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Response of establishment methods and weed management practices on weeds, N uptake and yield of direct seeded rice (*Oryza sativa* L.)

Sanjay Kumar, Nareshmani Pandey, Ashok Kumar Singh and Ghanshyam Singh

Abstract
A field experiment was conducted during *Kharif* season of 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. crus galli, E. colona* and *P. maximum* of grassy, *Commelina benghalensis* L. and *Eclipta alba* of broad leaved group and *Cyperus* spp. of sedges group. However, grassy weeds were dominant over other weeds species. Lower values of weed density and dry weight, yield and yield attributes of crop were recorded significantly due to manual weeding thrice, and pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (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. Various weed management practices influenced the nitrogen uptake by weed and crop significantly. Whereas total N uptake by weed definitely in more weed population treatments and higher N uptake by crop weed free and pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 leaf stage of rice crop) that means less competition. On the basis of two years experimentation, it may be concluded that higher values of grain yield 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 0-2DASfbalmix @ 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. It is commonly grown by transplanting seedlings into puddled soil (wet tillage) in Asia. This production system is labor, water, and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce. 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]. Rice protein through small in amount is of high nutritional value. In India, it is cultivated under different situations that is from below sea level in Kerala to about 2000m altitude in Himalayan region, from 80 N latitude in Kanyakumari to350N latitude in Kashmir, annual rainfall from 1250 cm (Assam) to 25cm (Rajasthan) from sandy loam soils to heavy black cotton soil and from normal to saline alkali soils. 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 it consumes 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, pretilachlor, 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- Raebareli 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), pendimethalin @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 0-2DASfb almix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop), pyrazosulfuran @ 20 g/ha at 0-2DAS fb ethoxysulfuron @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 ^{0}C 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.

Results and Discussion

The dominant weed floras of the experimental field were among grasses, *Echinochloa crus-galli* and *Echinochloa colona*, *Panicum maximum*. In case of BLWs, *Eclipta alba*, *Commelina benghalensis*. Among the sedges, *Cyperus rotundus*, *Cyperus difformis*, *Cyperus esculentus* as well as *Fimbristylis dentatum* were recorded, but *Cyperus rotundus* 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 25g ha^{-1} as PoE application 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 yield

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. 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 0-2DASfb almix @ 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.

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 pendimethalin @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 age caused severe competitive stress on 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].

Effect on N uptake

The weeds in dry seeded plots took up significantly the maximum; while the treatments with drum seeding in wet beds exhibited the least uptake by weeds. There is not much to explain the behaviour of treatments as crop uptake is directly a function of biological yield and content. The plots giving higher biological yields exhibited higher nutrient uptake and so on in other cases. Similarly, as the dry seeded plots offered greater opportunity to weeds to come up and grow, their weeds took up a lion's share of nutrients from the plots. On the other hand puddling is well known to suppress weeds particularly of broad leaved group hence; weeds there did not get congenial conditions for their growth and development. (De Datta, 1981; Chatterjee and Maity, 1981). Hence, the nutrient uptake by weeds under wet seed bed was comparatively low. Various weed management practices influenced the nitrogen uptake by weeds significantly (Table 1). Nitrogen uptake by weeds at 60 days and at harvest stage recorded lower values due to thrice hand weeding (20, 40 and 60 DAS) and pretilachlore @ 750g/ha at 0-2DASfbalmix@ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) which were at par to each other. However, bispyribac-Na 25g ha-1 at 30 days stage PoE, recorded the lowest values of nitrogen uptake over weedy check treatment. Likewise weedy check treatment recorded higher nitrogen uptake by weed during both the years of experimentation. This directly correlated with the weed dry weight due to various weed control practices. Drum seeding and broad casting methods being at par recorded significantly higher quantity of nitrogen uptake over dry-seeding treatments while, drum seeding method of rice establishment recorded higher nitrogen uptake by crop over broad-casting method. Such type of effects of management is due to the extent of weed control due to the various establishments. Various weed management practices influenced the nitrogen uptake by crop significantly (Table4.25). The manual weeding (20, 40 and 60 DAS) and pretilachlore @ 750g/ha at 0-2DASfbalmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) being at par recorded significantly higher values of nitrogen uptake as compared to herbicide treatment alone and weedy check. These results are in close conformity with those of Shekhar *et al*. (2009); Kumar *et al*. (2010) and Parashivamurthy *et al*. (2012).

Conclusions

On the basis of two years experimentation, it may be concluded that Drum and broad casting along with three hand weeding at 20, 40 and 60 days stages and pretilachlore @ 750g/ha at 0-2DAS fb almix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) being at par recorded significantly higher grain and straw yield due to weeds as compared to other treatment combination respective of the years. The same combination recorded significantly higher values of nitrogen uptake by crop during both of the years. However, direct seeding of rice through drum along with pretilachlore @ 750g/ha at 0-2DAS fb almix @ 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.

