

Effect of chemical weed management on growth, yield and economics of drum seeded rice (*Oryza sativa*)

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ABSTRACT

Field experiment was conducted at Periyankunam, Bhuvanagiri Taluk, Cuddalore District during *Kuruvai* 2021 and 2022 to study the effect of different herbicidal weed management on growth, yield and economics of drum seeded rice (*Oryza sativa* L.) variety 'ASD 16'. The experiment was conducted in randomized block design with four replications. The treatments comprised of six weed management practices and are made up of a combination of herbicides (pre-emergence, early-post and post-emergence herbicides) with hand weeding, which was compared with unweeded control and twice hand weeding on 25 and 45 DAS. Application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 660 g a.i./ha PE fb metsulfuron methyl 10% + chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS fb hand weeding on 45 DAS recorded the highest weed control efficiency of 77.55 and 74.23% during *Kuruvai* 2021 and 2022 respectively, growth attributes at 60 DAS viz., plant height (96.82 and 91.79 cm), tillers/m² (367 and 343) and dry matter production (8.01 and 7.78 t/ha), yield attributes like productive tillers/m² (319 and 312), filled grains/panicle (100.64 and 98.42), grain yield (6.19 and 6.11 t/ha) and benefit cost ratio (2.78 and 2.49) during *Kuruvai* 2021 and 2022, respectively over bispyribac sodium 10% SC @ 25 g a.i./ha PoE on 20 DAS fb hand weeding on 45 DAS (farmers practice). Hence, it is an efficient weed management practice and an economically feasible method for achieving the maximum growth, yield and economics of drum seeded rice.

Key words: Bensulfuron methyl+pretilachlor, Bispyribac sodium, Drum seeded rice, Yield

Rice (*Oryza sativa* L.) is a staple food crop accounting major share in the total food grain production. In India, rice occupies 43.90 million hectares with a production of 114.45 million tonnes and productivity of 2.61 t/ha (Directorate of Economics and Statistics, 2022). In Tamil Nadu, production and productivity under rice is 2.21 million hectares, 8.07 million tonnes and 3.65 t/ha respectively (DES, 2022). Direct seeded rice refers to the process of growing rice crop by directly sowing seeds in the field rather than by transplanting rice seedlings from the nursery (Yadav *et al.*, 2018). Direct seeded rice required less labour and offers the advantages of quicker and easier planting, tolerance to water deficit which resulted in higher profit besides reduction in carbon footprints (Avasthe *et al.*, 2023 and Yadav *et al.*, 2020). Drum seeding of rice offers many advantages: its light weight, easy to transport, gender-neutral, and addresses labor shortages. It allows for sowing larger areas quickly, ensures uniform spacing, reduces production costs, and boosts returns on investment. However, the con-

trol of weeds in drum seeded rice is a challenging task for effective crop production (Suganya, 2023).

Herbicides are essential for weed management, offering timely, effective, economical, and practical control. Selecting the right herbicide, dose, and method at the right time is crucial for managing weeds and increasing crop yield (Singh *et al.*, 2023). Single herbicide applications are often insufficient due to diverse weed flora and potential herbicide resistance. Therefore, sequential applications of pre- and post-emergence herbicides, combined with hand weeding, or using tank-mix or ready-mix herbicides with different modes of action can control a broad spectrum of weeds and delay resistance (Gogoi and Deka 2023). New-generation herbicide mixes reduce usage rates, minimize crop injury, lower application costs, and lessen residual buildup.

Bensulfuron methyl 0.6% + pretilachlor 6% GR is a new generation pre-emergence herbicide mix that effectively controls perennial and annual weeds in rice. Its granular formulation simplifies application for farmers. Triafamone 20% + ethoxysulfuron 10% WG is a recent herbicide providing excellent weed control, enhancing productivity, and saving time and labor. Weeds mainly observed it by leaves and metabolized to inhibit acetolactate

synthase (ALS), crucial for amino acid biosynthesis. Metsulfuron methyl 10% + chlorimuron ethyl 10% WP offers long-term weed management in rice at low doses and costs. Bispyribac sodium 10% SC, a post-emergence herbicide, effectively controls major grasses, sedges, and broad-leaved weeds by interfering with ALS synthesis. Early weed control in drum-seeded rice through pre-emergence and early post-emergence herbicides prevents weed seed germination and growth, avoiding weed seed bank development. Subsequent weed flushes are managed with post-emergence herbicides and hand weeding. This study focuses on the response of new-generation herbicide combinations on the growth and yield of drum-seeded rice.

