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Impact of Soil Mulch Sowing and Herbicides on Weed Growth and Productivity of Direct Seeded Rice in Lateritic Soil of West Bengal

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ABSTRACT: The field experiment was carried out at the Agricultural Farm of the Institute of Agriculture in Visva-Bharati, Sriniketan, Birbhum, West Bengal, during the *kharif* season of 2021 to study the impact of soil mulch sowing and herbicides on growth of weed species and productivity of direct seeded rice (DSR). Two main plot treatments *viz.* soil mulch (pre-sowing irrigation followed by sowing) and no mulch (sowing followed by irrigation) and five subplot treatments, *viz.* pre-emergence (PE) oxadiargyl at 90 g ha^{-1}; post emergence (PoE) bispyribac sodium at 25 g ha^{-1}; PE oxadiargyl at 90 g ha^{-1} *fb* PoE bispyribac sodium 25 g ha^{-1}; premix triafamone 20% + ethoxysulfuron 10% at 60 g ha^{-1} and unweeded control were assigned in a split-plot design replicated thrice. Rice cultivar "MTU 1010" was grown as a test crop. The major weed species infesting the DSR throughout the cropping period were *Echinochloa colona, Paspalum notatum, Cyperus iria, Ludwigia parviflora, Alternanthera philoxeroides* and *Sphenoclea zeylanica*. The density and dry weight of each weed species as well as grain and straw yield of rice did not vary significantly within sowing methods, however, it varied significantly among the weed management practices. The density and dry weight of weed species was numerically less under sowing after pre-sowing irrigation (soil mulch) method. Among weed management methods, the treatment PE application of oxadiargyl at 90 g ha^{-1} *fb* PoE bispyribac sodium at 25 g ha^{-1} recorded significantly lower values of density and biomass of all weed species and was followed by PoE premix triafamone 20% + ethoxysulfuron 10% at 60 g ha^{-1}. The PE application of oxadiargyl at 90 g ha^{-1} *fb* PoE bispyribac sodium at 25 g ha^{-1} recorded significantly higher grain and straw yield of rice. Sequential application of PE oxadiargyl at 90 g ha^{-1} *fb* PoE bispyribac sodium at 25 g ha^{-1} or PoE premix triafamone 20% + ethoxysulfuron 10% at 60 g ha^{-1} proved to be effective for management of complex weed flora and higher productivity of direct seeded rice in lateritic soil of West Bengal.

Keywords: Direct seeded rice, pre-emergence herbicides, post emergence herbicide, pre-mix herbicide, soil mulch sowing, weed management.

INTRODUCTION

Rice (*Oryza sativa* L.) is the principal and staple food crop for the large and growing population of the India. During the 2024–2025 growing season, about 149.07 mt rice has been produced on an area of 51.42 mha in India (Anonymous, 2025). Frequent puddling has a detrimental effect on the physical characteristics of soil by dissolving soil aggregates and decreasing permeability in subsurface layers. Additionally, puddling and transplanting processes use up to 30% of the water needed for rice cultivation (Chauhan, 2012) and labor, both of which are becoming scarce and costly, which lowers the profitability of rice production. These limitations of puddled transplanted rice are driving the search for alternative options. The search for alternative crop establishment methods is also prompted by the monsoon's unpredictable nature.

