Effect of integrated weed management practices involving oxadiargyl and pretilachlor on microbial population in soil, yield and economics in wet direct seeded rice

ABSTRACT

An experiment had been conducted at the Agronomy Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) in the *kharif* season of 2019, to determine the effects of integrated weed management practices on microbial population in soil, yield and economics in wet direct seeded rice. Pre-emergence herbicides (Oxadiargyl and Pretilachlor) were followed by post-emergence herbicide (Bispyribac-Na), mechanical and manual weeding. Plots treated with oxadiargyl performed better than pretilachlor. Oxadiargyl when was integrated with Hand Weeding (HW) at 35 days after sowing (DAS) gave results which were better than twice HW plot (T_{10}). Oxadiargyl @ 70g/ha at 7-11 DAS *fb* HW at 30-35 DAS (T_4) proved to be superior to all the treatments when yield and economics of wet direct seeded rice was concerned and was statistically at par with twice HW plot (T_{10}) and oxadiargyl @ 70 g/ha at 7-11 DAS *fb* bispyribac-Na @ 25 g/ha at 30-35 DAS (T_2). The unsprayed and two-hand weeding treatments had much lower levels of fungi, actinobacteria, and bacteria than the other weed control methods. The herbicidal treatments had much higher microbial populations at all stages of observation.

Keywords: Oxadiargyl, pretilcahlor, wet direct seeded rice, integrated weed management, weed control efficiency

INTRODUCTION

Rice (*Oryza sativa* L.) is considered the most important staple crop of Asia and other tropical and subtropical regions of the world. Rice accounts for 35-80% of total calorie consumption in Asia **(Anonymous, 1997)**. Around one third of their daily calorie requirement is met through rice in Asia **(Anonymous, 2013)**. By the virtue of high yielding varieties, irrigation resources, fertilizer application etc., rice production has increased by six times since 1950. Globally, rice demand is expected to grow by 25% from the year 2001 to 2025 to meet the requirement of increasing population **(Rosegrant *et al.*, 2002)**. Approximatively 500 million tons of milled rice had been produced globally during the 2019/2020 marketing year **(Anonymous, 2020)**. In India, increase in minimum support price of rice and its adaptability to various biotic and abiotic factors have made it a preferable crop for farmers especially those who fall under the category of marginal farmers. In Indian subcontinent 121.46 million tonnes of rice was produced in the year 2020-21 **(Anonymous, 2020)**.

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The three principal methods through which rice being cultivated are, dry- direct seeding, wet-direct seeding and transplanting **(Kumar *et al.*, 2015)**. In Asia, even though transplanting on puddled soil is beneficial but it is less economic because of rising labor cost and unavailability of water for irrigation. Puddling and transplanting together consume around 30% of total water required for rice cultivation **(Chauhan, 2012)**. Compared to transplanted rice, direct seeded rice (DSR) consumes 35-57% less water and also 67% less labour is required **(Chauhan *et al.*, 2012)**. **Ali *et al.* (2014)** reported that in Asia, 2 M ha of fully irrigated and 13 M ha of partially irrigated land experience water scarcity during wet season and 22 M ha of irrigated lands in the dry season would face economic water scarcity by 2025. Wet-direct seeding of rice is a method in which pre-germinated seeds are sown in line or broadcasted into puddled field. Seeds are pre-germinated by soaking them in water for 24 hrs after which they are transferred into jute-bag and kept in it for 24 hrs to drain out excess water. The seed if left longer becomes entangled making it difficult to separate and thus causing damage to the seed when planted.

Herbicides are considered of great significance for economical weed control in direct wet-seeded rice. Since the mode of action can not necessarily rely on soil particle adsorption or uptake by weeds in an aqueous environment the choice of herbicide for wet seeding, where soil may be saturated or may have standing water is relatively narrow compared to dry seeding. Application of pre-emergence herbicides such as pendimethalin, butachlor, oxadiargyl, pretilachlor, all-mix, etc., have been recommended.

