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Effect of weed management in transplanted rice under new alluvial zone of West Bengal

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Abstract
A field experiment was conducted at the Agricultural D Block Farm, situated in Kalyani, West Bengal. The primary objective of this experiment was effectiveness of employing herbicides as a weed management strategy in transplanted rice cultivation, specifically within the emerging alluvial zone of West Bengal. The experimental evaluations were undertaken during the *kharif* seasons of both 2020 and 2021. The outcomes unveiled a noteworthy finding. The treatment pretilachlor 50% EC @ 0.70 kg/ha as a pre-emergence followed by conoweeder, succeeded by another application of pretilachlor 50% EC at 0.70 kg/ha as pre-emergence followed by bispyribac-Na 10% SC at 25 g/ha at 25 DAT as a post-emergence intervention, showcased compelling results. This combined approach remarkably delivered a comprehensive and wide-ranging management of weeds. Furthermore, it was associated with the lowest recorded densities and dry weights among the predominant weed species. Pretilachlor 50% EC @ 0.70 Kg/ha PE *fb* triafamone + ethoxysulfuron @ (44.0+22.5 g/ha) and hand weeding (20 and 40 DAT) also provided better weed control and was comparable to pretilachlor 50% EC @ 0.70 kg/ha PE *fb* cyhalofop-butyl 5.1% + penoxsulam 1.02% OD @ 112.5 + 22.5 g/ha. (RM). The highest grain and straw yield was recorded under pretilachlor 50% EC @ 0.70 Kg/ha PE *fb* passing of conoweeder which was comparable with pretilachlor 50% EC @ 0.70 kg/ha PE *fb* bispyribac-Na 10% SC @ 25 g/ha 25 DAS as POE. The weedy check plots exhibited the highest levels of weed density and dry weight, resulting in the lowest grain yield upon harvesting. Based on the findings, pretilachlor 50% EC @ 0.70 kg/ha PE *fb* bispyribac-Na 10% SC @ 25 g/ha 25 DAS as POE was the best weed management practices which appeared as effective and safe for managing of broad spectrum weeds & to reduce considerable loss in yield over other weeds management practices.

Keywords: Weed management, transplanted rice, alluvial zone

Introduction
Rice (*Oryza sativa* L.) stands as one of the most crucial cereal crops globally, cultivated in diverse agro-ecosystems (Jahan *et al*., 2020) [8]. Serving as a staple food for over half of the world's population, it caters to 20% of the global calorie demand and 31% of domestic consumption (Sandhu *et al*., 2015) [12]. Its role in ensuring food security is paramount, especially considering the challenge of feeding the steadily growing global population, which is projected to surpass nine billion people by 2050 (Godfray *et al*., 2010) [7]. According to USDA records, global rice production has reached 493.79 million tons. In India, rice holds significant importance as a major staple food crop, predominantly grown in lowland rainfed conditions (Basak *et al*., 2017) [1]. The demand for rice is steadily increasing and is projected to continue rising in the foreseeable future. However, rice production has either remained stagnant or, in certain instances, even experienced decline. A critical impediment to rice cultivation is the pervasive presence of weeds, especially exacerbated within the context of transplanted rice ecosystems (Choudhary and Dixit, 2018) [3]. Weeds pose a substantial threat to the triumph of transplanted rice, as they vigorously vie for essential environmental resources both above ground - such as light, CO2, and space - and below ground - comprising moisture and vital plant nutrients. This competitive pressure significantly jeopardizes the crop's viability and potential yield (Choudhary and Dixit, 2021) [2]. While manual weed management has proven effective, it is an expensive undertaking. Recent times have witnessed a shortage of adequately skilled labor, resulting in escalated labor costs. In light of these circumstances, herbicides have emerged as pivotal and dependable tools for weed management, contributing significantly over the past few decades. The attributes of herbicides, including their cost-effectiveness, ease of application, and efficacy in combatting weed infestations within crop fields, are well-established (Nandula *et al*., 2005) [11].

Nevertheless, the consistent employment of a solitary herbicide utilizing the same mode of action, and that too multiple times within a single growing season, elevates the potential hazard of engendering weed biotypes resistant to the herbicide. This phenomenon has assumed significant importance within the agricultural sphere (Fartyal *et al*., 2018; Choudhary *et al*., 2021) [6, 2]. Consequently, the imperative lies in the evaluation of novel herbicides capable of managing a broad spectrum of weed varieties. Presently, the trend in herbicide usage revolves around identifying efficacious means of weed control through the utilization of low doses of high-efficiency herbicides. This approach not only curtails the overall herbicide volume but also renders application more feasible and cost-effective (Kathiresan, 2001) [9]. The identification of suitable herbicides offering both economical and safe weed control measures holds paramount importance in augmenting the productivity and sustainability of rice cultivation. Keeping in view these points, the present study was conducted to know the bio-efficacy of herbicides weed management in transplanted rice under new alluvial zone of West Bengal.

