



## RESEARCH ARTICLE

# Interactive effect of sowing date and weed management options on associated weeds and productivity of dry direct-seeded rice

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### ABSTRACT

A field study was carried out during *Kharif*, 2023 and 2024 at Agriculture research station, Binjhagiri, Chatabar, Odisha with an objective to study the interactive effect of sowing dates and weed management options on weed growth and productivity of dry direct-seeded rice. The experiment was laid out in split plot design with three replications. The three dates of sowing, viz. S<sub>1</sub>: 10<sup>th</sup> June; S<sub>2</sub>:25<sup>th</sup> June; S<sub>3</sub>:10<sup>th</sup> July, were in main plots and five weed management treatments, viz. pre-emergence application (PE) of pendimethalin 1.0 kg/ha, pendimethalin 1.0 kg/ha PE followed by (*fb*) post-emergence application (PoE) of fenoxaprop-p-ethyl + ethoxysulfuron (tank-mix) 90.0 +15.0 g/ha, pendimethalin 1.0 kg/ha PE *fb* one hand weeding (HW) at 40 days after seeding (DAS), hoeing and weeding twice at 20 and 40 DAS and weedy check, were in subplots. The lowest density and biomass of all types of weeds and maximum value of rice yield attributes and yield were recorded with normal date of sowing (25<sup>th</sup> June) followed by early sowing (10<sup>th</sup> June). Among the weed management treatments, hoeing and weeding twice at 20 and 40 DAS recorded lower total weed density, maximum value of rice yield attributes and yield, and was at par with pendimethalin 1.0 kg/ha PE *fb* one HW. Interaction effect was found significant and the timely sown (25<sup>th</sup> June) along with hoeing and weeding twice recorded the highest rice yield and was at par with timely sown (25<sup>th</sup> June) along with pendimethalin 1.0 kg/ha PE *fb* one HW.

**Keywords:** Dry direct-seeded rice, Fenoxaprop-p-ethyl + ethoxysulfuron, Integrated weed management, Pendimethalin, Sowing dates

### INTRODUCTION

Rice is one of the most important food crops in India, Asia, and the World. India is the world's top rice producing country in terms of area and ranks first in terms of production. To meet global rice demand, it is projected that an additional 96 million tons of milled rice will be needed by 2040 as compared to 2015 (Balié and Valera 2020). Time of sowing of the crop is a non-monetary input, but greatly affects the productivity of rice. Several studies have shown that sowing of rice after onset of monsoon gave higher grain yield due to less infestation of weeds. However, very late sowing could reduce the vegetative and reproductive growth period of rice, resulting into low crop yield. Alternating the time of sowing and effective weed management methods can decrease losses due to weeds and improve the productivity of direct-seeded rice (DSR). Weed infestation is one of the major constraints for low productivity and causes 50-60% yield loss due to simultaneous germination of both crop and weed seeds (Rao *et al.* 2007, Pinjari *et al.*

2016). Manual weeding is considered to be the best, but it is uneconomical and hence herbicides are being considered as better alternative to hand weeding in DSR (Singh *et al.* 2006, Rao *et al.* 2017). Though herbicides are being extensively used to control weeds, single herbicide cannot control all types of weeds in the agricultural fields (Sar *et al.* 2022). Therefore, an integrated weed management strategy is strongly recommended to improve agricultural sustainability (Rao and Korres 2024). Thus, for effective weed management in DSR, integrated approaches are to be optimized. The present study was conducted to study the effect of date of sowing and weed management options on weed growth and productivity in dry-DSR.