MATERIALS AND METHODS

Field experiment was conducted at Periyankunam, Bhuvanagiri taluk, Cuddalore District during *Kuruvai* 2021 and 2022. The field is geographically located at 11°46' North latitude, 79°49' East longitude at an altitude of +5.79 m above mean sea level. The weather of the experimental site is moderately warm with hot summer months. The texture of the experimental field soil is clay loam with pH (6.80), EC (0.18 dS/m), Available nitrogen (236.42), phosphorus (20.63) and potassium (305.30) kg/ha. The experimental design adopted was randomized block design with four replications and a gross plot size of 5×4 m. The experimental period for *Kuruvai* 2021 was 26 May to 12 September 2021 and for *Kuruvai* 2022 was 24 May to 10 September 2022. The treatments comprised of T₁ - unweeded control, T₂ - twice hand weeding on 25 and 45 DAS (days after sowing), T₃ - application of bispyribac sodium 10% SC @ 25 g a.i./ha PoE on 20 DAS fb hand weeding on 45 DAS, T₄ - application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 660 g a.i./ha PE fb metsulfuron methyl 10% + chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS, T₅ - application of bensulfuron methyl 0.6% + pretilachlor 6% @ 660 g a.i./ha PE fb metsulfuron methyl 10% + chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS fb hand weeding on 45 DAS and T₆ - application of triafamone 20% + ethoxysulfuron 10% WG @ 60 g a.i./ha early post-emergence (EPoE) on 12 DAS fb metsulfuron methyl 10% + chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS fb hand weeding on 45 DAS. The field was ploughed to fine tilth and made to puddled condition. Rice seeds at the rate of 40 kg/ha were soaked in water for 24 hours and stored in gunny bags for 24 hours. The seeding drums were filled with the pre-germinated seeds up to three-fourths of its capacity and sown in the field with a spacing of 20 cm between the rows and 10 cm between the plants of rows. The short duration rice cultivar 'ASD 16' was used as test variety for the experiment.

A fertilizer schedule of 120-17-27 kg N-P-K/ha, respectively was applied. 50% N, full dose of P and 50% K were applied as basal. The remaining 50% each of N were top dressed in two equal splits at active tillering and panicle initiation stages. The balance 50% of potassium was top dressed at panicle initiation stage. The fertilizer materials used were urea, single super phosphate and muriate of potash to supply nitrogen, phosphorus and potassium respectively. As per the treatment schedule, the pre-emergence herbicide, bensulfuron methyl 0.6% + pretilachlor 6% GR (ready mix) @ 660 g a.i./ha was broadcasted. The granular herbicide was applied with dry sand @ 50 kg/ha. The early post emergence herbicide, triafamone 20% + ethoxysulfuron 10% WG (ready mix) @ 60 g a.i./ha was applied on 12 DAS and the post emergence herbicide metsulfuron methyl 10% + chlorimuron ethyl 10% (ready mix) @ 4 g a.i./ha was applied on 25 DAS and bispyribac sodium 10% SC @ 25 g a.i./ha was applied on 20 DAS. The post emergence herbicides are Acetolactate Synthase (ALS) inhibitors and calculated quantity was mixed with water @ 500 L/ha and sprayed through knapsack sprayer fitted with flood jet nozzle. A thin film of water was maintained at the time of both liquid and granular herbicide application. Two hand weeding were done on 25 and 45 DAS. The unweeded control plots were maintained unweeded throughout the cropping period.

Plant height was measured from the base of the plants to the tip of the top most leaf and expressed in cm. In each plot, four quadrates of 0.25 m² each were placed at random and the total tillers were counted and expressed in number/m². Five hills from each plot were selected from outside the net plot of each treatment area and harvested by cutting close to the ground level at 30, 60 DAS and at 90 DAS. These plants were first air dried in shade and then oven dried at 80 ± 5°C for 48 hrs. The oven dry matter production of plant samples was computed and expressed as kg ha⁻¹. At harvest, four quadrates of 0.25 m² area were marked in each plot and the number of productive tillers was counted. After counting the number of productive tillers/m², five sample panicles per treatment plot were separated and grains were counted and used for determining the mean number of filled and unfilled grains/panicle. The grains from net plot were cleaned, sun dried and weighed at 14 per cent moisture content and the grain yield was calculated, computed and expressed in kg/ha. The gross and net income/ha for each treatment was worked out based on the prevailing market rates. The net income was calculated by deducting the cost of cultivation from the gross return. Benefit cost ratio was worked out by dividing the gross return by the cost of cultivation. The data on various characters studied during the course of investigation were statistically analyzed as suggested by Panse and

Sukhatme (1978). Data on weed population and weed dry matter production showed high variation and hence they were subjected to square root transformation $\sqrt{(x + 0.5)}$ and analyzed. Wherever, statistical significance was observed the critical difference at 0.05 level of probability was worked out for comparison and the non-significant comparison was indicated as 'NS'.

