SHORT COMMUNICATION

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Control of complex weed flora in direct-seeded and transplanted rice with early post emergence herbicide

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ABSTRACT

A field experiment was conducted during wet season of 2010 at the research farm of the Indian Agricultural Research Institute, New Delhi to study the efficiency of new low dose herbicide penoxsulam on growth and development of rice, associated weeds and micro flora. Penoxsulam 24 SC at 25 g ha^{-1} applied at 10 DAS/DAT significantly reduced the weed population, increased growth, grain yield (4.86 t ha^{-1}) and yield attributes of rice crop. Herbicidal treatments provided an yield advantage of 65.98% to 72.63%, respectively over weedy check. Herbicides exerted a significant detrimental effect on soil bacteria, fungi and actinomycetes. The soil microbes were more sensitive at 10 DAS/DAT to penoxsulam 25 g ha^{-1} and pre-mergence application pretilachlor @ 750 g ha^{-1} as evident from significant reduction in their population, eventually microbial density started to recover slowly.

Key words: *rice, direct seeded, transplanted, microbial population, weeds, penoxsulam, pretilachlor*

Rice is mainly grown as transplanted, wet seeded and direct-seeded. Uncontrolled weed growth in transplanted rice causes 45-51% loss in yield (Veeraputhiran and Balasubramanian, 2013), whereas weed growth under direct-seeded rice causes yield losses up to 80% (Jabran *et al*. 2012). A number of herbicides, namely butachlor, anilofos and pretilachlor are being used as pre-emergence treatment for weed control in rice. But, they do not provide satisfactory control of sedges and broad-leaved weeds. The addition of herbicides can cause alterations in the soil microbial population and may kill soil microbes that combat disease causing microorganisms, thereby upsetting the balance between beneficial and harmful microorganisms. This change in the soil microflora has been listed as one of the causes of productivity decline in rice cultures (Reichardt *et al.,* 1998). Thus, there is a need to study the effect of new low dose high efficacy herbicides on the wide spectrum of weeds and microflora and their activities in rice soils. Penoxsulam is a new low dose acetolactate synthase (ALS) inhibitor herbicide for control of grasses, sedges and broad leaved weeds in rice culture. Hence, the present study was undertaken to evaluate the performance of penoxsulam for weed management in rice.

The field experiment was conducted at Indian Agricultural Research Institute, New Delhi during wet season 2010. The soil was sandy loam with pH 7.5, organic carbon 0.53%, available P 14.50 kg ha^{-1}, and available K 247 kg ha^{-1}. Treatments comprising of two establishment methods (transplanted and direct-seeding) as main-plot and seven weed control measures (two doses of penoxsulam (20 and 25 g ha^{-1}) each applied at 10 and 15 days after transplanting (DAT)/days after sowing (DAS), pretilachlor at 750 g ha^{-1}as pre-emergence, along with weed-free and weedy checks) as sub-plot were laid-out in a split-plot design with three replications. An uniform dose of 120 kg N ha^{-1} in the form of urea, 60 kg P_2O_5 ha^{-1} through single super phosphate and 40 kg K_2O ha^{-1} through muriate of potash was applied. Rice cv. Pusa Sugandh 5 was sown in rows at a seed rate of 40 kg ha^{-1} using *kera* method of sowing at a row spacing of 20 cm on non-puddled soil while 21 days old seedlings were transplanted using two seedling hill^{-1} at spacing of 20 x 10 cm. Data on weeds were recorded at 40 days after sowing in each

plot in two quadrats, each measuring 50 cm X 50 cm. The population of total heterotrophic bacteria, fungi and actinomycetes was counted using serial dilution and plating technique.

The dominant weed flora distributed in the experiment comprised of *Echinochloa crus-galli* (L.), *Echinochloa colona* (L.), *Leptochloa chinensis* (L.), *Eclipta alba* (L.) and *Cyperus difformis* (L.). *Echinochloa crus-galli* (28-30%) was found as the predominant weed in both the methods of rice establishment, whereas the lower density (10-11%) was found in case of *Cyperus difformis* showing its effective control through penoxsulam. All the weed control treatments proved effective in minimizing the density and dry weight of weeds (Table 1). Transplanted rice culture registered the lowest density and dry weight of weeds. This might be due to the fact that in transplanted rice, the germinating weeds have to compete with the established crop seedlings, whereas in the direct-seeded crop, both the rice crop and weeds germinate simultaneously and compete with each other for essential inputs.