One method of weed control is not sufficient to manage the weeds in rice. Therefore, integrated approach is required to manage the weeds in rice. Currently there are strong environmental and economic incentives for adopting alternative practices for weed management such as integrated weed management (IWM) **(Swanton and Weise, 2004)**. One goal of IWM is to maintain weed population below an economic threshold level **(Auld and Tisdell, 2003)**.

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MATERIALS AND METHODS

Field experiment

The field experiment was conducted at Agronomy Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) in the *kharif* season of 2019. Experimental site was situated at 21°4' N latitude and 81°35' E Longitude with an altitude of 290.20 meter above the mean sea level. Rice variety "Rajeshwari" was grown as test crop. The crop duration is about 120-125 days. To prepare the field, one deep ploughing was done on 10th August, 2019 before the start of the experiment. Finally, the field was puddled with caged wheel which was followed by planking. Recommended dose of nutrient 120:60:40 kg N: P_2O_5: K_2O ha^{-1} was applied through urea, diammonium phosphate (DAP) and muriate of potash (MOP), respectively. Urea was applied in three split doses as basal, at tillering and panicle initiation stage while DAP and MOP was applied as basal. The experiment was replicated three times and design was randomized block design. The treatment details have been given in Table I. The soil of experimental field was clayey (*Vertisols*) in texture, which was low, medium and medium in available N (164.50 kg/ha.), P (15.80 kg/ha.) and K (278.00 kg/ha.), respectively. The pre-germinated seeds were sown using drum seeder. The seed rate used was 40 kg/ha and inter-row distance was 20 cm. Herbicides were dissolved thoroughly in water at the rate of 500 litre/ha as carrier and sprayed in their respective plots. Ambika paddy weeder was used for inter-row mechanical weeding. Sowing was done using a drum seeder by filling the drum seeder up to 2/3rd of the height using a seed rate of 40 kg/ha and 20 cm spacing was maintained in between of rows. Seeds were pre-germinated by soaking them in water for 24 hrs after which they were kept in jute-bag under shade for 24 hrs to drain out excess water. Seeds before sowing were kept under the open sky for an hour, hence, it made sowing convenient as slightly dried seeds separated easily and there was less entanglement. Two hand weedings were done at 25 and 50 days after sowing (DAS) in T_{10} and only one hand weeding at 30-35 DAS was done in T_4 and T_8. Mehcanical weeding was performed according to integrated weed management treatments in standing water by ambika paddy weeder at 20-25 DAS and 40-45 DAS for T_9 and at 30-35 DAS for T_3 and T_7. Herbicides were sprayed by knapsack sprayer attached with flat fan nozzle by making stock solution of 200 ml/plot which was diluted in 1 L of water for every plot and the sprayer was rinsed after every different chemical was used.

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Table I. Treatment details of experiment

Tr. No.	Treatment details	Dose	Time of application
T_1	Oxadiargyl	70 g/ha	7-11 DAS
T_2	Oxadiargyl + Bispyribac-Na	70 g/ha and 25 g/ha	7-11 DAS and 30-35 DAS
T_3	Oxadiargyl + Mechanical weeding	70 g/ha	7-11 DAS and 30-35 DAS
T_4	Oxadiargyl + Hand weeding	70 g/ha	7-11 DAS and 30-35 DAS
T_5	Pretilachlor	750 g/ha	7-11 DAS
T_6	Pretilachlor + Bispyribac-Na	750 g/ha and 25 g/ha	7-11 DAS and 30-35 DAS
T_7	Pretilachlor + Mechanical weeding	750 g/ha	7-11 DAS and 30-35 DAS
T_8	Pretilachlor + Hand weeding	750 g/ha	7-11 DAS and 30-35 DAS
T_9	Mechanical weeding twice	-	20-25 and 40-45 DAS
T_{10}	Hand weeding twice	-	25 and 50 DAS
T_{11}	Weedy check	-	-