### MATERIALS AND METHODS

A field experiment was conducted during *Kharif* season at Agricultural Research Station, Faculty of Agricultural Sciences, SOADU, Odisha, India, during 2023 and 2024. Soil texture of the experimental plot was sandy loam. The experiment was laid out in split plot design with three replications. Treatments consisted of three dates of sowing, viz. S<sub>1</sub>: 10<sup>th</sup> June; S<sub>2</sub>:25<sup>th</sup> June; S<sub>3</sub>:10<sup>th</sup> July, in main plots and five weed

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management treatments, viz. W<sub>1</sub>: pre-emergence application (PE) of pendimethalin 1.0 kg/ha, W<sub>2</sub>: pendimethalin 1.0 kg/ha PE followed by (*fb*) post-emergence application (PoE) of fenoxaprop-p-ethyl + ethoxysulfuron (tank-mix) 90.0 +15.0 g/ha, W<sub>3</sub>: pendimethalin 1.0 kg/ha PE *fb* one HW at 40 DAS, W<sub>4</sub>: hoeing and weeding at 20 and 40 days after seeding (DAS) and W<sub>5</sub>: weedy check, in subplots. The field was prepared by one ploughing with disc harrow and cross ploughing using cultivators. Planking was done after each ploughing to make soil friable to ensure proper germination. The rice variety CR Dhan 205, popularly known as aerobic rice was used in this experiment using seed rate of 60 kg/ha. Fertilizers applied include: 80 kg N, 40 kg P and 40 K kg/ha. Half the dose of N, full dose of P and K were applied as basal at the time of sowing. Remaining half dose of N was applied as top-dressing using urea in two equivalent splits at 25 and 45 DAS. The extra plants in the rows were thinned out and gap filling was done within two weeks of sowing in order to maintain optimum plant population. Herbicides were sprayed knap sack sprayer with flat fan nozzle at their respective doses at appropriate stages. All other recommended agronomic practices were followed and plant protection measures were adopted as per need. Weed density of different species was counted by placing the quadrat (50 cm × 50 cm) randomly in the sampling area and after drying of the sampled weeds in a hot air oven at 70-72°C for 72 hours, the dry weight of weeds (weed biomass) was recorded. The yield components and yield of DSR were also recorded and statistically analysed at 5% level of significance (Gomez and Gomez 1984).

## RESULT AND DISCUSSION

### Effect on weeds

The dominance of weeds varied across different dates of sowing and weed management treatments. Weeds observed in the experimental field include: *Digitaria sanguinalis*, *Echinochloa colona*, among grasses; *Ludwigia parviflora*, *Hedyotis corymbosa*, *Lindernia ciliata*, *Cleome viscosa*, among broad-leaved weeds and *Cyperus iria*, among sedges. Similar weed flora in DSR was also reported by Chakraborti *et al.* (2018), Dhanapal *et al.* (2018), Banjara *et al.* (2019), Yadav *et al.* (2019) and Sar *et al.* (2024). Among the different dates of sowing, the lowest density and biomass of total weeds were recorded with normal sowing date (25<sup>th</sup> June) followed by early sowing date (10<sup>th</sup> June). Similar trend was reported by Mandal *et al.* (2011). Due to high photoperiods with favourable weather condition for germination, thereby weeds emerged and established more in early sown date (Upasni *et al.* 2014).

The lowest density and biomass of total weed was recorded with hoeing and weeding twice and was at par with pendimethalin 1.0 kg/ha PE *fb* one HW (**Table 1**) as reported by Sar *et al.* (2025). The application of pre-emergent (PE) herbicide alone was not adequate to manage the weeds in rice. The herbicides application sequentially followed by manual weeding performed better against diverse weed flora as compared to herbicides use alone (Chauhan 2012). Pendimethalin 1.0 kg/ha PE *fb* one hand weeding recorded 47.43% and 48.2% lower biomass of total weeds as compared to pendimethalin

**Table 1. Density and biomass of weeds at 60 days after seeding (DAS) in dry direct-seeded rice (DSR) as affected by different sowing dates and weed management treatments**

