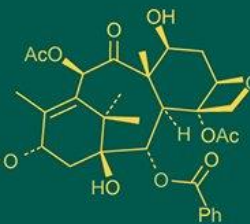
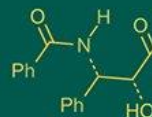
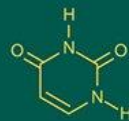
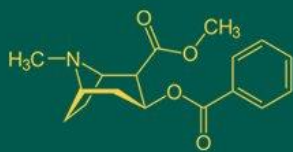


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Chlorophyll pigment dynamics: Transient physiological responses of transplanted rice (*Oryza sativa* L.) to selective pre and post emergence herbicides

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Abstract

A field experiment was conducted during the late *samba* season (October 2019-February 2020) at the Wetland Farm of Tamil Nadu Agricultural University, Coimbatore. Fourteen treatments comprising of six pre emergence herbicides viz, Bensulfuron methyl 0.6%+ Pretilachlor 6% GR @ 10 kg ha⁻¹, Metsulfuron methyl 10.1% + Chlorimuron ethyl 10.1% WP @ 20 g ha⁻¹, Oxadiargyl 80% WP @ a.i 100 g ha⁻¹, Pendimethalin 30% EC @ 1 kg a.i ha⁻¹, Butachlor 50%EC @ 1kg a.i ha⁻¹, Pretilachlor 50 EC @ ai 1 kg ha⁻¹ applied on 3 DAT. Two early post emergence herbicides viz., Imazethapyr 10% SL @ 50 g a.i ha⁻¹ and Bispyribac sodium 10% SC @ 50 g a.i ha⁻¹ applied on 15 DAT, Post emergence herbicides viz., Fenoxaprop-P-ethyl 69 EC @ a.i 60 g ha⁻¹, Cyhalofop-butyl 10% EC a.i @ 70 g ha⁻¹ applied on 20 DAT, Pyrazosulfuron-ethyl 10% WP @ a.i 10 g ha⁻¹ applied on 25 DAT and hand weeding twice on 15 and 25 DAT, weed free check and unweeded control were evaluated in a randomized complete block design with three replications. The chlorophyll content was estimated on 1, 3, 7 and 14 days after herbicide application (DAHA). Significant variations in chlorophyll content were observed among the selective herbicide treatments. Among the pre-emergence herbicides, Chlorimuron-ethyl + Metsulfuron-methyl caused significant decrease in chlorophyll content and recorded lower chlorophyll a (0.54 mg g⁻¹ FW), chlorophyll b (0.19 mg g⁻¹ FW), and total chlorophyll (0.73 mg g⁻¹ FW) on 3 DAHA. Oxadiargyl and Pretilachlor also resulted in significant decrease during the initial observation period. Among early post and post emergence herbicides, Imazethapyr and Fenoxaprop-P-ethyl significantly decreased chlorophyll content with chlorophyll a declining to 0.53 and 0.64 mg g⁻¹ FW, respectively on their respective 3 DAHA. Correspondingly, lower chlorophyll b (0.20 and 0.24 mg g⁻¹ FW) and total chlorophyll (0.74 and 0.89 mg g⁻¹ FW) values were recorded under Imazethapyr and Fenoxaprop-P-ethyl treatments on 3 DAHA. Despite the initial decline, most treatments exhibited gradual recovery of chlorophyll content by 14 DAHA. The weed-free check consistently maintained higher chlorophyll content.