Materials and Methods

A field experiment was meticulously conducted at the Agricultural D Block Farm, located in Kalyani, West Bengal, situated at coordinates 22°97' N and 88°46' E. The experimental site is positioned at an elevation of 257 meters above the mean sea level. This investigation took place over the kharif seasons of both 2020 and 2021. The geographical region experiences an average annual rainfall of approximately 1150 mm. Notably, the temperature range spans from 10°C during the winter months to 42°C throughout the summer period. The soil composition at the experimental site is characterized by a clay texture, with moderate organic carbon content measuring 0.46%. The soil's nutrient composition includes 192.60 kg/ha of available nitrogen, 205.94 kg/ha of available potassium, and notably higher levels of available phosphorus, measuring 22.6 kg/ha. For the cultivated crop, a nutrient regimen of 80 kg N, 60 kg P2O5, and 40 kg K2O/ha was applied. Of these, the full dose of P2O5 and ¾ of K2O were judiciously administered just prior to sowing, effectively laying the foundation for the ensuing growth cycle. The experiment was laid out in randomized block design (RBD) with 9 treatments *viz.* oxadiagryal 80% WP @ 0.1 kg/ha PE fb 2,4-D @ 0.5 kg/ha 25 DAT as POE, pretilachlor 50% EC @ 0.70 kg/ha PE, pretilachlor 50% EC @ 0.70 kg/ha PE *fb* bispyribac-Na 10% SC @ 25 g/ha 25 DAS as POE, pretilachlor 50% EC @ 0.70 kg/ha PE *fb* cyhalofop-butyl 5.1% + penoxsulam 1.02% OD @ 112.5 + 22.5 g/ha. (RM), oxadiagryal 80% WP @ 0.1 kg/ha PE *fb* passing of conoweeder, pretilachlor 50% EC @ 0.70 Kg/ha PE *fb* passing of conoweeder, pretilachlor 50% EC @ 0.70 Kg/ha PE *fb* triafamone + ethoxysulfuron @ (44.0+22.5 g/ha), 2 hand weeding at 20 & 40 DAT and weedy check (control) and replicated thrice. The required amount of herbicide was sprayed with 375 L/ha water volume with the help of knapsack sprayer fitted with a flat fan nozzle.

At the 30 days after transplanting (DAT) stage, a systematic sampling procedure was undertaken to determine weed density and dry weight. This involved placing a quadrat measuring 50 cm × 50 cm (0.25 m²) at two distinct locations within each experimental plot. Weed density was ascertained by species-specific counts within each quadrat, while the dry weight of the collected weeds was subsequently measured. The drying process was conducted in a hot air oven at a controlled temperature of 65±2 °C, continued until a constant dry weight was achieved. To gauge the efficacy of weed control measures, as well as to establish a measure of weed presence, standard formulas devised by Mani *et al*. (1973) [10] and Das (2008) [5] were employed to calculate weed control efficiency and weed index, respectively. For the assessment of crop yield, both grain and straw outputs were recorded within a demarcated area of 10 m² and then extrapolated to a hectare for broader analysis. The collected data underwent thorough statistical analysis using the dedicated OPSTAT software. Recognizing the non-uniform nature of the weed data, a square root transformation ($\sqrt{x+0.5}$) was applied to normalize the values. However, to ensure clarity and facilitate comprehension, the original values were also presented parenthetically alongside the transformed data.

Result and Discussion

Weed flora

The experimental field encompassed a variety of weed species, including *Echinochloa spp*., *Cynodon dactylon, Eleusine indica, and Panicum repens* within the grass family. Among sedges, the field featured *Cyperus iria* and *Fimbristylis miliacea,* while *Alternanthera phyloxeroides, Malva neglecta, Eclipta alba, Ludwigia parviflora,* and *Monochoria vaginalis* represented the broadleaf weed (BLW) category. Within this diverse array of weeds, the field's composition was primarily dominated by broadleaf weeds, followed by grasses and sedges. For detailed insights into the density and dry weight of grassy, BLW, and sedge weeds, please refer to Figure 1.