Treatment*	Total weed density (no./m <sup>2</sup> )		Total weed biomass (g/m <sup>2</sup> )	
	2023	2024	2023	2024
<i>Sowing dates</i>				
S <sub>1</sub> - 10 <sup>th</sup> June	10.1(101.0)	9.8(94.7)	9.4(87.1)	9.0(80.4)
S <sub>2</sub> - 25 <sup>th</sup> June	9.2(84.0)	8.8(77.6)	8.5(71.1)	8.0(64.4)
S <sub>3</sub> - 10 <sup>th</sup> July	10.9(118.7)	10.6(111.5)	10.2(104.3)	9.9(97.3)
LSD (p=0.05)	0.43	0.38	0.34	0.39
<i>Weed management treatment</i>				
W <sub>1</sub> - Pendimethalin 1.0 kg/ha PE at 3 DAS	12.1(145.3)	11.8(138.5)	11.5(132.6)	11.2(125.6)
W <sub>2</sub> - Pendimethalin 1.0 kg/ha PE <i>fb</i> fenoxaprop-p-ethyl + ethoxysulfuron (tank-mix) 90+15 g/ha PoE at 20 DAS	9.7(93.6)	9.3(85.9)	9.0(80.4)	8.6(72.7)
W <sub>3</sub> - Pendimethalin 1.0 kg/ha PE at 3 DAS followed by 1 HW at 40 DAS	7.4(54.9)	7.1(50.2)	6.5(42.3)	6.2(37.7)
W <sub>4</sub> - Hoeing and weeding at 20 and 40 DAS	7.2(52.0)	6.9(47.4)	6.3(39.4)	5.9(34.8)
W <sub>5</sub> -Weedy check	13.8(191.2)	13.5(182.0)	13.4(178.3)	13.0(168.3)
LSD (p=0.05)	0.45	0.49	0.52	0.56

\*PE=pre-emergence application; PoE=post-emergence application; Figures in parentheses are the original values. The data was transformed to SQRT ( $\sqrt{x+0.5}$ ) before analysis

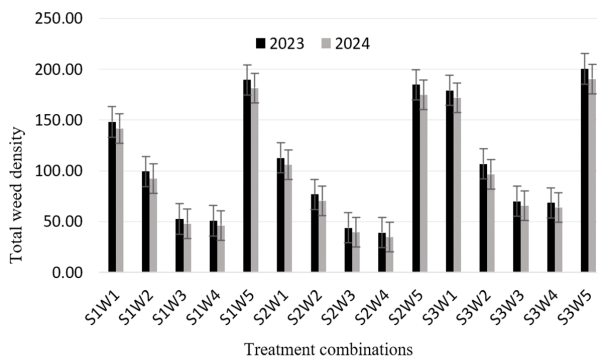
1.0 kg/ha PE *fb* fenoxaprop-p-ethyl + ethoxysulfuron (tank-mix) 90+15 g/ha PoE, in 2024 and 2025, respectively. Interaction effect was found significant and it was observed that timely sown (25<sup>th</sup> June) along with hoeing and weeding twice or

pendimethalin 1 kg/h PE *fb* 1 HW recorded the lowest biomass of total weed at 60 DAS (Figure 1 and 2).

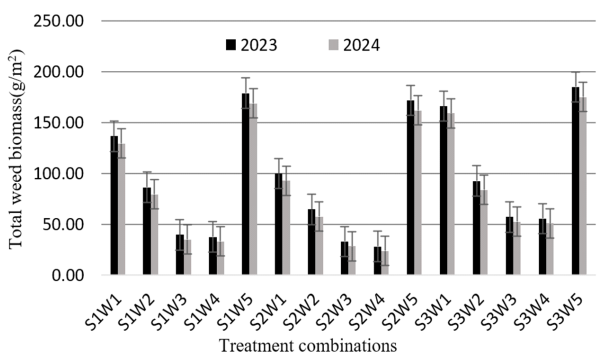
**Effect on rice**

The yield attributes, viz. panicles/m<sup>2</sup>, filled grains/panicle and thousand grain weight, and rice grain yield were markedly influenced by variations in sowing dates and weed management practices, reflecting the critical role of crop establishment time and effective weed management in optimizing rice performance. Among the sowing dates, normal sowing (25<sup>th</sup> June) was superior in recording higher values of all yield attributes, followed by early sowing (10<sup>th</sup> June), indicating that synchronization of crop phenology with prevailing favourable environmental conditions plays a decisive role in determining rice productivity. The superiority of normal sowing may be attributed to the alignment of critical growth stages with favourable temperature, radiation, and moisture regimes, thereby facilitating enhanced assimilate production and translocation. In contrast, deviations from the optimum sowing window might have imposed sub-optimal environment conditions, leading to reduce sink development and grain filling (Jena *et al.* 2024).