Keywords: Selective herbicides, Chlorophyll, Days after herbicide application (DAHA)

Introduction

Weed infestation continues to be one of the major constraints limiting rice productivity, particularly under evolving crop establishment methods and the increasing scarcity of labour and irrigation water. Among various biotic factors affecting rice cultivation, weeds account for substantial yield losses. In transplanted rice, yield reductions attributable to weed competition have been estimated at approximately 15-20 per cent (Koushik *et al.*, 2019) [6]. To combat these losses, herbicides are widely used as an effective weed management strategy. However, even selective herbicides may induce phytotoxic effects and trigger a range of biochemical and physiological responses in crop plants (Song *et al.*, 2007) [9]. In transplanted rice, the crop gets exposed to the applied pre- and post-emergence herbicides, making it susceptible to herbicide-induced xenobiotic stress. These changes may manifest as oxidative stress resulting from the accumulation of reactive oxygen species (ROS). When the production of ROS exceeds the plant's natural removal mechanisms, it can damage nucleic acids, proteins, and lipids, while also harming the photosynthetic apparatus through photo inhibition.

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The exposure may affect physiological processes by altering photosynthetic activity, disrupting stomatal regulation, and modifying metabolic functions. Such changes may also increase crop susceptibility to fungal infections and other stress-related disorders (Das and Mondal, 2014) [5].

Photosynthesis is the fundamental physiological process governing plant growth and biomass accumulation, and chlorophyll pigments play a pivotal role in light harvesting and energy conversion. Chlorophyll *a* serves as the primary photosynthetic pigment, whereas chlorophyll *b* functions as an accessory pigment that broadens the spectrum of light absorption and facilitates energy transfer to the reaction centers. The total chlorophyll content reflects the overall photosynthetic capacity and physiological status of plants. Any alteration in chlorophyll concentration can directly affect carbon assimilation, growth, and yield formation in rice.

Given the pivotal role of chlorophyll pigments in photosynthesis and plant productivity, understanding their response to herbicide-induced stress is important for assessing crop tolerance and physiological changes. Therefore, the present study was undertaken to evaluate the transient changes in chlorophyll *a*, chlorophyll *b*, and total chlorophyll content of transplanted rice following the application of selective pre-emergence, early post-emergence, and post-emergence herbicides. Chlorophyll pigments were assessed at 1, 3, 7, and 14 days after herbicide application to characterize the temporal physiological responses of the crop.

Material and methods

A field experiment was conducted at wetland farm of Tamil Nadu Agricultural University, Coimbatore during late samba season (October 2019 - February 2020) using medium duration rice variety CO-52. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. A total of fourteen treatments including selective pre-emergence, early-post emergence and post-emergence herbicides were taken up in three replications, which are namely, T₁: Bensulfuron methyl 0.6%+ Pretilachlor 6% GR @ 10 kg ha⁻¹ applied on 3 DAT; T₂: Metsulfuron methyl 10.1% + Chlorimuron ethyl 10.1% WP applied on 3 DAT @ 20 g ha⁻¹; T₃: Oxadiargyl 80% WP @ a.i 100 g ha⁻¹ applied on 3 DAT; T₄: Pendimethalin 30% EC @ 1 kg a.i ha⁻¹ applied on 3 DAT; T₅: Butachlor 50%EC applied on 3 DAT @ 1kg a.i ha⁻¹; T₆: Pretilachlor 50 EC @ a.i 1 kg ha⁻¹ applied on 3 DAT; T₇: Imazethapyr 10% SL @ 50 g a.i ha⁻¹ applied on 15 DAT; T₈: Bispyribac sodium 10% SC @ 50 g a.i ha⁻¹ applied on 15 DAT; T₉: Fenoxaprop-P-ethyl 69 EC @ a.i 60 g ha⁻¹ applied on 20 DAT; T₁₀: Cyhalofop-butyl 10% EC a.i @ 70 g ha⁻¹ applied on 20 DAT; T₁₁: Pyrazosulfuron-ethyl 10% WP @ a.i 10 g ha⁻¹ applied on 25 DAT; T₁₂: Hand weeding twice on 15 and 25 DAT; T₁₃: Weed free check and T₁₄: Unweeded Control. The gross plot size and net plot size were 7 × 3 m and 5.8 × 2.4 m respectively. A spacing of 20 cm x 10 cm was adapted. The experimental soil was clay loam in texture with a pH of 8.0 and an electrical conductivity (EC) of 0.54 dS m⁻¹. The soil was low in available nitrogen (246 kg ha⁻¹), high in available phosphorus (31.8 kg ha⁻¹), and high in available potassium (683 kg ha⁻¹).