Weed density

The application of weed management treatments exerts a pronounced influence on the density of grasses, broad-leaved weeds (BLWs), and sedges, as evidenced in Table 1. Embracing weed management strategies that incorporate herbicides notably resulted in a substantial reduction in the densities of all three categories of weeds, as compared to the unchecked growth observed in the weedy control group. However, pretilachlor 50% EC @ 0.70 Kg/ha PE *fb* passing of conoweeder 30 DAT was the most effective with 91.78% of WCE followed by pretilachlor 50% EC @ 0.70 kg/ha PE *fb* bispyribac-Na 10% SC @ 25 g/ha 25 DAS as POE and pretilachlor 50% EC @ 0.70 Kg/ha PE *fb* triafamone + ethoxysulfuron (44.0+22.5 g/ha) (89.29 & 86.01%). The remaining herbicidal treatments exhibited weed control capabilities, although to a lesser extent, ranging from 82.58% to 74.52% of Weed Control Efficiency (WCE) compared to the weedy control group. In comparison to the weedy control, pretilachlor 50% EC at 0.70 kg/ha as a pre-emergence measure demonstrated the lowest efficacy with a WCE of 72.64%. This treatment exhibited limited effectiveness in controlling the majority of the weed population. The plots maintained as weedy controls registered the highest weed density in the study.

Table 1: Effect of weed management treatments on weed density, weed dry weight, weed control efficiency and weed index of weeds at 30DAT of transplanted rice during kharif 2020 & 2021(Pooled value of two years)

Treatments	Weed density (no./m²)			WCE (%)	Weed dry weight (g/m²)			WI (%)
	Grass	Broad Leaf	Sedge		Grass	Broad Leaf	Sedge	
Oxadiagryal 80% WP @ 0.1 kg/ha PE fb 2,4-D @ 0.5 kg/ha 25 DAT	3.13 (9.31)	3.12 (9.28)	2.08 (3.86)	79.33	2.27 (4.68)	2.38 (5.16)	1.22 (0.99)	23.08
Pretilachlor 50% EC @ 0.70 kg/ha	3.42 (11.24)	3.29 (10.38)	2.22 (4.46)	72.64	2.59 (6.24)	2.53 (5.94)	1.28 (1.16)	28.14
Pretilachlor 50% EC @ 0.70 kg/ha PE *fb* bispyribac-Na 10% SC @ 25 g/ha 25 DAS	2.23 (4.48)	2.42 (5.37)	1.75 (2.59)	89.29	1.41 (1.49)	1.98 (3.43)	1.03 (0.58)	4.29
Pretilachlor 50% EC @ 0.70 kg/ha PE *fb* cyhalofop-butyl 5.1% + penoxsulam 1.02% OD @ 112.5 + 22.5 g/ha	2.75 (7.08)	2.82 (7.48)	1.95 (3.33)	82.58	1.88 (3.05)	2.29 (4.77)	1.17 (0.88)	15.57
Oxadiagryal 80% WP @ 0.1 kg/ha PE *fb* passing of conoweeder	3.27 (10.23)	3.20 (9.79)	2.14 (4.09)	74.52	2.39 (5.22)	2.47 (5.60)	1.36 (1.37)	26.91
Pretilachlor 50% EC @ 0.70 Kg/ha PE *fb* passing of conoweeder	2.04 (3.68)	2.13 (4.07)	1.60 (2.07)	91.78	1.36 (1.35)	1.77 (2.65)	0.96 (0.43)	0
Pretilachlor 50% EC @ 0.70 Kg/ha PE *fb* triafamone + ethoxysulfuron @ (44.0+22.5 g/ha)	2.38 (5.16)	2.60 (6.29)	1.85 (2.94)	86.01	1.69 (2.37)	2.11 (3.96)	1.10 (0.71)	10.72
2 hand weeding at 20 & 40 DAT	2.89 (7.890	3.29 (10.36)	2.03 (3.62)	80.36	2.15 (4.16)	2.32 (4.91)	1.17 (0.87)	18.71
Weedy check (control)	5.46 (29.39)	5.61 (31.00)	2.97 (8.32)	0	4.54 (20.18)	5.14 (25.97)	2.35 (5.03)	55.47
S.Em (±)	0.41	0.53	0.14	-	0.2	0.22	0.1	-
CD at 0.05	1.19	1.55	0.40	-	0.58	0.66	0.48	-