Weed management treatments exerted profound influence on yield attributes and rice grain yield, with hoeing and weeding twice registering the highest values of panicles/m<sup>2</sup>, 1000 grain weight, filled grains/panicle and rice grain yield and straw yield (Table 2). However, it was at par with pendimethalin 1.0 kg/ha PE *fb* one hand weeding (Table 2). The greater rice productivity with these treatments can be ascribed to sustained weed management during the critical period of crop-weed competition, ensuring



**Figure 1. Interaction effect of sowing dates and weed management treatments on total weed density at 60 days after seeding (refer table 1 for details of treatments)**



**Figure 2. Interaction effect of sowing dates and weed management treatments on total weed biomass (g/m<sup>2</sup>) at 60 days after seeding (refer table 1 for details of treatments)**

**Table 2. Dry direct-seeded rice yield attributes and yield as influenced by sowing dates and weed management treatments**

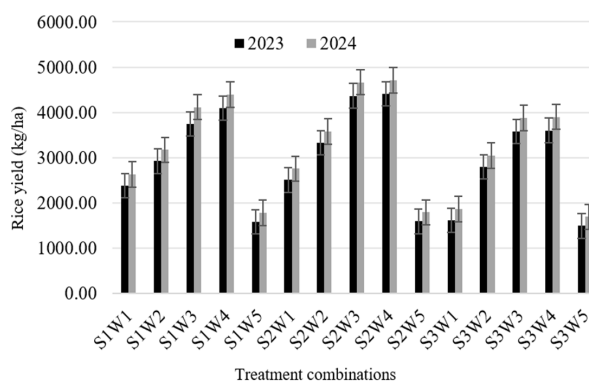
Treatment*	Panicle weight(g)		No of panicles/ m <sup>2</sup>		No of grains /panicle		No of filled grains/ panicles		Grain yield (t/ha)		Straw yield (t/ha)	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
	<i>Sowing dates</i>											
S <sub>1</sub> -10 <sup>th</sup> June	1.93	2.22	217	225	103	108	93	95	2.94	3.22	3.67	4.08
S <sub>2</sub> - 25 <sup>th</sup> June	2.18	2.48	233	241	117	124	110	114	3.24	3.50	3.91	4.31
S <sub>3</sub> - 10 <sup>th</sup> July	1.78	2.05	200	205	95	100	82	85	2.61	2.87	3.36	3.76
LSD (p=0.05)	0.13	0.14	15	12	7	6	5	6	0.28	0.25	0.23	0.21
<i>Weed management treatment</i>												
W <sub>1</sub> -Pendimethalin 1.0 kg/ha PE at 3 DAS	1.62	1.85	186	191	89	93	78	81	2.16	2.41	2.96	3.37
W <sub>2</sub> - Pendimethalin 1.0 kg/ha PE <i>fb</i> fenoxaprop-p-ethyl + ethoxysulfuron (tank-mix) 90+15 g/ha PoE at 20 DAS	2.15	2.45	222	227	106	108	91	95	3.01	3.26	3.58	3.98
W <sub>3</sub> - Pendimethalin 1.0 kg/ha PE at 3 DAS followed by 1 HW at 40 DAS	2.41	2.71	263	271	127	132	121	120	3.99	4.22	4.57	4.98
W <sub>4</sub> - Hoeing and weeding at 20 and 40 DAS	2.43	2.74	267	275	133	141	125	129	4.03	4.33	4.69	5.09
W <sub>5</sub> - Weedy check	1.21	1.50	145	157	68	80	61	66	1.55	1.75	2.44	2.84
LSD (p=0.05)	0.10	0.11	16	15	8	9	7	9	0.20	0.21	0.31	0.30

\*PE = pre-emergence application; PoE = post-emergence application DAS = days after seeding

uninterrupted access to essential growth resources (Mishra *et al.* 2025).

