedi SK, De GC, Dhua SR. Weed dynamics and grain yield as influenced by sowing time and system of cultivation of rice genotypes. *Journal of Crop and Weed*. 2016;12(1):107-111.
 6. Fikriyah VN, Darvishzadeh R, Laborte A, Khan NI, Nelson A. Discriminating transplanted and direct seeded rice using Sentinel-1 intensity data. *International Journal of Applied Earth Observation and Geoinformation*. 2019;76:143-153.
 7. Joshi N, Singh VP, Dhyani VC, Chandra S, Guru SK. Weed management under different planting geometry in dry direct-seeded rice. *Indian Journal of Weed Science*. 2015;47(2):203-205.
 8. Kashyap S, Singh VP, Guru SK, Pratap T, Singh SP, Kumar R. Effect of integrated weed management on weed and yield of direct seeded rice. *Indian Journal of Agricultural Research*. 2022;56(1).
 9. Kaur S, Singh S. Bioefficacy of different herbicides for weed control in direct seeded rice. *Indian Journal of Weed Science*. 2015;47:106-109.
 10. Kaur S, Kaur T, Bhullar MS. Pendimethalin plus pyrazosulfuron for pre-emergence control of complex weed flora in dry-seeded rice. *Indian Journal of Weed Science*. 2023;55(4):364-368.
 11. Kumar J, Singh D, Singh B, Singh R, Panwar S, Gupta AK. Sowing time and weed management practices to enhance yield of direct-seeded rice. *Indian Journal of Weed Science*. 2012;44(4):207-209.
 12. Mani V, Malla M, Gautam KC, Bhagawadas. Weed killing chemicals in potato cultivation. *PAN*. 1973;23(8):17-18.
 13. Mir MS, Singh P, Kanth RH, Shah ZA, Dar EA, Bhat JA, *et al*. Influence of sowing dates and weed management practices on weed dynamics, productivity and profitability of direct seeded rice. *Scientific Reports*. 2024;14(1):18877.
 14. Parthipan T, Ravi V, Subramanian E. Integrated weed management practices on growth and yield of direct-seeded lowland rice. *Indian Journal of Weed Science*. 2013;45(1):7-11.
 15. Phukan J, Kalita S, Bora P. Weed management in direct seeded rice: A review. *Journal of Pharmacognosy and Phytochemistry*. 2021;10:742-748.
 16. Sanodiya P, Singh MK. Integrated weed management in direct-seeded rice. *Indian Journal of Weed Science*. 2017;49(1):10-14.
 17. Sar K, Mishra G, Rath S, Padhi I. Weed growth and productivity of direct-seeded rice under different weed management practices. *Indian Journal of Weed Science*. 2024;56(1):8-11.
 18. Shanta CM, Ramesha YM, Krishnamurthy D, Umesh MR, Bhanuvally M. Growth and yield response of direct seeded rice (*Oryza sativa* L.) to dates of sowing and varieties. *International Journal of Conservation Sciences*. 2020;8(4):295-299.
 19. Shekhawat K, Rathore SS, Chauhan BS. Weed management in dry direct-seeded rice: A review on challenges and opportunities for sustainable rice production. *Agronomy*. 2020;10(9):1264-1264.
 20. Sondhia S, Sreekanth D, Pawar VD, Geetha KN, Sen AK. Crop-weed competition and herbicide bioefficacy: Implications in a changing climate. *Indian Journal of Weed Science*. 2024;56(4):391-403.
 21. Swathi S, Srinithan T, Ivin JJS, Sowmiya S. Evaluation of new generation herbicide-based weed management strategies on direct sown rice production in Cauvery Deltaic Zone. *Journal of Advances in Biology and Biotechnology*. 2024;27(7):1270-1280.
 22. Toppo O, Kewat ML, Jha AK, Yadav PS, Verma B. Effect of sowing time and weed management practices on weed dynamics, productivity and economics of direct-seeded rice. *Ecology, Environment and Conservation*. 2023;29(3):80-85.
 23. USDA. World agricultural production. 2026.
 24. USDA. Production rice. 2026.
 25. Yogananda SB, Thimmegowda P, Shruthi GK. Weed management in wet (drum)-seeded rice under Southern dry zone of Karnataka. *Indian Journal of Weed Science*. 2021;53(2):117-122.
 26. Zhang RP, Zhou NN, Ashen RG, Zhou L, Feng TY, Zhang KY, *et al*. Effect of sowing date on the growth characteristics and yield of growth-constrained direct-seeding rice. *Plants*. 2023;12(9):1899-1899.