Microbial study

The composite soil samples were taken at 30 DAS (i.e., 0 days after spray of post-emergence herbicides and 30 days after spray of pre-emergence herbicides), 60 and 90 DAS. Four samples of soil under each treatment were taken from 0-15 cm soil depth and mixed so as to have a representative sample of the treatment. The viable microbial counts were analyzed by the standard technique of serial dilution and pour plating. The bacterial population was estimated by growing on soil extract agar **(Allen, 1957)** culture media composing 1.0 g glucose, 0.5 g KH_2SO_4, 0.1g KNO_3, 100 ml soil extract, 15 g agar, and 1000 ml distilled water with pH of 6.8-7.0. The population of actinobacteria was grown on dextrose nitrate agar **(Küster and Williams 1964)** culture media comprising 1 g dextrose, 0.1 g KH_2PO_4, 0.1 g $NaNO_3$, 0.1 g KCl, 15 g agar, and 1000 ml distilled water with pH of 7.0- 7.2. The fungal population was cultured on rose bengal agar **(Martin, 1950)** culture media having 10 g dextrose, 5 g peptone, 1 g K_2HPO_4, 0.05 g $MgSO_4.7H_20$, 0.033 g rose bengal, 15 g agar, and 1000 ml distilled water with pH of 5.5. After allowing for development of discrete bacterial colonies during incubations under suitable conditions, the colonies were counted and the number of viable bacteria, fungi and actinobacteria [expressed as colony forming units (cfu)] per gram dry weight of soil was estimated by taking into account the soil dilutions. Statistical significance of the treatment effects on different parameters was determined for the least significant difference (LSD) at 5% level of significance using analysis of variance for a randomized complete block design **(Cochran and Cox, 1957)**.

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Statistical analysis

The experiment was laid out in randomized block design (RBD). The data obtained from different characters under study were analyzed using the variance analysis method as defined by **Gomez and Gomez (1984)**. The level of significance used in "F" test is given at 5 per cent. Critical difference (CD) values and standard error of means (**SEm±**) are given in the table at 5 per cent level of significance, wherever the "F" test was significant at 5 per cent level. The skeleton of analysis of variance and formula used for various estimations are given in Table II.

Table II: The skeleton of analysis of variance

Source of Variation	DF	SS	MSS	F cal	F tab	S Em±	CD 5%
Replication	(r-1)	RSS	RMS	RMS/EMS			
Treatment	(t-1)	TSS	TMS	TMS/EMS			
Error	(r-1)(t-1)	ESS	EMS				
Total	rt-1						

The formulas used for estimation of standard error mean (S.Em±), critical difference (CD) and co-efficient of variance (CV) are given below:

S.Em± = √(EMS/r)

C.D = √(2EMS/r) X t error d.f. at 5%

C.V. (%) = (√EMS / GM) X 100

RESULT and DISCUSSION

Microbial population

Fungi and actinobacteria numbers were considerably influenced by different herbicides 90 days after application, while bacteria counts were unchanged (Table III). The unsprayed and two-hand weeding treatments had much lower levels of fungi, actinobacteria, and bacteria than the other weed control methods. The herbicidal treatments had much higher microbial populations at all stages of observation, which could be attributable to a healthier and more favorable habitat for the microorganisms than the control. The microbial counts did not show any specific trend across the weed control treatments, but they were much lower in control plots. It is possible to conclude that the biological properties of the soil increased in well aerated aerobic soil conditions found in direct seeded rice, which could be attributed to an improvement in the nutrient status as well as the physical conditions of the soil, resulting in better microorganism growth. It's also possible that the microbial population began to recover after weeds were killed by herbicides and mixed in with the soil during this time, which may have helped to increase nutrients. Herbicide degradation could be providing a carbon source for microbial development. Similar results were obtained by **Kaur and Surjit, 2015**.

Comment [A21]: no a proper reason, herbicide may kill the microbial population

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Table III: Microbial population as affected by weed control treatments in direct seeded rice