Undisturbed soil structure, up to 60% less irrigation water, 40% less labor, up to 60% less energy (compared to diesel), time, a reduction in greenhouse gas emissions and global potential, increased fertilizer use efficiency, early maturity of 7–10 days, improved growth of subsequent crops, increased system productivity, etc. are some benefits of direct seeding. Though, DSR offers several advantages, but poor germination, uneven crop stand and high weed infestation are the major constraints in DSR (Farooq *et al*., 2010). Yield loss due to weed competition typically ranges between 15 and 73 percent (Duary *et al*., 2015), but in extreme situations, it may result in total crop failure (Jayadeva *et al*., 2011). Rice grain yield may be reduced by up to 37.3% in due to weed competition in wet DSR (Satapathy *et al*., 2017). The DSR may be established by sowing in moist soil (soil mulch sowing) or dry soil followed by irrigation (dry-DSR) (Sudhir *et* *al*., 2013). To improve weed control and reduce evaporation losses, soil mulch sowing is a simple management change that involves pre-sowing irrigation and shallow tillage (to break soil capillaries and form soil mulch) before to rice seeding. By reducing the need for early irrigation, soil mulch sowing makes it possible to plant DSR two to three weeks prior to the start of the monsoon, when rice may be established and the risk of stand death from flooding from the monsoon rains is minimized (Sarangi *et al*., 2020). By postponing irrigation for 21 days after sowing instead of immediately after, soil mulch sowing also reduced early weed pressure (weed density and biomass were roughly 71-74% and 62% lower, respectively), saving 12% on irrigation water (IRRI, 2020).

Herbicides have significantly improved agriculture in conditions where farmers have been unable to adopt manual and mechanical methods of controlling weeds in rice because of high labor costs, a shortage of labor during the crucial weed competition period, and unfavorable weather conditions during weeding. Due to labor costs and shortages, the most cost-effective and logical option for controlling weeds in large-scale rice farming has been the use of herbicides (Anwar *et al*., 2011). Effective weed control requires integrated weed management, which combines herbicide with other methods. Pre-emergence herbicide use combined with subsequent post emergence herbicide or mechanical or human weeding has been shown to improve weed-control efficiency in upland DSR (Singh *et al.*, 2016).

MATERIALS AND METHODS

A. Study location details

The experiment was carried out during *kharif* season (June – October) of the year 2021 at the Agricultural Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal, India (23°40′N, and 87°39′E, 58.9 m above mean sea level). The experimental station lies within typical sub humid tropical climate in the red and lateritic agro-ecological zone. The soil of the study site is sandy loam in texture. The experimental soil contains 0.43% organic carbon, 296.2 kg ha^{-1} alkaline permanganate oxidizable nitrogen (N), 27.3 kg ha^{-1} available phosphorus (P) and 196.8 kg ha^{-1} 1 N ammonium acetate exchangeable potassium (K). The pH of the soil was 5.62 (1:2.5 soil: water ratio).

B. Experimental details

Two soil mulch sowing practices *viz.*, sowing after pre-sowing irrigation (soil mulch) and sowing followed by irrigation (no mulch) were allocated in the main plot and five weed management practices *viz.*, PE oxadiargyl at 90 g ha^{-1}, PoE bispyribac sodium at 25 g ha^{-1}, PE oxadiargyl at 90 g ha^{-1}*fb* PoE bispyribac sodium at 25 g ha^{-1}, PoE application of premix triafamone 20% + ethoxysulfuron 10% at 60 g ha^{-1} and unweeded control were allocated in the sub plot in split plot design replicated thrice. The crop was fertilized with 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O, respectively. Half quantity of nitrogen and full amount of phosphorus and potassium were applied in each plot as basal during final land preparation. Rest one-fourth quantity of N was applied at maximum tillering and other one fourth at panicle initiation stage. The elite, high-yielding, short duration, widely cultivated mega-variety of rice, *Cottondora Sannalu* "MTU 1010" (Acharya NG Ranga Agricultural University, India) was used as a test crop. Using a power-operated knapsack sprayer, all of the herbicides were evenly sprayed throughout the experimental plots according to treatments using 500 liters of water per hectare. The weed density (expressed as no. m^{-2}) and biomass was measured by counting and removing all weeds that were inside the randomly placed quadrats of 50 cm × 50 cm at four places as sampling area in each plot. These collected weed species were then dried in a hot air oven at 70- 75°C to determine weed biomass and expressed in g m^{-2}. The grain and straw of rice was recorded after proper threshing and drying. The distribution of the data on weed was normalized by applying a square root transformation. The "analysis of variance" technique was used to statistically assess the experimental data, and significance was tested by variance ratio *i.e*. value at 5% level of significance as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

A. Effect on weeds

The DSR experimental field was infested with seven weed species out of which *Echinochloa colona* (L.) Link and *Paspalum notatum* Flüggé among grasses; *Cyperus iria* (L.) among sedges and *Ludwigia parviflora* Roxb., *Alternanthera philoxeroides* (Mart.) Griseb. and *Sphenoclea zeylanica* Gaertner among broadleaved weeds were predominant. Malik *et al*. (2021); Jaiswal *et al*. (2022); Sar and Duary (2022) have documented a similar composition of weed flora in DSR in this region.