Among the herbicidal treatments, penoxsulam at 25 g ha^{-1} applied at 10 DAS/DAT had recorded significantly lowest weeds density and dry weight showing higher weed control efficiency (69.67%) and was on par with its application at 15 DAS/DAT, irrespective of its dose. In contrast to all other treatments, weed free check recorded lowest weed density and dry weight. The weed density and dry weight decreased with increment in doses (20-25 g ha^{-1}) of penoxsulam at 10 and 15 DAS/DAT. Application of penoxsulam was found more effective against *E. crus-galli*, *E. colona* and *C. difformis* as compared to pretilachlor. Yadav *et al.* (2008) also documented the better efficacy of penoxsulam applied at 10 DAT than at 5 DAT in controlling *E. colana, C. difformis* and *E. crus-galli*. The lowest reduction in weed growth (21-28%) was observed with pre-emergence application of pretilachlor at 750 g ha^{-1} which was on par with penoxsulam 20 g ha^{-1} applied at 10 and 15 DAS/DAT. Herbicidal treatments provided an yield advantage of 65.98% to 72.63% over weedy check.

Significant increase in the growth, yield and yield attributes were recorded in transplanted method of rice culture than that of direct-seeded rice due to

Table 1. Total weed density and dry weight, growth and yield attributes and yield of rice as affected by methods of rice culture and weed control measures.

Treatment	Total weed density (no m^{-2}) 40 DAS	Total weed dry weight (g m^{-2}) 40 DAS	Plant height (cm) 40 DAS	Plant tillers m^{-2} 40DAS	Shoot dry weight (g m^{-2}) 40 DAS	LAI 40DAS	Panicle length (cm)	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	WCE (%)
Method of rice establishment											
Direct seeded	9.80 (112.38)	6.25 (45.18)	43.7	135.3	45.7	2.71	25.7	22.9	3.76	7.56	46.83
Transplanted	6.47(48.94)	4.15(19.78)	46.8	160.7	51.5	2.85	27.4	23.6	4.25	8.98	55.41
CD ($P<0.05$)	0.63	0.40	2.24	10.29	2.90	0.14	1.25	NS	0.23	0.52	
Weed control measures											
Penoxsulam @ 20 g ha^{-1} at 10 DAS/DAT	8.89(81.30)	5.58(31.95)	45.0	143.1	44.8	2.73	26.0	23.1	4.13	8.67	49.62
Penoxsulam @ 25 g ha^{-1} at 10 DAS/DAT	7.1(54.2)	4.4(20.2)	51.2	168.4	60.9	3.10	29.6	24.6	4.86	9.17	62.10
Penoxsulam @ 20 g ha^{-1} at 15 DAS/DAT	9.83(100.20)	6.23(39.60)	41.8	141.1	42.3	2.70	25.0	23.0	4.06	8.37	44.54
Penoxsulam @ 25 g ha^{-1} at 15 DAS/DAT	7.94(65.83)	4.99(25.88)	48.2	157.4	56.0	2.96	28.5	24.3	4.67	8.98	59.34
Pretilachlor @ 750 g ha^{-1} PE	9.94(102.30)	6.24(40.23)	40.8	137.5	41.6	2.62	24.8	23.0	3.91	8.30	42.24
Weed free check	0.71(0.00)	0.71(0.00)	53.8	179.1	61.3	3.30	29.7	25.1	5.07	11.14	100.00
Weedy check	12.49(160.72)	8.25(69.52)	36.0	109.5	33.6	2.01	22.3	19.8	1.33	3.28	0.00
CD ($P<0.05$)	0.67	0.43	3.15	11.40	3.86	0.22	1.37	1.11	0.32	0.61	

Figures in parentheses are the values

favorable effect of puddling on nutrient availability. Early post-emergence application of penoxsulam 25 g ha^{-1} at 10 DAS/DAT caused the highest increase in plant height (51.2 cm), tillers m^{-2} (168.4), leaf area index (3.10), shoot dry weight (60.9 g m^{-2}), panicle length (29.6 cm), test weight (24.6 g), grain yield (4.86 t ha^{-1}) and straw yield (9.17 t ha^{-1}) over the rest of the herbicidal treatment except its same dose applied at 15 DAS/ DAT (Table 1). This might be due to better control of grassy weeds and sedges which resulted in less crop-weed competition. Efficacy of penoxsulam in controlling weeds and increasing grain yield was also reported by Malik *et al.* (2011) and Jabran *et al.* (2012).

