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Effect of establishment methods and weed management practices on weeds, yield attributes and yield of rice

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Abstract
A field experiment was conducted during *Kharif* season for two consecutive years of 2015 and 2016 to find out the comparative understanding of the effect of various rice establishment methods and weed management practices in direct seeded rice. The major weed flora recorded were *E. crusgalli, E. colona* and *P. maximum* of grassy, *Commelinabenghalensis* L. and *Eclipta alba* of broad leaved group and *Cyperus* Spp. of sedges group. However, grassy weeds were dominant over other weeds species. Significantly lower values of weed density and dry weight, yield and yield attributes of crop were recorded due to manual weeding thrice, and pretilachlore @ 750g/ha at 0-2 DAS fbalmix @ 4 g/ha at 25 DAS (3-4 leaf stage of rice crop) being at par at all characters during both the years. Both the establishment methods (wet) drum seeding and broadcasting being at par recorded significantly lower values of weed density, weed dry weight and higher values of growth and yield attributes, grain and straw yield over dry seeding methods during both the years. On the basis of two years experimentation, it may be concluded that higher values of grain yield and net returns may be obtained due to drum seeding methods of establishment of rice along with integrated method of using weed management by pretilachlore @ 750g/ha at 0-2 DAS fbalmix @ 4 g/ha at 25DAS (3-4 leaf stage of rice crop), while, broadcasting (wet)showed the same response However, for resource poor farmers, direct seeding of rice through drum along with pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 leaf stage of rice crop) proved superior (BCR values of Rs 2.12 per ha) over other methods of rice establishment under puddled condition.

Keywords: Rice; establishment methods; weed management practices; weeds; yield attributes; yield

Introduction
Rice (*Oryza sativa* L.) a member of Poaceae family is relished as staple food by majority (more than 60%) of world's population. Rice plays a pivotal role in Indian agriculture, as it is the principal food crop for more than 70 per cent of the world population. Among the cereal crops, it serves as the principal source of nourishment for over half of the global population (Davla *et al*., 2013) [4]. Crop establishment in rice largely affects the initial stand and uniformity. Although transplanting method of establishment has been reported to be the best amongst all the factors for higher productivity of rice, this method is not much profitable as itconsumes a large quantity of water (Bouman and Tuong, 2001) [3]. Nowadays, water scarcity is a major concern in many regions of the world, the migration of rural labor to urban areas, because of industrialization, causes a shortage of labor during the peak season of transplanting in many regions of Asia (Mahajan *et al*. 2013; Pandey and Velasco, 2005) [7, 11]. Some alternatives such as drum seeding, zero tillage, direct seeding in rows or broadcast of sprouted seeds under puddle condition have been tried (Vivek *et al*., 2010) [21]. Weed control is particularly challenging in DSR systems because of the diversity and severity of weed infestation, the absence of standing water layer to suppress weeds at the time of rice emergence, and no seedling size advantage of rice over the weed seedlings as both emerge simultaneously. A variety of herbicides have been screened and found effective for pre-plant/burn-down, pre-emergence, and post emergence weed control in direct drill-seeded rice systems (Singh *et al*., 2006 and Anwar *et al*., 2012a) [17, 1]. Application of different pre-emergence herbicides including thiobencarb, pendimethalin, butachlor, oxadiazon and nitrofen has been found to control weed satisfactorily in direct seeded rice (Moorthy and Manna, 1993;

Pellerin and Webster, 2004) [10, 12]. Among the post emergence herbicides, ethoxysulfuron, cyhalofop-butyl, pritilachlor, chlorimuron, metsulfuron, bispyribac sodium and penoxsulam effectively controlled weeds in direct seeded rice (Mann *et al*., 2007; Singh *et al*., 2008 and Mahajan *et al*., 2009) [9, 16, 8].