The density and dry weight of different weed species reported did not vary significantly under both the mulch and non-mulch sowing methods. Though the density of weed species was numerically lower under sowing after pre-sowing irrigation (soil mulch) method, regardless of herbicidal treatments. The effect of soil mulching was not obtained due to occurrence of rainfall (34.3 mm) immediately after one day of sowing leading to equalization of soil mulch sowing and no mulch sowing resulting in no or little difference between these two methods of sowing. Mulching generally suppresses weeds by blocking light, modifying soil temperature, which inhibits weed seed germination by allowing them to remain dormant initially, minimizing early competition. However, after the occurrence of rainfall, mulching did not remain effective and weed germination was accelerated across both mulched and non-mulched plots, reducing the observable differences in weed density and biomass. Weed emergence is highly sensitive to soil moisture and temperature, both of which were altered by the rainfall immediately after sowing. Among different weed management practices, PE application of oxadiargyl at 90 g ha^{-1}*fb* PoE application of bispyribac sodium at 25 g ha^{-1} in DSR was found to be significantly superior over other treatments in reducing the densities of mentioned weed species and was followed by PoE application of premix triafamone 20% + ethoxysulfuron 10% at 60 g ha^{-1}. Weedy check plots registered the highest weed density of all the species at 60 DAS. PE application of oxadiargyl at 90 g ha^{-1}*fb* PoE application of bispyribac sodium at 25 g ha^{-1} effectively reduced the densities of *E. colona, P. notatum, C. iria, L. parviflora, A. philoxeroides* and *S. zeylanica* by 94.40%, 75.18%, 100%, 87.72% 95.69% and 98.55% respectively, over weedy check at 60 DAS. The density of *C. iria* at 60 DAS was effectively controlled by PE application of oxadiargyl at 90 g ha^{-1} *fb* PoE application of bispyribac sodium at 25 g ha^{-1}.

The PE application of oxadiargyl at 90 g ha^{-1} *fb* PoE application of bispyribac sodium at 25 g ha^{-1} significantly reduced the biomass of the all the weed species among different weed management practices and was followed by with PoE application of premix triafamone 20% + ethoxysulfuron 10% at 60 g ha^{-1}. The species of grasses, broad-leaved and sedges accumulated the highest biomass of each at 60 DAS under weedy check. PE application of oxadiargyl at 90 g ha^{-1} *fb* PoE application of bispyribac sodium at 25 g ha^{-1} significantly reduced the biomass of *C. iria* at 60 DAS. The application of oxadiargyl as PE at 90 g ha^{-1} and bispyribac sodium as PoE at 25 g ha^{-1} over a weedy check at 60 DAS reduced the biomass of E. *colona, P. notatum, C. iria, L. parviflora, A. philoxeroides, S. zeylanica*, and *J. repens* by 83.98%, 88.86%, 100%, 87.19%, 84.6% and 77.34%, respectively. Verma *et al.* (2016); Kumar *et al.* (2022) concluded that mulching and herbicides reduced the dry weight and density of weed species. In the present experiment soil mulching was not so effective because of rainfall immediately after sowing. Otherwise, mulching might have resulted significant difference over no mulching as observed in earlier research findings by Chauhan *et al*. (2012), who concluded that mulching can prevent weed germination and growth by acting as a physical barrier, reducing light availability, and modifying soil temperature and moisture conditions. Similarly, the notion that early weed pressure can be reduced by sowing with soil mulch has also been reported (IRRI, 2020). Furthermore, Mohapatra *et al.* (2021); Jaiswal *et al.* (2022) reported in their findings that a broad spectrum of weed flora could be effectively controlled by the sequential application of herbicides, which was superior to the pre-emergence application of herbicides alone.