RESULTS AND DISCUSSION

Weed characteristics

The predominant weed flora of the experimental field was *Echinochloa colona*, *Echinochloa crus-galli* among grasses, *Cyperus difformis*, *Cyperus rotundus* among sedges, *Eclipta alba* and *Bergia capensis* among broad-leaved weeds. Application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 660 g a.i./ha PE fb metsulfuron methyl 10% + chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS fb hand weeding on 45 DAS recorded the lowest grasses (21.78 and 27.12/m²), sedges (15.98 and 19.16/m²), broad-leaved weed population (9.73 and 11.77/m²), total weed population (47.49 and 58.05/m²), weed dry matter production (23.81 and 28.90 g/m²) (Table 1) and the highest weed control efficiency (77.55 and 74.23%) during *Kuruvai* 2021 and 2022 respectively (Fig. 1).

This might be due to pre-emergence application of herbicides will maintain weed free condition up to 15 DAS,

post-emergence herbicides may maintain weed free condition up to 35 DAS and the weeds emerged at the later stage was removed by hand weeding at 45 DAS (Singh *et al.*, 2023). The highest grasses (98.38 and 106.01/m²), sedges (66.30 and 70.28/m²), broad-leaved weed population (46.82 and 48.93/m²), total weed population (211.50 and 225.22/m²), weed dry matter production (138.90 and 146.39 g/m²) was recorded under unweeded control.

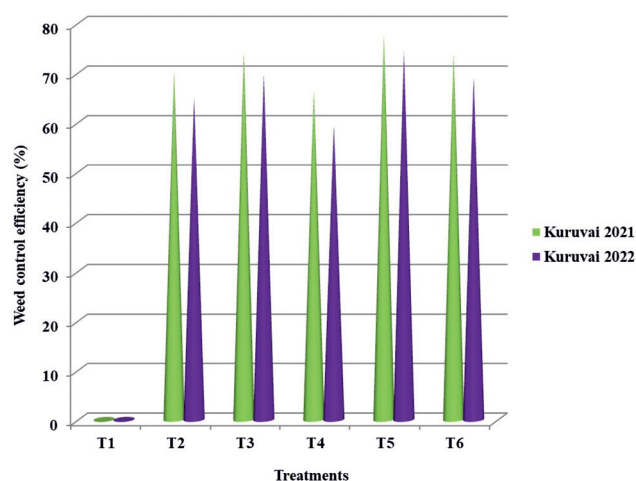


Fig. 1. Effect of chemical weed management on weed control efficiency in drum seeded rice (*Oryza sativa* L.) during *Kuruvai* 2021 and 2022

Table 1. Effect of chemical weed management population and dry weight of weed in drum seeded rice (*Oryza sativa* L.) during *Kuruvai* 2021 and 2022

Treatment	Total grass weed population (No./m ²) at 60 DAS		Total sedge population (No./m ²) at 60 DAS		Total broad-leaved weed population (No./m ²) at 60 DAS		Total weed population (No./m ²) at 60 DAS		Total weed dry matter production (g/m ²) at 60 DAS	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T ₁	(9.94)	(106.01)	(66.30)	(70.28)	(46.82)	(48.93)	(211.50)	(225.22)	(138.90)	(146.39)
	98.38	10.32	8.17	8.41	6.88	7.03	14.56	15.02	11.81	12.12
T ₂	(28.20)	(35.52)	(21.09)	(26.57)	(13.57)	(17.10)	(62.86)	(79.19)	(33.92)	(42.47)
	5.36	6.00	4.65	5.20	3.75	4.19	7.96	8.93	5.87	6.56
T ₃	(24.90)	(31.29)	(18.13)	(23.28)	(11.43)	(13.73)	(54.46)	(68.30)	(28.27)	(35.30)
	5.04	5.64	4.32	4.88	3.45	3.77	7.41	8.29	5.36	5.98
T ₄	(31.80)	(41.06)	(23.62)	(30.49)	(15.57)	(20.10)	(70.99)	(91.65)	(39.72)	(52.24)
	5.68	6.45	4.91	5.57	4.01	4.54	8.46	9.60	6.34	7.26
T ₅	(21.78)	(27.12)	(15.98)	(19.16)	(9.73)	(11.77)	(47.49)	(58.05)	(23.81)	(28.90)
	4.72	5.26	4.06	4.43	3.20	3.50	6.93	7.65	4.93	5.42
T ₆	(25.10)	(31.80)	(18.47)	(23.40)	(11.59)	(14.68)	(55.16)	(69.89)	(28.67)	(36.33)
	5.06	5.68	4.36	4.89	3.48	3.90	7.46	8.39	5.40	6.07
SEm±	0.13	0.15	0.11	0.13	0.09	0.11	0.20	0.21	0.15	0.17
C.D (p=0.05)	0.28	0.31	0.24	0.28	0.20	0.23	0.42	0.45	0.32	0.35