Material and Methods

The field experiment was conducted at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology Kumarganj, Faizabad (U.P.) during rabi season of 2013-14 and 2014-15. The farm is located 42 km away from Faizabad city on Faizabad- Raebareily road at 26.47˚ N latitude and 82.12˚ E longitude and about 113 meters above the mean sea level. Summer is hot and dry. Generally, the mean maximum temperature during the hottest month (May) vary from 33.0 to 41.7 0C and minimum during the coolest month (December and January) varies from 4.5 to 8.8 0C. The mean average precipitation of Kumarganj, Faizabad is 837.4 mm, most of which received during the period of June to September. The treatment was carried out with 24 treatment combination formed with laid out in split-plot design with three replications taking four establishment methods *viz.*, Dry Seeding, Seeding through Drum Seeder (Wet) and Broadcasting (Wet) under puddled condition in main plot, and eight weed management practices *viz.* bispyribac-Na @ 25g/ha at 25DAS (3-4 Leaf stage of rice crop), pendimethaline @100g/ha at 0-2DAS fb bispyribac-Na@25g/ha at 25DAS (3-4 Leaf stage of rice crop), oxadiargyl @100g/ha 0-2DASfb bispyribac-Na@25g/ha at 25DAS (3-4 Leaf stage of rice crop), pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop), pyrazosulfuran @ 20 g/ha at 0-2DAS fbethoxysulfuran @18.75 g/ha at 25DAS (3-4 Leaf stage of rice crop),Manual Weeding (20, 40, 60 DAS), Weed free and weedy check were kept in sub-plot. For direct seeding treatments (dry seeding,drum seeding and broad casting), a seed rate of 80 and 45 kg/ha was used for broad-casting and drum seeding treatments, respectively, the seeds were soaked in water for 24 hours then incubated for 8-10 hours prior to sowing by a drum-seeder and broadcasting on puddled soil and the crop was fertilised with an uniform dose of 60 kg P, 40 kg K/ha and half dose of the N (100 kg/ha) through urea were applied as a basal dose while the remaining nitrogen was applied in two equal split doses at tillering and panicle initiation stages of crop growth. The herbicides were applied with the help of manually operated Knapsack sprayer fitted with flat fan nozzle using 500 litres of water per hectare. Data on weeds were recorded at different growth stage of crop in each plot in two quadrates, each 50x50 cm. weeds were counted species wise and were removed for recording their total dry weight. Weed samples were sun dried before oven drying at 70^0C until constant weight was attained. The grain yield were recorded and adjusted to 14% of the moisture content. Weed data were subjected to square root $\left(r = \sqrt{X + 0.5}\right)$ transformation before statistical analysis.

The recovery of grains from the total harvested produce was considered as harvest index. Harvest index of each experimental plot was calculated by using formula as described by Singh and Stockopf (1971).

$$H.I.(\%) = \frac{Grain\ yield\ (\frac{q}{ha})}{Total\ biological\ yield\ (\frac{q}{ha})} \times 100$$

Results and Discussion

The dominant weed floras of the experimental field were among grasses, *Echinochloacrusgalli* and *Echinochloacolona*, *Panicummaxicum.* In case of BLWs, *Ecliptaalba*, *Commelinabenghalensis*. Among the sedges, *Cyperusrotundus*, *Cyperusdifformis*, *Cyperusesculentus* as well as *Fimbristylisdentatum* were were recorded, but *Cyperusrotundus* proved dominant species, at al growth stage of crop during both the years and rest of weed species were considered as other weeds.

Effect on Weeds

The density of the different weed species were recorded at 60, 90 days and at harvest stages of crop growth. The presence of the individual weed species and other weeds as well as total weeds and their dry weight was affected significantly due to different establishment methods of rice. However, dry seeding of rice (DSR) recorded significantly higher weed density of grassy, BLWs and sedges as compared to drum seeding treatment. Where number of weed species under broad casting being at par with drum seeding and also drum seeding method of rice establishment recorded significantly less total weed dry weight over dry seeding of rice establishment due to fewer weeds recorded during both the year of experimentation.