Chlorophyll content

Chlorophyll *a*, chlorophyll *b*, and total chlorophyll contents were estimated following the procedure described by Arnon (1949). A leaf sample weighing 250 mg was collected from

each plot and macerated in 10 ml of 80% acetone. The homogenate was centrifuged at 3000 rpm for 10 minutes and the resulting supernatant was collected and its volume was adjusted to 25 ml using 80% acetone. The OD value of the extract was recorded at 663 nm and 645 nm wavelength using a spectrophotometer. The Chlorophyll *a*, *b* and total were calculated based on the formulae:

$$\text{Chlorophyll } a = (12.7 \times \text{OD at } 663) - (2.69 \times \text{OD at } 645) \times \frac{V}{1000 \times W}$$

$$\text{Chlorophyll } b = (22.9 \times \text{OD at } 645) - (4.68 \times \text{OD at } 663) \times \frac{V}{1000 \times W}$$

$$\text{Total Chlorophyll} = (8.02 \times \text{OD at } 663) - (20.2 \times \text{OD at } 645) \times \frac{V}{1000 \times W}$$

Where, V is the final volume of supernatant (ml) and W is the weight of the leaf sample (g)

Chlorophyll content (*a*, *b* and total) of the rice subjected to herbicidal treatments were measured on various Days after herbicide application (DAHA) which include 1, 3, 7 and 14 DAHA for all the herbicide treatments.

The subsequent analyses that 1, 3, 7 and 14 DAHA correspond to 4, 6, 10 and 17 DAT for the pre-emergence herbicide applications; 16, 18, 22 and 29 DAT for the early post-emergence herbicide applications; 21, 23, 27 and 34 DAT for the post-emergence herbicide applications and 26, 28, 32 and 39 DAT for the one late post-emergence herbicide application. In addition, three herbicide free treatments were studied which include two-hand weeding (15 and 25 DAT), a weed free check and an unweeded control were maintained as benchmark.

Results

Chlorophyll *a*

The chlorophyll *a* content of transplanted rice plants subjected to selective herbicides is presented in Table 1.

The selective herbicide application resulted in lower chlorophyll *a* content than that of the weed free check treatment on all the days of observation. The pre-emergence application of Chlorimuron-ethyl + Metsulfuron-methyl resulted in significantly lower chlorophyll *a* content, followed by pre-emergence application of Oxadiargyl and Pretilachlor which were on par on all 1 (4 DAT), 3 (6 DAT) and 7 DAHA (10 DAT), with lower chlorophyll *a* content of 0.54 mg g⁻¹, 0.54 mg g⁻¹ and 0.79 mg g⁻¹ observed on 3 DAHA (6 DAT) (Table 1). However, the chlorophyll *a* content in these treatments recovered to about 1.19 to 1.25 mg g⁻¹ on 25 DAHA (28 DAT).

Among the post-emergence herbicide applications, early post-emergence application of Imazethapyr and post-emergence application of Fenoxaprop-P-ethyl showed significantly low chlorophyll *a* content of 0.53 mg g⁻¹ and 0.64 mg g⁻¹ on 3 DAHA (18 DAT) and 1 DAHA (21 DAT), respectively.

Thus, the pre-emergence application of Chlorimuron-ethyl + Metsulfuron-methyl and Oxadiargyl, early post-emergence herbicide application of Imazethapyr and post-emergence application of Fenoxaprop-P-ethyl caused a significant decrease in the chlorophyll *a* content (0.53 to 0.64 mg g⁻¹) on corresponding 1 to 3 DAHA.