T₁ - Unweeded control, T₂ - Twice hand weeding on 25 and 45 DAS, T₃ - Bispyribac sodium 10% SC @ 25 g a.i./ha PoE on 20 DAS fb hand weeding on 45 DAS, T₄ - Bensulfuron methyl 0.6% + pretilachlor 6% GR @ 660 g a.i./ha PE fb Metsulfuron methyl 10% + Chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS, T₅ - Bensulfuron methyl 0.6% + Pretilachlor 6% GR @ 660 g a.i./ha PE fb Metsulfuron methyl 10% + Chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS fb hand weeding on 45 DAS and T₆ - Triafamone 20% + Ethoxysulfuron 10% WG @ 60 g a.i./ha EPoE on 12 DAS fb Metsulfuron methyl 10% + Chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS fb hand weeding on 45 DAS, PE - pre emergence, EPoE - early post emergence, PoE - post emergence, DAS - days after sowing and fb - followed by. *transformed value, **original value.

Grasses were vigorous competitors, exhausting greater portion of the nutrients and were dominant followed by sedges and broad-leaved weeds. Similar findings were also reported by Sangramsingh *et al.* (2022) and Singh *et al.* (2022).

Growth and yield

Application of pre-emergence herbicide *fb* post emergence on 25 DAS *fb* hand weeding on 45 DAS (T_5) recorded the highest growth attributes *viz.*, plant height (96.82 and 91.79 cm), tillers (367 and 343/m²) and dry matter production (8.01 and 7.78 t/ha) during *Kuruvai* 2021 and 2022, respectively (Table 2). The increase in plant height could be due to maximum absorption of plant nutrients from the soil as least density of weeds and increased crop root, shoot growth, increased number of leaves that produced larger amount of photosynthates, resulting in more cell division, cell enlargement and lastly rapid vegetative growth (Verma *et al.*, 2023). Also, effective control of weeds led to better availability of the nutrients and other growth input required for plants. Higher availability of nutrient enabled proper synchronized tillering (Haldar and Thakur 2023). The combination of one herbicide followed by one or two hand weeding effectively decreased the weed density, facilitated the crop to absorb more nutrients from soil and produce more photosynthates through expansion of leaf area which ultimately produce higher dry matter production (Parameswari and Srinivas, 2014).

The lowest growth attributes were recorded under un-weeded control. This might be due to higher weed competition, and lesser input availability to plants thus reduced the plant height to a greater extent (Padhan *et al.*, 2021). The least dry matter accumulation by crop might be due to adverse effect of crop-weed competition as evident from maximum dry matter production by weeds (Yadav *et al.*, 2018). The T_5 also recorded the highest yield attributes *viz.*, productive tillers (319 and 312/m²), filled grains/panicle (100.64 and 98.42) and yield of 6.19 and 6.11 t/ha during *Kuruvai* 2021 and 2022, respectively (Table 2).

Production of more photosynthates via more effective tillers/m² and proper dry matter partitioning (source to sink) resulted in higher grain and straw (Verma *et al.*, 2023). The lowest yield attributes and yield were recorded under unweeded control. These results were in line with the findings of Keerthi De *et al.* (2024). Higher competition by weeds for the available resources resulted in lower growth and yield attributes and finally lower grain and straw yield (Padhan *et al.*, 2021).