As far as the various weed control treatments were concerned, lower weed density was recorded due to various weed management practices over weedy check. manual weeding thrice (20, 40 & 60 days of seeding) and pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) being at par recorded significantly less weed density and weed dry weight over bispyribac-Na 25g ha^{-1} as PoE application alone and weedy check treatments. Weed population of individual species and other species as well as total weed species less in sole post emergence application bispyribac-Na 25g ha^{-1} as PoE application alone then control weedy check. The combinations of pre and post application of herbicide were significantly more effective in compression with sole application of bispyribac-Na 25gha^{-1} as Po Eapplication alone. Similarly manual weeding at 25 days after sowing next only to pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) being at par to each other. It is also clear from the data that lower density of weeds due to bispyribac-Na 25g ha^{-1} as PoE application alone was proved significantly superior with respect to controlling the weeds and lower values of weed dry weight over weedy check during both the years of experimentation. The efficacy of herbicides and their combination are interplay of weed flora present under varying establishment methods as explained by Singh and Paikra (2014) [15]. The combination capable of covering the maximum diversity of weed flora performed comparatively better. The results as regards to weed population and their bio-mass accumulation are in close conformity with the results reported earlier by Verma *et al.* (2015) [20] Singh and Toung *et al.* (2000) [19] and Ravi Shankar *et al*. (2008) [14].

Effect on crop

The plant height and crop dry matter accumulation (gm^{-2}) of the DSR (wet) methods (Drum and broad casting) being at par recorded significantly more plant height and crop dry matter accumulation (gm^{-2}) over dry seeding treatments. However, broadcasting treatments recorded numerically higher values of plant height over drum seeding method, respectively, but statically similar to DSR wet method at all the stages. Dry

matter accumulation is directly related to the growth pattern of the crop, which influences the grain yield directly. In case of direct seeding of rice treatments, drum seeding treatment recorded significantly more dry matter accumulation as compared to broad-casting of rice (DSR) treatments at all the stages of crop growth during both the years of experimentation.

Weed management practices were concerned, plant height and dry matter accumulation was influenced significantly at successive stage that manual weeding thrice (20, 40 and 60 days) and pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) being at par recorded significantly over bispyribac-Na alone and weedy check treatments, Likewise, all pre and post herbicide combination also recorded being at par to each other. However, weedy check treatment recorded significantly lower plant height and dry matter accumulation over rest of the weed control treatments during both the years.

Effect on Yield

Among the various establishment methods, broad-casting and drum seeding method being at par recorded significantly higher values of effective shoot (m^{-2}) over dry seeding. Drum seeding being at par with broadcasting (wet) produced significantly higher grain and straw yields over all other establishment methods during both the years. Higher yield under drum seeding was due to better crop growth and devolvement resulting into higher values of yield attributes which increase the grain yield.

All the weed control treatments significantly improve yield and yield contributing character over unweeded control. The results of the present experiment showed that the weed free condition recorded significantly higher seed yield and remained comparable with manual weeding as well as pre emergence application of pretilachlore @ 750g/ha fb post emergence of almix @ 4 g/ha during both years. Unweeded check resulted in lowest seed yield. The better yield with the pre and post- emergence herbicidal treatments due to more effective tillers, grain per penicle and penicle length as compare with unweeded check and sole application of herbicides treatments. The weed free treatments remained at par with pre emergence application of pretilachlore @ 750g/ha fb post emergence of almix @ 4 g/ha, pre emergence application pendimethaline @100g/ha at 0-2DAS fbBispyribac-Na@25g/ha at 25DAS (3-4 Leaf stage of rice crop). Higher yield due to realization of better growth and yield attributes. The unweeded control treatment recorded lowest yield. This may be explained on the basis that the menace of weeds go on increasing with increase in agecaused severe competitive stresson crop plants for growth resources and led to inferior yield attributing traits hence minimum yield. The results are in agreement with the findings of Khattak *et al.* (2006) [6], Aslam *et al.* (2008) [2], Tamilselvan and Budhar (2002) [18], Jayadeva *et al*. (2009) [5] and Pramanick *et al*. (2014) [13].