Chlorophyll *b*

The chlorophyll *b* content of transplanted rice influenced by selective herbicide treatments is presented in Table 2. The pre-emergence application of Chlorimuron-ethyl +

Metsulfuron-methyl (0.34 mg g^{-1}), Oxadiargyl (0.36 mg g^{-1}) and Pendimethalin (0.40 mg g^{-1}) resulted in lower chlorophyll *b* content that were on par on 1 DAHA (4 DAT). Chlorimuron-ethyl + Metsulfuron-methyl and Oxadiargyl exhibited lower chlorophyll *b* on 3 DAHA (6 DAT) and the Chlorimuron-ethyl + Metsulfuron-methyl application showed lower chlorophyll *b* on 7 DAHA (10 DAT) in the range of 0.19 to 0.28 mg g^{-1} . The chlorophyll *b* content, however, showed recovery in all these treatments between 7 to 14 DAHA (10 to 17 DAT). Among the post-emergence herbicides, early post-emergence application of Imazethapyr recorded significantly lower chlorophyll *b* content 0.20 mg g^{-1} on 3 DAHA (18 DAT). Post emergence application of Fenoxaprop-P-ethyl led to significantly lower content of 0.24 mg g^{-1} on 1 DAHA (21 DAT). The selective herbicide application resulted in lower chlorophyll *b* content than that of the weed free check treatment on all the days of observation.

Total chlorophyll

The total chlorophyll content of transplanted rice as influenced by selective herbicide treatments is presented in Table 3.

The effect of selective herbicides on the total chlorophyll content was found to be consistent with that observed for chlorophyll *a* and chlorophyll *b* content. Among the pre-emergence herbicide treatments, Chlorimuron-ethyl + Metsulfuron-methyl recorded significantly lower total chlorophyll content (0.73 - 0.89 mg g^{-1}) on all 1 (4 DAT), 3 (6 DAT) and 7 DAHA (10 DAT) followed by Oxadiargyl (0.74 - 1.18 mg g^{-1}) and Pretilachlor (1.07 - 1.17 mg g^{-1}) which were on par with each other.

However, among the post-emergence herbicides, significant decrease was observed in the early post-emergence application Imazethapyr (0.74 mg g^{-1}) on 3 DAHA (18 DAT) and post-emergence application of Fenoxaprop-P-ethyl (0.89 mg g^{-1}) on 1 DAHA (21 DAT). Thus Chlorimuron-ethyl + Metsulfuron-methyl as pre-emergence herbicide, Imazethapyr as early post-emergence herbicide and Fenoxaprop-P-ethyl as post-emergence herbicide caused a significant decrease in the total chlorophyll content. The recovery was found to be the lower for the early post-emergence application of Imazethapyr. The total chlorophyll content of the pre-emergence application of Bensulfuron-methyl + Pretilachlor, Butachlor and Pendimethalin were on par on either 1 or 14 DAHA (4 or 17 DAT).

Discussion

The chlorophyll molecules are considered important pigments responsible for the capture of light essential to carry out the photochemical reactions, in the photosystem's reaction centres (Taiz and Zeiger, 2009) ^[10]. Among the pre-