Weed dry weight

Parallel to the trends observed in weed density, the quantification of weed dry weight similarly followed suit. The results demonstrated the most minimal accumulations of dry weight in grasses (ranging from 1.35 to 20.18 g/m²), broad-leaved weeds (ranging from 2.65 to 25.97 g/m²), and sedges (ranging from 0.43 to 5.03 g/m²) under the treatment involving Pretilachlor 50% EC at 0.70 Kg/ha as a pre-emergence measure, followed by the utilization of a conoweeder at the 30-day after transplanting (DAT) stage, resulting in a remarkable 0.00% Weed Index (WI). Nevertheless, notable parallels were also discerned in the cases of Pretilachlor 50% EC at 0.70 kg/ha as pre-emergence, coupled with Bispyribac-Na 10% SC at 25 g/ha at 25 DAS as post-emergence, and Pretilachlor 50% EC at 0.70 Kg/ha as pre-emergence, followed by the application of a combination of Triafamone and Ethoxysulfuron at 44.0 g/ha and 22.5 g/ha, respectively. These combined herbicide applications exhibited an enhanced impact on weed control, resulting in reduced weed dry weights with Weed Indices ranging from 4.29% to 10.72% (Table 1). Among the array of herbicidal treatments, the application of Pretilachlor 50% EC at 0.70 Kg/ha as pre-emergence, followed by the combination of Triafamone and Ethoxysulfuron at 44.0 g/ha and 22.5 g/ha, respectively, emerged as notably superior to the other herbicides. This observation underscores the advantageous aspect of employing combined herbicide applications, which demonstrates superior efficacy compared to the use of individual herbicides. It is noteworthy that the unchecked growth of weeds was associated with higher densities across all weed groups.

Grain and straw yields

The management of weeds in transplanted rice significantly influenced both the grain and straw yields, as well as the harvest index, as indicated in Table 2. Notably, the treatment involving the application of pretilachlor 50% EC at a rate of 0.70 Kg/ha as a pre-emergence measure, followed by the use of a conoweeder, resulted in the highest recorded grain yield of 6.70 tons per hectare. This achievement was closely pursued by the treatment regimen featuring Pretilachlor 50% EC @ 0.70 kg/ha in conjunction with Bispyribac-Na 10% SC @ 25 g/ha at 25 days after transplanting (DAS) as a post-emergent application, along with Pretilachlor 50% EC @ 0.70 kg/ha followed by a combination of Triafamone + Ethoxysulfuron @ 44.0 g/ha and 22.5 g/ha, respectively, resulting in grain yields of 6.33 t/ha and 6.06 t/ha, respectively. This notable increase in grain yield can be attributed to the effective mitigation of weed competition through the implementation of pre-emergence (PE) herbicides during the early stages. This early intervention curtailed weed growth during the initial growth phase of the crop. Furthermore, the subsequent application of post-emergent (POE) measures further controlled subsequent waves of weed emergence, thereby ensuring comprehensive weed management throughout the entire crop cycle. This combined PE and POE approach collectively contributed to the improved crop growth conditions, ultimately leading to enhanced grain yield. Among the herbicidal treatments, pretilachlor 50% EC @ 0.70 kg/ha PE *fb* bispyribac-Na 10% SC @ 25 g/ha 25 DAS as POE recorded a higher grain yield than other treatments due to the mode of action of pretilachlor involves inhibiting the biosynthesis of fatty acids in the target weeds. Specifically, it interferes with the Acetyl-CoA carboxylase (ACCase) enzyme, which plays a crucial role in fatty acid synthesis. By inhibiting ACCase, pretilachlor disrupts grassy weeds' normal growth and development, ultimately leading to their control (Shilpakar *et al.* 2020) [13]. After that bispyribac-sodium consists in the inhibition of the branched amino acid biosynthesis. This substance exhibits a favorable eco-toxicological profile, effectively disrupting the growth of various weed species across multiple cycles. Notably, it demonstrates notable efficacy against weeds such as *Dinebra retroflexa, Eleucine indica, Digitaria sanguinalis, Alternanthera sessilis*, and *Cyperus iria*. Among these, the compound exhibits its potency in managing successive infestations of these weed species. The recorded minimum grain yield was observed in the weedy control group. This outcome can be attributed to the heightened weed pressure within this group, which subsequently intensified the competition for essential resources at the cultivation site (Choudhary *et al*., 2021) [4]. Grain yield exhibits a negative correlation with weed density and weed dry weight. To capture this relationship, a second order polynomial model was employed to describe the variation of grain yield concerning changes in weed density and dry weight. The model yielded an R-squared value of 0.996 & 0.994 (Fig 1).