Economics

The maximum cost of cultivation (Rs. 34170 ha^{-1}) was obtained in broadcasting with weed free treatment combination followed by with Manual weeding thrice (table 3). It might due to more cost involved in weed freelabour charges incurred on weeding. The Minimum cost of cultivation was recorded in direct-seeding method of establishment along with weedy check treatment. The maximum gross return was obtained broadcasting with weed free treatment combination followed by with Manual weeding thrice. It might be due to higher yield of rice. The maximum net return (Rs. 43044 ha^{-1}) was recorded in drum seeding with pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) where the minimum net return of was recorded in dry seeding with no weed control treatment due to low yield of ricein pooled results. The highest benefit-cost ratio (Rs. 2.12 ha^{-1}) was obtained alsounder drum seeding with pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop). These results are in close conformity with those of Aslam *et al.* (2008) [2] and Shivaramu and Krishnamurthy (2011).

Table 1: Effect of establishment methods and weed management practices ontotal weed density (m^{-2}) and totalweed dry weight (g m^{-2}) at different stage of crop growth of rice

Treatments	total weed density (m^{-2})						total weed dry weight (gm^{-2})					
	60 DAS		90 DAS		At harvest		60 DAS		90 DAS		At harvest	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Methods of rice establishment												
Dry seeding	(65.14) 8.10	(57.43) 7.61	(60.87) 7.83	(56.22) 7.53	(57.76) 7.62	(51.07) 7.18	(37.53) 5.81	(37.13) 5.79	(39.00) 5.92	(38.00) 5.85	(42.96) 6.20	(39.54) 5.96
Drum seeder	(44.19) 6.68	(38.97) 6.27	(41.19) 6.46	(38.05) 6.21	(38.96) 6.28	(34.56) 5.92	(25.25) 5.26	(25.13) 5.23	(26.37) 5.29	(25.15) 5.23	(29.04) 5.61	(26.73) 5.43
Broadcasting (wet)	(55.45) 7.48	(48.88) 7.03	(51.81) 7.23	(47.85) 6.95	(49.00) 7.04	(43.47) 6.63	(31.94) 5.38	(31.58) 5.36	(32.83) 5.46	(32.33) 5.42	(36.53) 5.74	(33.62) 5.52
SEm±	1.15	1.10	1.12	1.10	1.02	1.40	0.03	0.04	0.05	0.05	0.06	0.05
LSD (P=0.05)	0.82	0.25	1.87	1.81	1.62	2.16	0.14	0.15	0.19	0.20	0.21	0.19
Weed management practices												
Bis.	(63.08) 7.97	(55.61) 7.49	(53.31) 7.71	(49.25) 7.41	(50.42) 7.50	(44.73) 7.07	(37.38) 6.17	(38.76) 6.28	(39.01) 6.30	(37.84) 6.21	(42.96) 6.60	(39.54) 6.34
Pendi. Fb Bis.	(44.06) 6.73	(38.84) 6.32	(41.17) 6.51	(38.03) 6.26	(38.93) 6.33	(34.54) 5.97	(29.41) 5.49	(30.12) 5.56	(30.49) 5.59	(29.78) 5.53	(33.58) 5.86	(30.91) 5.63
Oxadi. Fb Bis.	(57.06) 7.59	(50.30) 7.13	(46.57) 7.34	(43.01) 7.05	(44.40) 7.14	(39.07) 6.73	(32.02) 5.73	(31.57) 5.69	(33.31) 5.84	(32.42) 5.76	(36.68) 6.12	(33.76) 5.88
Preti. Fb Alm.	(34.57) 6.68	(28.97) 6.27	(31.91) 6.46	(29.91) 6.21	(39.39) 6.28	(33.39) 5.92	(18.29) 4.39	(17.32) 4.28	(19.49) 4.53	(16.87) 4.23	(22.68) 4.87	(19.10) 4.48
Pyra. Fb ethox.	(49.84) 7.10	(43.94) 6.67	(41.84) 6.86	(38.65) 6.60	(39.57) 6.67	(35.11) 6.29	(32.75) 5.79	(31.26) 5.66	(34.06) 5.90	(33.15) 5.83	(37.51) 6.18	(34.52) 5.94
Manual weed.	(26.00) 5.15	(22.92) 4.84	(24.30) 4.98	(22.44) 4.79	(22.98) 4.85	(20.39) 4.57	(15.61) 4.06	(15.45) 4.04	(16.22) 4.13	(15.80) 4.09	(17.86) 4.33	(16.44) 4.16