emergence herbicides, application of Chlorimuron-ethyl + Metsulfuron-methyl, Pretilachlor, and Oxadiargyl resulted in significantly lower total chlorophyll content than Bensulfuron-methyl + Pretilachlor, Pendimethalin, and Butachlor. Among the post-emergence herbicides, early post-emergence application of Imazethapyr recorded the lowest chlorophyll content, followed by post-emergence application of Fenoxaprop-P-ethyl. In contrast, the weed-free check consistently exhibited higher chlorophyll content on all days of observation, which may be attributed to the absence of abiotic and biotic stresses. These stress-free conditions likely promoted the normal synthesis and efficient functioning of chlorophyll. Exposure to various abiotic and biotic stress factors has been reported to reduce chlorophyll content in plants (Chaves *et al.*, 2009) ^[9]. Among various abiotic factors, herbicides are important synthetic compounds, among which few acts on synthesis of chlorophyll in the Porphyrinic portion, the main site of action for PROTOX inhibitors (Wakabayashi and Boger, 1999). These herbicides may inhibit a common enzyme involved in both chlorophyll and cytochrome biosynthetic pathways, resulting in the accumulation of intermediate tetrapyrroles and consequently arresting chlorophyll formation (Matringe *et al.*, 1989) ^[8]. This could explain the lower pigment content recorded in pre emergence selective herbicide Oxadiargyl treatment, a PPO (Protoporphyrinogen oxidase) inhibitor. A reduction in pigment content resulting from the action of PROTOX inhibitors has also been reported by several authors (Tripathy *et al.*, 2007) ^[11]. Similarly, the selective herbicides Metsulfuron-methyl + Chlorimuron-ethyl and Imazethapyr, which are Acetolactate Synthase (ALS) inhibitors, could have affected the autonomous machinery of chloroplasts and subsequently impaired protein synthesis. This, along with the phytotoxic effects associated with these herbicides (Plate1), might have contributed to the marked reduction in chlorophyll content. Likewise, A case inhibitors act on plastids within chloroplasts, leading to a reduction in chlorophyll content (Burton *et al.*, 1987) ^[3], which could account for the lower chlorophyll levels observed during the initial days following herbicide application.

The present findings are in agreement with earlier reports. Marchezan *et al.* (2017) ^[7] observed a marked reduction in total chlorophyll content in rice following the application of Imazethapyr + Imazapic and Imazapyr + Imazapic. Similarly, Agostinetto *et al.* (2016) ^[1] reported reduced chlorophyll content in wheat following the application of selective herbicides. Yin *et al.* (2008) ^[13] also reported an approximately 11% reduction in chlorophyll content in wheat treated with Isoproturon, even at a low application dose. Chlorophyll content exhibited a gradual recovery by 14 DAHA, indicating that the initial herbicide-induced stress was transient.



Plate1: Phytotoxic response of transplanted rice to application of Imazethapyr as early post emergence herbicide

Conclusion

The present study demonstrated that selective herbicides induced transient alterations in chlorophyll pigments of transplanted rice, with the magnitude of response varying among herbicide molecules and application timings. Significant reductions in chlorophyll a, chlorophyll b, and total chlorophyll content were observed during the initial days after herbicide application, particularly with chlorimuron-ethyl + metsulfuron-methyl, oxadiargyl, imazethapyr, and fenoxaprop-P-ethyl. The decline in

chlorophyll content indicates a temporary disturbance in the photosynthetic apparatus arising from herbicide-induced physiological stress. However, most herbicide treatments exhibited progressive recovery of chlorophyll pigments by 14 days after application, suggesting the ability of rice plants to overcome initial phytotoxic effects. The consistently higher chlorophyll content recorded under the weed-free check further highlights the importance of stress-free conditions for maintaining photosynthetic efficiency.

Table 1: Effect of selective herbicides on chlorophyll a (mg g⁻¹ FW) of transplanted rice