Economics

Among the weed management practices tested, application of bensulfuron methyl 0.6% + pretilachlor 6% GR @

Table 2. Chemical weed management effect on growth, yield and economics of drum seeded rice (*Oryza sativa* L.) during *Kuruvai* 2021 and 2022

Treatment	Growth attributes				Yield attributes and yield				Economics									
	Plant height at 60 DAS (cm)		Tillers at 60 DAS (m ²)		Dry matter production at 60 DAS (t/ha)		Productive tillers (m ²)		Filled grains/panicle		Grain yield (t/ha)		Gross income (Rs.×10 ⁶ /ha)		Net income (Rs.×10 ⁶ /ha)		Benefit Cost ratio (BCR)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1	60.31	56.12	267	254	4.67	4.51	229	224	74.72	74.49	3.76	3.71	71,861	64,356	34,703	27,198	1.93	1.73
T_2	82.60	77.95	306	289	6.67	6.43	288	279	88.19	87.73	5.30	5.23	1,00,745	90,414	56,837	46,506	2.29	2.06
T_3	91.13	86.27	345	328	7.38	7.19	305	302	96.26	93.78	5.86	5.71	1,11,177	98,582	70,344	57,749	2.72	2.41
T_4	75.22	70.83	285	270	6.28	6.03	274	266	83.67	83.15	4.97	4.86	94,523	84,096	54,515	44,088	2.36	2.10
T_5	96.82	91.79	367	343	8.01	7.78	319	312	100.64	98.42	6.19	6.11	1,17,363	1,05,347	75,105	63,089	2.78	2.49
T_6	87.17	82.40	330	317	7.05	6.90	302	294	92.65	92.31	5.59	5.50	1,06,030	94,936	63,425	52,331	2.49	2.23
S. Em±	1.98	1.96	7.57	6.40	0.19	0.16	6.39	4.18	2.16	1.86	0.15	0.12	2.61	1.84	2.37	2.67	—	—
C.D (p=0.05)	3.97	3.92	15.14	12.80	0.37	0.31	12.81	8.36	4.33	3.72	0.28	0.24	5.24	3.67	4.76	5.33	—	—

T_1 - Unweeded control, T_2 - Twice hand weeding on 25 and 45 DAS, T_3 - Bispyribac sodium 10% SC @ 25 g a.i./ha PoE on 20 DAS fb hand weeding on 45 DAS, T_4 - Bensulfuron methyl 0.6% + pretilachlor 6% GR @ 660 g a.i./ha PE fb Metsulfuron methyl 10% + Chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS fb hand weeding on 45 DAS and T_5 - Triafamone 20% + Ethoxysulfuron 10% WG @ 60 g a.i./ha EPoE on 12 DAS fb Metsulfuron methyl 10% + Chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS fb hand weeding on 45 DAS, T_6 - Bensulfuron methyl 0.6% + pretilachlor 6% GR @ 660 g a.i./ha PE fb Metsulfuron methyl 10% + Chlorimuron ethyl 10% WP @ 4 g a.i./ha PoE on 25 DAS fb hand weeding on 45 DAS, PE - pre emergence, EPOE - early post emergence, PoE - post emergence, DAS - days after sowing, fb - followed by and Rs. - rupees.

10 kg/ha PE fb metsulfuron methyl 10% + chlorimuron ethyl 10% WP @ 20 g/ha PoE on 25 DAS fb hand weeding on 45 DAS recorded the highest gross income (117.36 Rs.×10³/ha and 105.35 Rs.×10³/ha), net income (75.11 Rs.×10³/ha and 63.09 Rs.×10³/ha) and B:C ratio (2.78 and 2.49) during *Kuruvai* 2021 and 2022, respectively. Timely controls of weeds with timely application of herbicides has increased the yield, save the money in terms of labour cost reduces the cost of cultivation and get the higher gross income and monetary benefit returns. Cultivation of rice under direct seeding using drum seeder significantly lessens the dependency on labour thereby making it cost effective with timely intercultural operation. The lowest B:C ratio of 1.93 was recorded under unweeded control. This might be due to the highest weed infestation with the lowest yield.

Thus, it can be concluded that application of bensulfuron methyl 0.6% + pretilachlor 6% GR @ 10 kg/ha PE fb metsulfuron methyl 10% + chlorimuron ethyl 10% WP @ 20 g/ha PoE on 25 DAS fb hand weeding on 45 DAS can be recommended to achieve sustainable rice crop productivity and monetary returns in drum seeded rice. Future research work must be focused on the development of new herbicide combinations with different mode of actions for broad spectrum weed control. Low dosage new generation herbicides may also be developed for effective weed control with minimum environmental hazards.