Weed free	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00	(0.00) 1.00
Weedy	(154.32) 12.44	(136.06) 11.69	(144.20) 12.03	(133.19) 11.56	(136.37) 11.70	(120.99) 11.02	(67.52) 8.25	(64.13) 8.04	(69.10) 8.34	(68.35) 8.30	(77.09) 8.81	(70.95) 8.45
SEm±	0.48	0.41	1.44	1.40	1.33	1.28	0.06	0.06	0.08	0.07	0.09	0.09
LSD (P=0.05)	1.93	1.82	2.24	2.16	2.04	1.93	0.18	0.18	0.24	0.19	0.25	0.24

Table 2: Effect of establishment methods and weed management practiceson growth, yield attributes and yield of Direct seeded rice

Treatments	Plant height (cm)				Dry matter accumulation (gm^{-2})				Effective tillers (m^{-2})		Length of panicle (cm)		No. of grain panicle^{-1}		Test weight (g)		Grain yield (qha^{-1})		Straw yield		Harvest index (%)	
	60 DAS		90 DAS		60 DAS		90 DAS															
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Methods of rice establishment																						
Dry seeding	47.28	49.88	64.04	66.53	307.79	303.50	618.99	651.52	204.49	209.17	18.36	18.66	77.11	79.42	20.28	21.33	26.02	29.62	37.13	41.44	40.85	41.33
Drum seeding	52.26	53.62	72.23	75.60	358.07	365.89	755.37	799.96	268.75	274.89	22.43	22.79	95.74	99.57	22.22	23.38	35.68	40.62	47.75	53.31	42.56	43.03
Broadcasting (wet)	55.20	58.25	75.14	78.18	341.19	348.64	714.00	767.83	255.47	262.88	21.60	22.36	91.56	94.74	21.11	22.20	32.36	36.84	45.05	50.28	41.15	41.62
SEm±	1.05	1.11	1.73	1.79	5.64	5.59	11.03	13.07	3.73	3.83	0.57	0.60	1.39	1.42	0.62	0.65	0.84	0.96	1.18	1.22	0.38	0.39
LSD (P=0.05)	4.14	4.37	5.32	5.06	22.15	21.95	43.30	51.33	14.64	15.03	2.05	2.19	5.46	5.56	NS	NS	3.30	3.76	4.36	4.52	NS	NS
Weed management practices																						
Bis.	46.43	48.16	62.68	64.32	315.47	323.56	649.44	703.67	236.77	239.07	19.36	19.28	81.73	91.75	21.11	21.59	26.67	30.36	38.30	42.76	40.85	41.32
Pendi. Fb Bis.	51.45	54.07	70.31	70.48	334.00	332.97	694.80	732.02	242.95	250.22	20.11	20.12	89.87	93.19	21.83	22.58	32.68	37.19	44.74	49.94	42.05	42.52
Oxadi. Fb Bis.	49.68	52.73	68.68	69.62	328.88	328.27	681.84	719.99	240.89	243.93	19.57	19.89	86.17	87.44	21.18	21.79	28.65	32.62	40.10	44.76	41.57	42.05
Preti. Fb Alm.	52.33	55.22	71.93	74.49	348.99	351.01	727.20	773.25	250.38	259.36	20.38	20.72	95.04	99.32	21.92	22.78	36.23	41.24	48.99	54.69	42.49	42.97
Pyra. Fb ethox.	50.62	53.27	69.26	70.22	333.22	330.23	692.37	725.15	241.97	246.62	19.77	20.09	89.13	87.21	21.74	22.58	30.30	34.49	42.73	46.58	41.99	42.46
Manual weed.	56.60	59.61	75.93	76.61	359.64	361.60	749.89	799.62	259.35	267.45	22.16	22.51	96.29	100.17	22.23	22.78	38.46	43.78	51.12	57.07	42.88	43.36
Weed free	58.26	61.45	78.74	79.56	372.65	374.55	779.86	833.37	267.72	278.05	22.69	23.70	99.76	103.99	22.90	24.94	41.67	47.44	54.30	60.61	43.20	43.68
weedy	36.62	39.19	53.55	55.77	292.60	312.58	593.58	631.12	203.20	207.13	18.32	18.65	67.09	66.90	20.71	21.40	16.19	18.43	27.19	30.35	37.11	37.57
SEm±	1.46	1.54	2.56	2.47	7.45	7.52	15.08	16.21	5.39	5.54	0.72	0.77	1.96	2.02	0.77	0.81	1.47	1.68	1.61	1.63	0.91	0.93
LSD (P=0.05)	4.16	4.39	5.79	6.02	21.27	21.45	43.04	46.28	15.40	15.80	2.23	2.35	5.59	5.75	NS	NS	4.21	4.79	5.59	5.67	NS	NS