Treatment		Days after transplanting															
		4	6	10	16	17	18	21	22	23	26	27	28	29	32	34	39
T ₁	PE Bensulfuron-methyl 0.6%+ Pretilachlor 6% @ 10 kg ha ⁻¹ on 3 DAT	1.17	1.02	1.08	1.28	1.29	1.28	1.30	1.30	1.30	1.31	1.31	1.31	1.31	1.31	1.32	1.38
T ₂	PE Chlorimuron-ethyl 10% + Metsulfuron-methyl 10% @ 20 g ha ⁻¹ on 3 DAT	0.62	0.54	0.61	1.07	1.07	1.08	1.08	1.08	1.18	1.06	1.16	1.22	1.09	1.16	1.17	1.22
T ₃	PE Oxadiargyl @ 100 g a.i. ha ⁻¹ on 3 DAT	0.98	0.54	0.86	1.14	1.14	1.10	1.15	1.15	1.15	1.16	1.16	1.19	1.16	1.17	1.17	1.23
T ₄	PE Pendimethalin @ 1.0 kg a.i. ha ⁻¹ on 3 DAT	1.08	0.76	1.30	1.33	1.34	1.34	1.35	1.35	1.35	1.36	1.40	1.36	1.36	1.35	1.36	1.51
T ₅	PE Butachlor @ 1.0 kg a.i. ha ⁻¹ on 3 DAT	1.15	0.81	1.04	1.24	1.24	1.24	1.25	1.25	1.25	1.32	1.40	1.46	1.33	1.34	1.35	1.68
T ₆	PE Pretilachlor @ 1.0 kg a.i. ha ⁻¹ on 3 DAT	0.76	0.79	0.86	1.01	1.02	1.17	1.02	1.02	1.02	1.10	1.10	1.25	1.10	1.10	1.14	1.47
T ₇	EPOE Imazethapyr @ 50 g a.i. ha ⁻¹ on 15 DAT	1.20	1.21	1.26	0.61	0.56	0.53	0.74	0.74	0.75	0.91	0.88	0.96	0.99	1.00	1.01	1.17
T ₈	EPOE Bispyribac sodium @ 50 g a.i. ha ⁻¹ on 15 DAT	1.24	1.27	1.31	1.11	1.10	1.10	0.87	0.87	0.88	1.00	1.01	1.06	1.07	1.18	1.23	1.30
T ₉	POE Fenoxaprop-P-ethyl @ 60 g a.i. ha ⁻¹ on 20 DAT	1.20	1.22	1.26	1.28	1.29	1.29	0.64	0.69	0.75	0.98	1.04	1.06	1.07	1.09	1.12	1.20
T ₁₀	POE Cyhalofop-butyl @ 70 g a.i. ha ⁻¹ on 20 DAT	1.22	1.22	1.28	1.30	1.31	1.31	0.81	0.87	1.02	1.05	1.12	1.13	1.15	1.14	1.18	1.29
T ₁₁	POE Pyrazosulfuron-ethyl @ 10 g a.i. ha ⁻¹ on 25 DAT	1.21	1.22	1.27	1.30	1.30	1.34	1.31	1.32	1.30	1.10	1.12	1.14	1.18	1.20	1.23	1.28
T ₁₂	Two hand weeding (15 and 25 DAT)	1.20	1.22	1.28	1.28	1.29	1.30	1.35	1.33	1.37	1.37	1.35	1.37	1.38	1.45	1.47	1.69
T ₁₃	Weed free check	1.26	1.25	1.31	1.35	1.35	1.35	1.34	1.37	1.35	1.42	1.42	1.48	1.42	1.53	1.55	1.69
T ₁₄	Control (unweeded)	1.21	1.22	1.31	1.33	1.34	1.32	1.26	1.31	1.27	1.33	1.33	1.33	1.35	1.39	1.41	1.60
	SED	0.04	0.03	0.05	0.04	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.04	0.05	0.04	0.06
	CD (P=0.05)	0.08	0.07	0.10	0.08	0.06	0.08	0.07	0.08	0.08	0.09	0.10	0.10	0.08	0.10	0.09	0.12

Table 2: Effect of selective herbicides on chlorophyll b (mg g⁻¹ FW) of transplanted rice