Table 1: Effect of establishment methods and weed management practices on total weed density (m^{-2}), total weed dry weight (g m^{-2}) and N uptake by weed and crop at different stage of crop growth of rice

Treatments	total weed density (m^{-2})				total weed dry weight (gm^{-2})				N uptake by weed ($kgha^{-1}$)							N uptake by crop ($kgha^{-1}$)
	60 DAS		90 DAS		60 DAS		90 DAS		60 DAS		At harvest		Total			
	2015	2016	2015	2016	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	(37.53) 5.81	(37.13) 5.79	(39.00) 5.92	(38.00) 5.85	8.68	8.76	9.55	10.63	18.23	19.39	61.56	60.84
Drum seeder	(44.19) 6.68	(38.97) 6.27	(41.19) 6.46	(38.05) 6.21	(25.25) 5.26	(25.13) 5.23	(26.37) 5.29	(25.15) 5.23	5.92	5.53	6.50	6.20	12.42	11.72	79.03	79.94
Broadcasting (wet)	(55.45) 7.48	(48.88) 7.03	(51.81) 7.23	(47.85) 6.95	(31.94) 5.38	(31.58) 5.36	(32.83) 5.46	(32.33) 5.42	6.90	6.67	8.06	7.47	14.97	14.14	72.50	72.74
SEm±	1.15	1.10	1.12	1.10	0.03	0.04	0.05	0.05	0.13	0.13	0.15	0.15	0.28	0.28	2.11	2.09

LSD (P=0.05)	0.82	0.25	1.87	1.81	0.14	0.15	0.19	0.20	0.52	0.51	0.57	0.60	1.09	1.11	8.28	8.19
Weed management practices																
Bis.	(63.08) 7.97	(55.61) 7.49	(53.31) 7.71	(49.25) 7.41	(37.38) 6.17	(38.76) 6.28	(39.01) 6.30	(37.84) 6.21	8.56	8.24	9.59	9.58	18.15	17.82	65.14	64.01
Pendi. fbBis.	(44.06) 6.73	(38.84) 6.32	(41.17) 6.51	(38.03) 6.26	(29.41) 5.49	(30.12) 5.56	(30.49) 5.59	(29.78) 5.53	7.54	7.45	8.47	8.67	16.00	16.12	73.16	74.09
Oxadi.fbBis.	(57.06) 7.59	(50.30) 7.13	(46.57) 7.34	(43.01) 7.05	(32.02) 5.73	(31.57) 5.69	(33.31) 5.84	(32.42) 5.76	8.28	7.99	9.28	9.30	17.56	17.29	67.63	67.35
Preti.fbAlm.	(34.57) 6.68	(28.97) 6.27	(31.91) 6.46	(29.91) 6.21	(18.29) 4.39	(17.32) 4.28	(19.49) 4.53	(16.87) 4.23	7.22	7.17	8.12	8.35	15.34	15.53	77.93	79.05
Pyra.fbethox.	(49.84) 7.10	(43.94) 6.67	(41.84) 6.86	(38.65) 6.60	(32.75) 5.79	(31.26) 5.66	(34.06) 5.90	(33.15) 5.83	7.89	7.72	8.85	8.98	16.74	16.70	72.70	70.91
Manual weed.	(26.00) 5.15	(22.92) 4.84	(24.30) 4.98	(22.44) 4.79	(15.61) 4.06	(15.45) 4.04	(16.22) 4.13	(15.80) 4.09	6.98	7.04	7.86	8.21	14.84	15.25	77.55	81.96
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	0.00	0.00	0.00	0.00	0.00	84.61	86.89
Weedy	(154.32) 12.44	(136.06) 11.69	(144.20) 12.03	(133.19) 11.56	(67.52) 8.25	(64.13) 8.04	(69.10) 8.34	(68.35) 8.30	10.87	10.07	12.13	11.69	23.00	21.76	49.53	45.11
SEm±	0.48	0.41	1.44	1.40	0.06	0.06	0.08	0.07	0.23	0.230	0.26	0.27	0.50	0.50	2.67	2.64
LSD (P=0.05)	1.93	1.82	2.24	2.16	0.18	0.18	0.24	0.19	0.67	0.66	0.75	0.77	1.42	1.43	7.62	7.54

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

Treatments	Plant height (cm)				Dry matter accumulation (gm^{-2})				Effective tillers (m^{-2})		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
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	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	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	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	0.84	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	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	26.67	30.36	38.30	42.76	40.85	41.32
Pendi. fbBis.	51.45	54.07	70.31	70.48	334.00	332.97	694.80	732.02	242.95	250.22	32.68	37.19	44.74	49.94	42.05	42.52
Oxadi.fbBis.	49.68	52.73	68.68	69.62	328.88	328.27	681.84	719.99	240.89	243.93	28.65	32.62	40.10	44.76	41.57	42.05
Preti.fbAlm.	52.33	55.22	71.93	74.49	348.99	351.01	727.20	773.25	250.38	259.36	36.23	41.24	48.99	54.69	42.49	42.97
Pyra.fbethox.	50.62	53.27	69.26	70.22	333.22	330.23	692.37	725.15	241.97	246.62	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	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	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	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	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	4.21	4.79	5.59	5.67	NS	NS

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