Table 3: Effect of establishment methods and weed management practices on Economics of Direct seeded rice

Treatment	Cost of cultivation (Rs.ha^{-1})	Gross returns (Rs.ha^{-1})	Net returns (Rs.ha^{-1})	Benefit : Cost (Rs.ha^{-1})
$M_1 W_1$	20780	37979	17199	0.83
$M_1 W_2$	21303	43555	22251	1.04
$M_1 W_3$	22390	40988	18598	0.83
$M_1 W_4$	20778	48837	28059	1.35
$M_1 W_5$	20905	43996	23091	1.10
$M_1 W_6$	27870	52002	24132	0.87
$M_1 W_7$	33870	53784	19914	0.59
$M_1 W_8$	18870	26130	7260	0.38
$M_2 W_1$	20288	54360	34072	1.68
$M_2 W_2$	20811	58833	38021	1.83
$M_2 W_3$	21898	54919	33021	1.51
$M_2 W_4$	20286	63329	43044	2.12
$M_2 W_5$	20413	57228	36815	1.80
$M_2 W_6$	27378	66755	39377	1.44
$M_2 W_7$	33378	69437	36059	1.08
$M_2 W_8$	18378	35246	16868	0.92
$M_3 W_1$	21080	47222	26142	1.24
$M_3 W_2$	21603	52746	31143	1.44
$M_3 W_3$	22690	48781	26091	1.15
$M_3 W_4$	21078	57507	36429	1.73
$M_3 W_5$	21205	52099	30894	1.46
$M_3 W_6$	28170	60464	32294	1.15
$M_3 W_7$	34170	71631	37461	1.10
$M_3 W_8$	19170	32249	13079	0.68

Conclusions

On the basis of two years experimentation, it may be concluded that higher values of grain yield and net return may be obtained due drum seeding methods of establishment of rice along with integrated method of using weed management by pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop), while, broadcasting (wet) showed the same response However, direct seeding of rice through drum along with pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) proved superior (BCR values of Rs 2.12 per ha) over other methods of rice establishment under puddled condition.

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