Treatment		Days after transplanting															
		4	6	10	16	17	18	21	22	23	26	27	28	29	32	34	39
T ₁	PE Bensulfuron-methyl 0.6%+ Pretilachlor 6% @ 10 kg ha ⁻¹ on 3 DAT	0.43	0.37	0.39	0.46	0.47	0.47	0.47	0.47	0.46	0.48	0.48	0.48	0.48	0.48	0.48	0.51
T ₂	PE Chlorimuron-ethyl 10% + Metsulfuron-methyl 10% @ 20 g ha ⁻¹ on 3 DAT	0.34	0.19	0.27	0.39	0.39	0.39	0.39	0.38	0.37	0.40	0.40	0.40	0.40	0.42	0.42	0.47
T ₃	PE Oxadiargyl @ 100 g a.i. ha ⁻¹ on 3 DAT	0.36	0.20	0.31	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.43	0.47
T ₄	PE Pendimethalin @ 1.0 kg a.i. ha ⁻¹ on 3 DAT	0.40	0.28	0.47	0.48	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.52
T ₅	PE Butachlor @ 1.0 kg a.i. ha ⁻¹ on 3 DAT	0.42	0.30	0.37	0.45	0.45	0.45	0.46	0.46	0.46	0.48	0.48	0.48	0.48	0.49	0.49	0.52
T ₆	PE Pretilachlor @ 1.0 kg a.i. ha ⁻¹ on 3 DAT	0.35	0.29	0.31	0.37	0.37	0.37	0.37	0.37	0.37	0.40	0.40	0.40	0.40	0.40	0.42	0.47
T ₇	EPOE Imazethapyr @ 50 g a.i. ha ⁻¹ on 15 DAT	0.44	0.44	0.45	0.22	0.21	0.20	0.28	0.27	0.27	0.37	0.33	0.35	0.35	0.36	0.37	0.39
T ₈	EPOE Bispyribac sodium @ 50 g a.i. ha ⁻¹ on 15 DAT	0.46	0.46	0.47	0.40	0.40	0.40	0.32	0.32	0.32	0.36	0.37	0.38	0.39	0.43	0.45	0.50
T ₉	POE Fenoxaprop-P-ethyl @ 60 g a.i. ha ⁻¹ on 20 DAT	0.44	0.44	0.45	0.47	0.47	0.47	0.24	0.25	0.27	0.36	0.38	0.38	0.39	0.39	0.41	0.46
T ₁₀	POE Cyhalofop-butyl @ 70 g a.i. ha ⁻¹ on 20 DAT	0.45	0.44	0.46	0.47	0.48	0.48	0.30	0.32	0.37	0.38	0.41	0.41	0.42	0.41	0.43	0.49
T ₁₁	POE Pyrazosulfuron-ethyl @ 10 g a.i. ha ⁻¹ on 25 DAT	0.45	0.44	0.46	0.47	0.48	0.47	0.48	0.48	0.47	0.40	0.41	0.42	0.43	0.44	0.45	0.49
T ₁₂	Two hand weeding (15 and 25 DAT)	0.44	0.44	0.46	0.47	0.47	0.47	0.49	0.49	0.50	0.49	0.49	0.50	0.50	0.53	0.53	0.58
T ₁₃	Weed free check	0.46	0.46	0.48	0.49	0.49	0.49	0.49	0.50	0.49	0.51	0.51	0.51	0.52	0.56	0.56	0.59
T ₁₄	Control (unweeded)	0.46	0.45	0.47	0.48	0.49	0.49	0.46	0.48	0.46	0.48	0.48	0.49	0.49	0.51	0.51	0.58
	SED	0.016	0.014	0.014	0.012	0.015	0.015	0.015	0.017	0.017	0.014	0.012	0.013	0.013	0.013	0.011	0.013
	CD (P=0.05)	0.033	0.028	0.030	0.025	0.031	0.032	0.031	0.035	0.035	0.029	0.026	0.026	0.026	0.026	0.023	0.023

Table 3: Effect of selective herbicides on total chlorophyll (mg g⁻¹ FW) of transplanted rice (main field)