Table 1: Effect of soil mulch and weed management practices on species wise weed density at 60 DAS.

Treatments	**Weed density (No. m^{-2}) at 60 DAS**					
	Paspalum notatum	***Echinochloa colona***	***Cyperus iria***	***Ludwigia parviflora***	***Alternenthera philoxeroides***	***Sphenoclea zeylanica***
Mulching practices						
Sowing after pre-sowing irrigation (soil mulch sowing)	5.41 (28.70)	4.28 (17.80)	4.02 (15.70)	5.00 (24.50)	4.37 (18.60)	4.97 (24.20)
Sowing followed by (*fb*) irrigation (no soil mulch)	6.32 (39.42)	4.49 (19.68)	5.03 (24.81)	6.16 (37.46)	4.70 (21.62)	5.43 (29.04)
S. Em(±)	0.21	0.08	0.17	0.24	0.17	0.10
LSD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management practices						
Oxadiargyl	5.19 (26.40)	3.37 (10.88)	3.95 (15.11)	5.62 (31.07)	4.76 (22.13)	4.88 (23.35)
Bispyribac-sodium	6.39 (40.31)	4.06 (15.99)	6.39 (40.31)	6.01 (35.67)	5.66 (31.50)	7.42 (54.52)
Oxadiargyl*fb* bispyribac-sodium	4.51 (19.85)	2.15 (4.11)	0.71 (0.00)	3.02 (8.64)	1.77 (2.62)	1.40 (1.47)
Triafamone + ethoxysulfuron	4.26 (17.62)	3.75 (13.59)	1.25 (1.07)	4.83 (22.87)	2.68 (6.69)	2.21 (4.37)
Unweeded control (Weedy check)	8.97 (79.97)	8.59 (73.37)	10.33 (106.16)	8.42 (70.38)	7.83 (60.78)	10.11 (101.78)
S.Em (±)	0.27	0.14	0.26	0.36	0.26	0.27
LSD(P=0.05)	0.81	0.43	0.79	1.08	0.77	0.80

*Figures within parentheses indicate original values and the data were transformed to $\sqrt{(X + 0.5)}$ before analysis; DAS = Day after sowing

Table 2: Effect of soil mulch and weed management practices on species wise weed biomass at 60 DAS.

Treatments	Weed biomass (g m^{-2}) at 60 DAS					
	Paspalum notatum	*Echinochloa colona*	*Cyperus iria*	*Ludwigia parviflora*	*Alternenthera philoxeroides*	*Sphenoclea zeylanica*
Mulching practices						
Sowing after pre-sowing irrigation (soil mulch sowing)	5.84 (33.60)	3.76 (13.70)	3.28 (10.30)	3.27 (10.20)	1.55 (1.90)	1.67 (2.30)
Sowing followed by (*fb*) irrigation (no soil mulch)	6.62 (43.37)	4.13 (16.59)	4.04 (15.79)	3.34 (10.64)	1.62 (2.13)	1.70 (2.39)
S. Em(±)	0.14	0.17	0.13	0.05	0.02	0.06
LSD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management practices						
Oxadiargyl	5.45 (29.18)	3.20 (9.71)	3.74 (13.46)	3.75 (10.20)	1.44 (1.58)	1.61 (2.10)
Bispyribac-sodium	6.49 (41.56)	4.94 (23.92)	5.36 (28.19)	3.88 (14.57)	1.53 (1.85)	1.70 (2.39)
Oxadiargyl*fb* bispyribac-sodium	4.14 (16.64)	2.25 (4.58)	0.71 (0.00)	1.78 (2.68)	1.13 (0.77)	1.32 (1.24)
Triafamone + ethoxysulfuron	4.87 (23.23)	2.90 (7.90)	1.21 (0.97)	2.53 (5.92)	1.48 (1.68)	1.32 (1.24)
Unweeded control (Weedy check)	10.22 (103.86)	6.45 (41.11)	7.29 (52.66)	4.57 (20.93)	2.34 (5.00)	2.46 (5.57)
S.Em (±)	0.32	0.19	0.20	0.15	0.08	0.08
LSD(P=0.05)	0.97	0.56	0.59	0.45	0.23	0.25