REFERENCES

- Avasthe, R.K., Devi, S.H., Bhupenanchandra, I., Kumar, A., Chongtham, S.K., Babu, S., Singh, R., Das, A., Gudade, B.A. and Bora, S.S. 2023. Agro-tactics for reducing carbon footprint in agricultural production systems: A review. *Indian Journal of Agronomy* **68**(2): 115-125 <https://doi.org/10.59797/ija.v68i2.332>
- DES. 2022. Agricultural Statistics at a Glance; Directorate of Economics and Statistics, Ministry of Agriculture, Cooperation and Farmers Welfare, Government of India: New Delhi, India, p. 24.
- Gogoi, B. and Deka, J. 2023. Effect of integrated weed-management practices in direct-seeded autumn rice (*Oryza sativa*) on growth, yield and soil microflora. *Indian Journal of Agronomy* 140-146: <https://doi.org/10.59797/ija.v68i2.340>
- Haldar, P. and Thakur, A.K. 2023. Effect of planting geometry and weed-management practices on yield of scented rice (*Oryza sativa*) varieties. *Indian Journal of Agronomy* **68**(4): 430-433: <https://doi.org/10.59797/ija.v68i4.5467>
- Keerthi De, Saravanane, P., Poonguzhalan, R. and Nadaradjan, S. 2024. Brown manuring for improved crop growth, yield and energetics of wet seeded-rice (*Oryza sativa*) in the coastal deltaic eco-system. *Indian Journal of Agronomy* **69**: 87-90.
- Padhan, S.R., Rathore, S.S., Prasad, S.M., Shekhawat, K. and Singh, V.K. 2021. Influence of precision nutrient and weed management on growth and productivity of direct-seeded upland rice (*Oryza sativa*) under Eastern Plateau and Hills Region. *Indian Journal of Agronomy* **66**: 366-369.
- Panse, V.G. and Sukhatme, P.V. 1978. Statistical method for agricultural workers. ICAR, New Delhi. 33rd Edn, p.145.
- Parameswari, Y.S. and Srinivas, A. 2014. Influence of weed management practices on nutrient uptake and productivity of rice under different methods of crop establishment. *Journal of Rice Research* **7**(1&2): 77-86.
- Sangramsingh P.K., Dash, S., Chowdhury, Md. R., Nanda, S.S., Sar, K., Behera, B., Gulati J.M.L. 2022. Effect of integrated application of herbicides and straw mulch on productivity and profitability of rainfed upland rice (*Oryza sativa*). *Indian Journal of Agronomy* **67**(3): 316-319.
- Singh, H., Sandhu, K.S. and Bansal K.K. 2022. Effect of first irrigation scheduling and herbicides on productivity of direct-seeded rice (*Oryza sativa*). *Indian Journal of Agronomy* **67**(1): 93-96. <https://doi.org/10.59797/ija.v67i1.95>
- Singh, S., Ghosh, A., Das, T.K., Dhar, S., Prasad, S.M., Tripathy, S., Verma, G. and Tomar J. 2023. Influence of nitrogen and weed-management practices on crop-growth indices and productivity of dry direct-seeded rice (*Oryza sativa*). *Indian Journal of Agronomy* **68**(1): 89-92 <https://doi.org/10.59797/ija.v68i1.209>
- Suganya, R. 2023. Efficacy of new generation herbicidal combination for weed management in direct seeded rice (*Oryza sativa* L.). Ph.D. (Agri.) Thesis, Department of Agronomy, Annamalai University.
- Verma, B., Bhan, M., Jha, A.K., Agrawal, K.K., Kewat, M.L. and Porwal, M. 2023. Weed management in direct-seeded rice (*Oryza sativa*) in central India. *Indian Journal of Agronomy* **68**(2): 211-214. <https://doi.org/10.59797/ija.v68i2.362>
- Yadav, G.S., Babu, S., Das, A., Mohapatra, K.P., Singh, R., Avasthe, R.K. and Roy, S. 2020. No till and mulching enhance energy use efficiency and reduce carbon footprint of a direct-seeded upland rice production system. *Journal of Cleaner Production* <https://doi.org/10.1016/j.jclepro.122700>
- Yadav, G.S., Das, A., Lal, R., Babu, S., Meena, R.S., Patil, S. B., Saha P. and Datta, M. 2018. Conservation tillage and mulching effects on the adaptive capacity of direct-seeded upland rice (*Oryza sativa* L.) to alleviate weed and moisture stresses in the North Eastern Himalayan Region of India. *Archives of Agronomy and Soil Science*, **64**(9): 1254–1267. <https://doi.org/10.1080/03650340.2018.1423555>