The population of bacteria, fungi and actinomycetes are influenced by methods of rice establishment and weed control measures. The microbial population was found to be significantly influenced by the type of herbicides, concentrations and the days after application of herbicides (Table 2). Compared to direct-seeded, transplanted method of rice culture recorded significant population of bacteria and fungi at 10, 30 days and harvest, respectively. However, the population of actinomycetes was significantly higher in direct-seeded condition as the population of actinomycetes was relatively higher in aerobic condition. At 10, 30 DAS/DAT and harvest, application of penoxsulam at 25 g ha^{-1} applied at 10 DAS/DAT resulted in the highest reduction in the population of bacteria (56%, 17.8% and 16.8%), fungi (77.5%, 59.0% and 39.1%) and actinomycetes (54.9%, 50.3% and 35.3%) as compared to untreated soil and was followed by same dose applied at 15 DAS/DAT. However, amongst herbicide treatments the lowest reduction in bacteria (37.5%, 9.1% and 7.6 %), fungi (40.4%, 34.0% and 21.3%) and actinomycetes (29.2%, 24.2% and 19%) was obtained with pretilachlor @ 750 g ha^{-1}. It was observed that fungal population were more sensitive to both penoxsulam and pretilachlor than bacteria and actinomycetes. The adverse effects of these herbicides on microbes were gradually reduced with the advancement of crop's age and significant recovery was observed towards harvest.

Table 2. Microbial population as affected by methods of rice culture and weed control measures.

Treatment	Bacteria (10^4 cfu g^{-1})			Fungi (10^1 cfu g^{-1})			Actinomycetes (10^3 cfu g^{-1})		
	10 DAS/ DAT	30 DAS/ DAT	At harvest	10 DAS/ DAT	30 DAS/ DAT	At harvest	10 DAS/ DAT	30 DAS/ DAT	At harvest
Method of rice culture									
Direct seeded	59.09	247.42	265.81	8.71	12.66	20.00	48.85	50.19	60.76
Transplanted	70.29	252.33	272.57	12.43	17.76	23.17	34.14	44.76	54.95
CD (P<0.05)	0.20	1.95	5.51	1.28	2.01	0.73	4.30	3.03	2.84
Weed control measure									
Penoxsulam @ 20 g ha^{-1} at 10 DAS/DAT	42.00	243.67	265.50	5.67	13.83	21.92	27.83	42.00	54.33
Penoxsulam @ 25 g ha^{-1} at 10 DAS/DAT	35.67	230.83	245.67	3.33	10.17	17.08	22.83	35.33	48.67
Penoxsulam @ 20 g ha^{-1} at 15 DAS/DAT	81.83	234.50	255.00	14.17	12.50	20.42	51.50	39.83	51.17
Penoxsulam @ 25 g ha^{-1} at 15 DAS/DAT	80.50	232.00	247.83	13.83	10.33	16.25	51.33	33.17	45.83
Pretilachlor @ 750 g ha^{-1} PE	51.00	255.00	272.67	8.83	16.17	22.08	35.83	53.17	60.50
Weed free check	80.17	272.50	284.83	13.33	18.67	25.25	50.50	63.67	69.17
Weedy check	81.67	280.67	295.33	14.83	24.83	28.08	50.67	70.17	75.33
CD (P<0.05)	1.96	4.85	5.70	1.59	1.63	1.67	2.95	3.71	2.96

cfu- colony forming unit

It may be concluded that weeds can be managed during critical period of competition with the application of penoxsulam at 25 g ha^{-1} at 10 DAS/DAT in both direct-seeded and transplanted rice establishment. The microbial population in rice soil was adversely affected by penoxsulam only during the initial stages. Significant variation was observed in the

population of all the three microbes under method of rice establishment and various herbicidal treatments.

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