Table 2: Effect of weed management treatments on Grain yield, straw yield and harvest index (%) in transplanted rice (Pooled value of two years)

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Oxadiagryal 80% WP @ 0.1 kg/ha PE fb 2,4-D @ 0.5 kg/ha 25 DAT	5.19	6.77	40.70
Pretilachlor 50% EC @ 0.70 kg/ha	4.90	6.33	40.56
Pretilachlor 50% EC @ 0.70 kg/ha PE *fb* bispyribac-Na 10% SC @ 25 g/ha 25 DAS	6.33	7.81	42.81
Pretilachlor 50% EC @ 0.70 kg/ha PE *fb* cyhalofop-butyl 5.1% + penoxsulam 1.02% OD @ 112.5 + 22.5 g/ha	5.74	7.29	41.33
Oxadiagryal 80% WP @ 0.1 kg/ha PE *fb* passing of conoweeder	5.03	6.44	40.6
Pretilachlor 50% EC @ 0.70 kg/ha PE *fb* passing of conoweeder	6.70	8.17	42.92
Pretilachlor 50% EC @ 0.70 kg/ha PE *fb* triafamone + ethoxysulfuron @ (44.0+22.5 g/ha)	6.06	7.56	41.86
2 hand weeding at 20 & 40 DAT	5.40	7.15	40.82
weedy check (control)	3.14	4.77	35.57
S.Em (±)	0.05	0.14	0.67
CD at 0.05	0.16	0.43	1.94

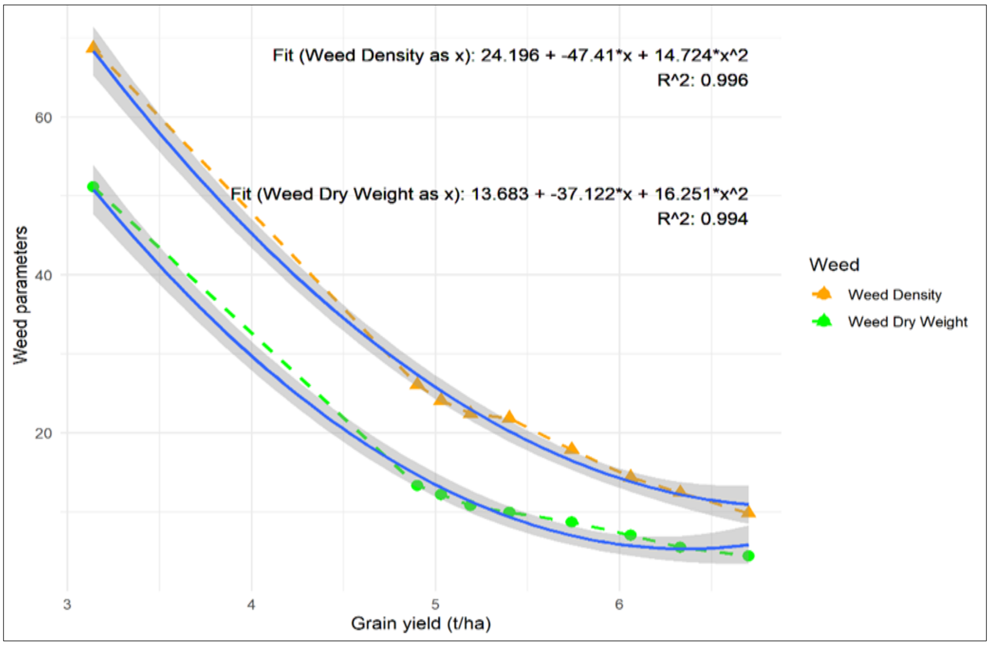

Fig 1: Relationship between grain yield and weed density and weed dry weight

Conclusion

Although the herbicide pretilachlor 50% EC @ 0.70 kg/ha PE *fb* passing of conoweeder considerably reduced the weed infestation and registered lower weed density, weed dry weight, weed index, higher WCE which was comparable to treatment pretilachlor 50% EC @ 0.70 kg/ha PE *fb* bispyribac-Na 10% SC @ 25 g/ha and hand weeding. It may be concluding that pretilachlor 50% EC @0.70 Kg/ha PE *fb* bispyribac-Na 10% SC @ 25 g/ha treatment appeared as effective and safe for managing of broad spectrum weeds & to reduce considerable loss in yield without leaving any residues in post-harvest soil in new alluvial zone of West Bengal.

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