Pendimethalin 1.0 kg/ha PE *fb* one hand weeding significantly augmented yield attributes, recording increases of 81.37, 86.76, 98.36% in panicles/m<sup>2</sup>, grains/panicle and filled grains/panicle respectively, over the weedy check, during 2023. A similar trend was observed in the second year also, with corresponding increases of 72.76%, 65.0% and 81.81%, respectively. Pendimethalin PE *fb* fenoxaprop-p-ethyl + ethoxysulfuron (tank-mix) PoE recorded 39.3% and 35.21% higher grain yield as compared to pendimethalin PE applied alone in 2023 and 2024, respectively. However, pendimethalin PE alone recorded 39.34% and 37.70% higher grain yield over weedy check in 2023 and 2024, respectively. These pronounced improvements highlight the pivotal role of early-season weed control through pre-emergent herbicides, complemented by subsequent manual intervention, in maintaining a weed-free environment during the most sensitive stages of crop growth.

Interaction effect was also found to be significant. The timely sowing (25<sup>th</sup> June) along with hoeing and weeding at 20 and 40 DAS recorded the highest grain and straw yield over others and it was at par with timely sown (25<sup>th</sup> June) along with pendimethalin 1.0 kg/ha PE *fb* one HW at 40 DAS (Figure 3). It may be due to higher weed control efficiency of these treatments which maintained lower weed density as well as biomass thus least crop weed competition from the very early stage of the crop till maturity facilitating higher nutrient and water uptake, accelerated photosynthetic activity, availability of optimum space for better crop growth,



**Figure 3. Interaction effect of sowing dates and weed management treatments on dry-seeded rice grain yield (refer table one for details of treatments)**

resulting into higher dry matter accumulation and yield. The lowest yield was recorded under weedy check plot. The crop weed competition as a result of uninterrupted growth of weeds caused lower values of growth, yield attributes and yield of rice in unweeded check (Duary *et al.* 2016). The maximum gross return was with S<sub>2</sub>W<sub>4</sub> [Timely sown (25<sup>th</sup> June) along with hoeing and weeding at 20 and 40 DAS]. The highest net return was recorded with S<sub>2</sub>W<sub>3</sub> [Timely sown (25<sup>th</sup> June) along with application of pendimethalin 1.0 kg/ha at 3 DAS followed by 1 HW at 40 DAS]. Return/rupee invested was highest (2.55) with S<sub>2</sub>W<sub>3</sub> [Timely sown (25<sup>th</sup> June) along with application of Pendimethalin 1kg/ha at 3 DAS followed by 1 HW at 40 DAS].

Thus, it may be concluded that the timely sowing (25<sup>th</sup> June) with pendimethalin 1.0 kg/ha PE *fb* one HW at 40 DAS is promising for attainment of effective weed management, higher rice productivity and profitability in dry direct-seeded rice in Odisha.

**Table 3. Economics of dry direct-seeded rice as influenced by different treatment combination treatments (pooled mean of two years)**

Treatment	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Return per rupee invested
S <sub>1</sub> W <sub>1</sub>	36626	60428	23802	1.65
S <sub>1</sub> W <sub>2</sub>	38115	72956	34841	1.91
S <sub>1</sub> W <sub>3</sub>	42026	97605	55579	2.32
S <sub>1</sub> W <sub>4</sub>	45506	100006	54500	2.20
S <sub>1</sub> W <sub>5</sub>	34706	40878	6172	1.18
S <sub>2</sub> W <sub>1</sub>	36626	63380	26754	1.73
S <sub>2</sub> W <sub>2</sub>	38115	82294	44179	2.16
S <sub>2</sub> W <sub>3</sub>	42026	107656	65330	2.55
S <sub>2</sub> W <sub>4</sub>	46506	108261	61755	2.33
S <sub>2</sub> W <sub>5</sub>	34706	41177	6471	1.19
S <sub>3</sub> W <sub>1</sub>	36626	42780	6154	1.17
S <sub>3</sub> W <sub>2</sub>	38115	69958	31843	1.84
S <sub>3</sub> W <sub>3</sub>	42026	89247	47221	2.12
S <sub>3</sub> W <sub>4</sub>	45506	89730	44224	1.97
S <sub>3</sub> W <sub>5</sub>	34706	38893	4187	1.12
LSD (p=0.05)	-	8249	8249	0.19

(Refer table one for details of treatments)

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