*Figures within parentheses indicate original values and the data were transformed to $\sqrt{(X + 0.5)}$ before analysis; DAS = Day after sowing

B. Effect on rice

Soil mulch sowing method did not vary significantly, but registered numerically higher values of test weight, grain and straw yield as well as harvest index of rice than no soil mulch sowing method (Table 3). This was due to the occurrence of rainfall immediately one day after sowing, which likely limited the time available for soil mulch sowing method to exhibit a significant impact on controlling weeds. Better weed control with effective soil mulching might have facilitated improved crop growth through the production of more number of tillers and higher accumulation of photosynthates resulting in significant improvement in yield. Among weed management practices, irrespective of the sowing method, test weight, grain yield and straw yield of rice was significantly higher with PE application of oxadiargyl at 90 g ha^{-1}*fb* PoE application of bispyribac sodium at 25 g ha^{-1} than other treatments and was followed by the treatment, PoE application of premix triafamone 20% + ethoxysulfuron 10% at 60 g ha^{-1}. Application of either pre emergence or post emergence herbicides as part of timely and effective weed management techniques effectively controlled dominant weed speices that appeared in the early stages of crop growth, resulting in less competition between rice and weed for nutrients, water, light, and space. This allowed for better utilization of sunlight, increased synthesis of carbohydrates, and better partitioning of photosynthates towards grain formation, all of which ultimately led to higher rice grain yield (Kumar *et al.*, 2023). Baghel *et al*. (2020) earlier reported that the sequential application of pre- and post-emergence herbicides with increased bio-efficacy against diverse weed flora in DSR, resulted in better crop growth and yield. Weedy check registered significantly lowest grain and straw yield encouraging the growth of weeds, resulting in yield losses. The weedy check plots recorded 79.44 and 39.13% lower grain and straw yield than PE application of oxadiargyl at 90 g ha^{-1} *fb* PoE application of bispyribac sodium at 25 g ha^{-1}. Saravanane (2020); Pavithra *et al.* (2021) also reported similar hindrance of rice growth by weed interference.

Table 3: Effect of soil mulch and weed management practices on test weight, grain yield, straw yield and harvest index of rice.

Treatments	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index
Mulching practices				
Sowing after pre-sowing irrigation (soil mulch sowing)	22.5	3998	6708	35.5
Sowing followed by (*fb*) irrigation (no soil mulch)	22.2	3567	6056	35.3
S.Em(±)	0.11	81	133	0.8
LSD (P=0.05)	**NS**	**NS**	**NS**	**NS**
Weed management practices				
Oxadiargyl	22.4	4347	6428	40.3
Bispyribac-sodium	22.3	3925	6469	37.8
Oxadiargyl*fb* bispyribac-sodium	23.2	5028	7487	40.2
Triafamone + ethoxysulfuron	22.6	4578	6968	39.7
Unweeded control (Weedy check)	21.1	1033	4557	18.9
S.Em (±)	0.25	90	271	1.0
LSD (P=0.05)	0.76	269	811	3.1

CONCLUSIONS

From the result, it can be concluded that effective soil mulching in direct seeded rice along with sequential application of pre-emergence oxadiargyl *fb* post emergence bispyribac-sodium or post emergence application of pre-mix triafamone + ethoxysulfuron appeared to be an effective and reliable approach for managing complex weed flora and higher productivity in lateritic soils of eastern India.

FUTURE SCOPE

The future scope of research in soil mulch sowing and herbicide use holds transformative potential for sustainable farming. By refining mulch materials and their application, we can enhance weed suppression, conserve water, and improve seedling vigor. Long-term studies are also needed to understand the impact on soil health, microbial diversity, and carbon dynamics. More research on this aspect of weed management should be conducted with different crops and cropping systems across different agro- climatic conditions.

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