Treatments	Viable counts in soil (cfu/g)								
	30 DAS			60 DAS			90 DAS		
	Fungi	Actinobacteria	Bacteria	Fungi	Actinobacteria	Bacteria	Fungi	Actinobacteria	Bacteria
T_1	17.7	20.2	11.5	19.7	32.2	21.5	21.4	39.7	15.5
T_2	18.3	21.4	12.1	20.3	33.4	22.1	22.1	42.4	16.1
T3	17.4	21.1	12.7	19.4	33.1	22.7	21.1	41.2	16.7
T4	17.9	20.8	11.9	19.9	32.8	21.9	20.5	40.6	15.9
T_5	16.9	21.9	11.2	18.9	33.9	21.2	23.5	43.4	15.2
T_6	17.5	21.4	12.9	19.5	33.4	22.9	24.8	44.5	16.9
T_7	17.1	22.3	14.2	19.1	34.3	24.2	23.7	43.7	18.2
T_8	18.2	21.6	12.4	20.2	33.6	22.4	23.1	42.8	16.4
T_9	16.8	19.7	11.9	18.8	31.7	21.9	21.2	41.5	15.9
T_{10}	15.1	18.6	10.5	17.1	30.6	20.5	14.6	24.5	14.5
T_{11}	15.4	18.1	10.1	17.4	30.1	20.1	13.5	24.1	14.1
CD (P=0.05)	NS	NS	NS	NS	NS	NS	5.7	7.9	NS

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Grain and straw yield

Data pertaining to grain yield has been presented in Table IV. It was distinct from the data that the different integrated weed management treatments significantly influenced the grain yield. Application of oxadiargyl @ 70 g/ha at 7-11 DAS *fb* HW at 30-35 DAS produced significantly higher grain yield, as compared to other treatments and remained at par with HW twice at 25 and 50 DAS. Application of oxadiargyl @ 70 g/ha at 7-11 DAS, oxadiargyl @ 70 g/ha at 7-11 DAS *fb* mechanical weeding at 30-35 DAS, pretilachlor with safener @ 750 g/ha at 7-11 DAS, pretilachlor with safener @ 750 g/ha at 7-11 DAS *fb* bispyribac-sodium @ 25g/ha at 30-35 DAS and pretilachlor with safener @ 750 g/ha at 7-11 DAS *fb* mechanical weeding at 30-35 DAS failed to show any appreciable impact on grain yield. Weedy check obtained minimum grain yield, which was significantly inferior to rest of the treatments. These results have also been corroborated by findings of **Kumari (2015)** and **Rao *et al.* (2019)**.

Reduction in grain yield in weedy check might be due to season long weed competition exerted by the weeds at the critical stages of crop growth which reduced the availability and uptake of nutrients and also the mutual shading by the weeds resulting in reduced photosynthesis and translocation of carbohydrates from source to sink **(Raj and Syriac, 2016)**.

Harvest index

Data with regard to harvest index (HI) has been presented in Table III. Highest harvest index was observed under oxadiargyl @ 70 g/ha at 7-11 DAS *fb* HW at 30-35 DAS which was statistically comparable with oxadiargyl @ 70 g/ha at 7-11 DAS *fb* bispyribac-sodium @ 25 g/ha at 30-35 DAS, pretilachlor with safener @ 750 g/ha at 7-11 DAS *fb* HW at 30-35, mechanical weeding at 20-25 and 40-45 DAS and HW at 25 and 50 DAS. The minimum harvest index was noted under pretilachlor with safener @ 750 g/ha at 7-11 DAS and it was at par with oxadiargyl @ 70 g/ha at 7-11 DAS, oxadiargyl @ 70 g/ha at 7-11 DAS *fb* mechanical weeding at 30-35 DAS, pretilachlor with safener @ 750 g/ha at 7-11 DAS *fb* bispyribac-sodium @ 25g/ha at 30-35 DAS, pretilachlor with safener @ 750 g/ha at 7-11 DAS *fb* mechanical weeding at 30-35 DAS and weedy check. Better partitioning of photosynthates from source to sink leading to better grain filling resulted in increased the grain yield subsequently increased harvest index. The results are in conformity with the findings of **Rao *et al.* (2019)**.

Weed index

Data with regard to weed index (WI) has been presented in Table III. Weed index is a measure of reduction of grain yield due to competition stress offered by weeds as against best weed management treatment.

The maximum weed index was recorded under weedy check. It means that there was yield reduction to the tune of 47.43% due to severe weed competition in weedy check. HW at 25 and 50 DAS was found to be best followed by oxadiargyl @ 70 g/ha at 7-11 DAS *fb* bispyribac-sodium @ 25 g/ha at 30-35 DAS and pretilachlor with safener @ 750 g/ha at 7-11 DAS *fb* HW at 30-35 DAS with respect to weed index.