Treatment		Days after transplanting															
		4	6	10	16	17	18	21	22	23	26	27	28	29	32	34	39
T ₁	PE Bensulfuron-methyl 0.6%+ Pretilachlor 6% @ 10 kg ha ⁻¹ on 3 DAT	1.60	1.40	1.48	1.74	1.76	1.75	1.77	1.78	1.77	1.79	1.79	1.79	1.79	1.79	1.80	1.90
T ₂	PE Chlorimuron-ethyl 10%+ Metsulfuron-methyl 10% @ 20 g ha ⁻¹ on 3 DAT	0.97	0.73	0.89	1.47	1.47	1.47	1.48	1.47	1.56	1.46	1.55	1.62	1.49	1.58	1.59	1.70
T ₃	PE Oxadiargyl @ 100 g a.i. ha ⁻¹ on 3 DAT	1.34	0.74	1.18	1.56	1.56	1.53	1.58	1.57	1.58	1.58	1.59	1.62	1.59	1.59	1.60	1.70
T ₄	PE Pendimethalin @ 1.0 kg a.i. ha ⁻¹ on 3 DAT	1.48	1.08	1.76	1.83	1.82	1.82	1.84	1.84	1.84	1.85	1.89	1.86	1.86	1.85	1.86	2.08
T ₅	PE Butachlor @ 1.0 kg a.i. ha ⁻¹ on 3 DAT	1.57	1.15	1.43	1.70	1.70	1.70	1.71	1.71	1.71	1.81	1.88	1.94	1.82	1.83	1.85	2.19
T ₆	PE Pretilachlor @ 1.0 kg a.i. ha ⁻¹ on 3 DAT	1.11	1.07	1.17	1.38	1.40	1.54	1.39	1.40	1.40	1.51	1.51	1.65	1.50	1.51	1.56	1.93
T ₇	EPOE Imazethapyr @ 50 g a.i. ha ⁻¹ on 15 DAT	1.64	1.65	1.71	0.83	0.79	0.74	1.02	1.02	1.03	1.28	1.21	1.31	1.34	1.36	1.38	1.57
T ₈	EPOE Bispyribac sodium @ 50 g a.i. ha ⁻¹ on 15 DAT	1.71	1.73	1.78	1.52	1.50	1.50	1.19	1.19	1.21	1.37	1.38	1.44	1.46	1.61	1.68	1.80
T ₉	POE Fenoxaprop-P-ethyl @ 60 g a.i. ha ⁻¹ on 20 DAT	1.64	1.67	1.71	1.75	1.76	1.76	0.89	0.94	1.02	1.33	1.42	1.45	1.46	1.48	1.54	1.66
T ₁₀	POE Cyhalofop-butyl @ 70 g a.i. ha ⁻¹ on 20 DAT	1.67	1.67	1.74	1.78	1.79	1.79	1.11	1.19	1.39	1.43	1.52	1.55	1.56	1.55	1.61	1.78
T ₁₁	POE Pyrazosulfuron-ethyl @ 10 g a.i. ha ⁻¹ on 25 DAT	1.66	1.67	1.73	1.77	1.78	1.81	1.80	1.80	1.78	1.50	1.53	1.56	1.61	1.64	1.68	1.78
T ₁₂	Two hand weeding (15 and 25 DAT)	1.64	1.67	1.75	1.75	1.76	1.78	1.86	1.82	1.87	1.86	1.85	1.86	1.88	1.98	2.00	2.27
T ₁₃	Weed free check	1.72	1.71	1.79	1.84	1.85	1.85	1.83	1.87	1.85	1.93	1.93	2.00	1.94	2.09	2.12	2.29
T ₁₄	Control (unweeded)	1.67	1.67	1.78	1.82	1.83	1.81	1.72	1.79	1.73	1.81	1.81	1.82	1.84	1.90	1.92	2.18
	S.Ed	0.04	0.04	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.07
	CD (P=0.05)	0.09	0.08	0.11	0.10	0.07	0.09	0.09	0.10	0.09	0.11	0.11	0.11	0.10	0.12	0.09	0.14

DAT: Days after transplanting; PE: Pre-Emergence; EPOE: Early Post-Emergence; POE: Post-Emergence

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