Table IV: Yield attributes, yield, harvest and weed index of rice as influenced by integrated weed management practices

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Weed index (%)
T_1	2.67	3.65	42.86	31.76
T_2	3.51	4.21	45.52	11.02
T_3	2.92	3.79	43.35	26.07
T_4	3.93	4.15	48.66	-
T_5	2.27	3.51	39.26	41.91
T_6	2.96	4.07	42.31	24.47
T_7	2.51	3.77	40.09	35.86
T_8	3.48	3.87	47.47	11.53
T_9	3.20	3.48	47.95	18.49
T_{10}	3.74	4.40	46.05	4.73
T_{11}	2.06	2.72	43.39	47.42
SEm±	0.08	0.25	2.10	-
CD (P=0.05)	0.25	0.75	4.39	-

Comment [A27]: Grain yield, straw yield, harvest index and

Comment [A28]: Weed index is calculated by taking the yield of weed free check, here author can take the T10 treatment for comparison, not the T4. Recaluculate

Economics of DSR

Data on economic parameters have been calculated based upon the prevailing market price of input and output and embodied in Table V. The maximum gross return, net return and B:C ratio was received under the application of oxadiargyl @ 70 g/ha at 7-11 DAS *fb* HW at 30-35 DAS. Although hand weeding twice at 25 and 50 DAS was found next best treatment for obtaining gross return but application of oxadiargyl @ 70 g/ha at 7-11 DAS *fb* bispyribac-sodium @ 25 g/ha at 30-35

DAS stood next best treatment with respect to net return and B:C ratio. The minimum gross return, net return and B:C ratio was noted under weedy check.

Gross return, net return and B:C ratio was increased in oxadiargyl @ 70 g/ha at 7-11 DAS *fb* bispyribac-sodium @ 25g/ha at 30-35 due to the fact that there was higher gross return associated with lower cost of cultivation. Similar findings have also been reported by **Mukherjee (2019), Nasseruddin and Subramanyam (2013) and Kiran *et al.* (2010)**.

Comment [A29]: 30-35 DAS

Table V: Economics of rice as influenced by different integrated weed management practices

Treatment	Total cost of	Gross monetary	Net monetary	B:C ratio
T_1	29,831	56,901	27,067	1.90
T_2	31,927	73,191	41,261	2.28
T_3	31,611	61,434	29,822	1.93
T_4	32,501	81,211	48,707	2.51
T_5	29,531	49,221	19,691	1.66
T_6	31,625	63,104	31,478	2.01
T_7	31,311	54,181	22,871	1.72
T_8	32,201	72,324	40,124	2.24
T_9	32,890	66,364	33,473	2.01
T_{10}	37,340	78,194	40,853	2.08
T_{11}	28,440	43,694	15,253	1.53

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Include

Comment [A31]: Suggeted to invlude the data on weed flora, Weed density, Weed dry weight *etc*

Conclusion

Application of oxadiargyl @ 70 g/ha at 7-11 days after sowing (DAS) *fb* hand weeding at 30-35 DAS or hand weeding twice at 25 and 50 DAS obtained similar and highest growth characters, yield attributes and yield of rice. Weed density and biomass were significantly reduced under hand weeding twice at 25 and 50 DAS. The weed control efficiency was highest under hand weeding twice at 25 and 50 DAS followed by oxadiargyl @ 70 g/ha at 7-11 DAS *fb* hand weeding at 30-35 DAS. Maximum gross returns, net returns and B:C ratio was received under the application of oxadiargyl @ 70 g/ha at 7-11 DAS *fb* HW at 30-35 DAS which was closely followed by oxadiargyl @ 70 g/ha at 7-11 DAS *fb* bispyribac-Na @ 25g/ha at 30-35 DAS.

Weeds are a menace when it comes to wet DSR so ween need more research so we can get a comprehensive understanding of weed control in different climates, for this in future research we can study the different timings of application of various weed control methods to evaluate their effect on weed management. Different combination of herbicides with physical methods of weed control should be tested to figure out a better method of weed management.

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