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Effect of Weed Management and Crop Establishment Methods on Weed Dynamics and Grain Yield of Rice

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ABSTRACT

Effect of rice establishment methods and weed management practices on weeds and grain yield of rice was studied. The maximum reduction of weed species was obtained with application of herbicides as pre-emergence supplemented by two hand weedings at 30 and 60 days after seeding/days after transplanting under all the establishment systems of rice. The maximum weed dry matter reduction was achieved due to herbicide supplemented with two hand weedings in transplanted rice followed by herbicide as pre-emergence supplemented with two hand weedings in wet seeded rice and zero till rice. The highest grain yield (4623 kg ha^{-1}) was achieved by the application of herbicide supplemented with two hand weedings in transplanted rice which was significantly higher than the other treatments. Among the direct seeded rice, the highest yield (4222 kg ha^{-1}) was recorded under wet seeding (WSR) employed with two hand weedings (WC_4 – two hand weedings) and on par with application of herbicide followed by one hand weeding (WC_2) under transplanting (TPR).

INTRODUCTION

Economic factors and developments in rice production technology are the major drivers that have led to the adoption of direct seeding rice establishment in place of transplanting in Asia (Pandey and Velasco, 2002). The rising cost of agricultural labour, need to intensify rice production through double and/triple cropping, the development of high yielding short duration varieties and the availability of chemical weed control method largely promoted this change as evident in Malaysia and Thailand in the late 1980's and 1990's. In the 21st century alongwith population pressure, the rising scarcity of agricultural land and water, and continuing shortage of labour will maintain pressure for a shift towards direct seeding methods (Mortimer *et al.*, 2005). Direct seeding does not require the large quantity of water for puddling prior to rice transplanting, nor is labour required for raising nursery beds and transplanting. Farmers growing direct seeded rice are however likely to encounter greater problems related to weed management because of lack of standing water for weed suppression. The transition to direct seeding of rice can therefore only be successful if accompanied by effective weed management practices (Singh *et al.*, 2003). To determine the impact of different establishment systems of rice, and to improve weed control measures, experiment was designed to explore a range of available options for weed management and direct seeding of rice using either dry or pre-germinated seeds.

MATERIALS AND METHODS

Field experiment was conducted at Sugarcane Research Station, Kashipur, G. B. Pant University of Agriculture & Technology, Pantnagar, U. S. Nagar (Uttaranchal) to examine weed and crop growth under different establishment methods of rice during **kharif** seasons of 2003 and 2004. Four

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rice establishment methods in main plots and four weed management practices in sub-plots were compared in split plot design. Rice establishment methods were conventional transplanting of 21 days old seedlings after soil puddling (TPR), wet seeding-sowing of pre-germinated seeds on puddle soil (WSR), dry seeding after conventional tillage (DSR), dry seeding zero-tillage after flush irrigation (ZTR).

Rice was sown at 50 kg ha^{-1} at row spacing of 20 cm in all the establishment methods except conventional system as transplanting (TPR). DSR, WSR and ZTR were done in the first week of June. For transplanting, rice nursery was seeded in puddle soil at same time when seeding was done in other rice establishment methods.

In sub-plots, four weed management practices were adopted : Weedy check (WC_1), pre-emergence application of herbicide followed by one hand weeding at 30 DAS/DAT (WC_2), pre-emergence application of herbicide followed by two hand weedings at 30 and 60 DAS/DAT (WC_3) and two hand weedings done at 30 and 60 DAS/DAT (WC_4). The herbicide use in weed management treatment differed according to the establishment of rice. For TPR butachlor at 1.5 kg ha^{-1} was applied 2-3 days after transplanting, in WSR plots anilofos at 0.4 kg ha^{-1} was applied 5-7 days after seeding and for DSR and ZTR pendimethalin at 1.0 kg ha^{-1} was applied within 3 DAS. The rice variety NDR-359 was used in experimental plot during both the **kharif** seasons. From each sub-plot, weed control and biomass by species were taken from 0.25 m x 1 m quadrates covering five crop rows at 56 DAS/DAT stages of crop for all the establishment methods.

RESULTS AND DISCUSSION

Effect on Weeds

The major weed species recorded in weedy plots were *Cyperus rotundus* (21.4%), *Eleusine indica* (19.8%), *Dactyloctenium aegyptium* (16.9%), *Echinochloa colona* (10.2%), *Corchorus acutangulus* (9.9%), *Alternanthera sessilis* (9.9%) and *Leptochloa chinensis* (8.0%). The density of *E. colona, D. aegyptium, L. chinensis* and *E. indica* was higher in wet seeded rice (WSR) followed by direct seeded (DSR) and zero tilled rice (ZTR). However, the maximum density of *A. sessilis* was in WSR, *C. acutangulus* and *C. rotundus* were higher in ZTR than in DSR. Among different establishment systems of rice, the minimum total weed density was recorded in transplanted rice. There were non-significant differences between the transplanting and other rice establishment methods with respect to density of *E. colona* and *E. indica*, while transplanting caused significant reduction in density of *D. aegyptium* in comparison to other establishment methods. WSR had less density of *L. chinensis* than other establishment methods, whereas minimum density of *A. sessilis* was recorded in ZTR, and that of *C. acutangulus* in WSR and DSR. The highest weed density was recorded in weedy plots. The minimum weed species was obtained with application of herbicides as pre-emergence supplemented by two hand weedings at 30 and 60 DAS/DAT. Pre-emergence application of herbicide supplemented with one hand weeding (WC_2) proved relatively higher weed density in all the establishments of rice than two hand weedings done at 30 and 60 DAS (WC_4). *D. aegyptium, L. chinensis, E. colona* and *C. acutangulus* in DSR, WSR or ZTR were similar to that in transplanting (TPR) with application of herbicide fb two hand weedings (WC_3). *E. indica* and *A. sessilis* were significantly less in WSR with the application of herbicide fb two hand weedings. Transplanted rice with application of herbicide followed by two hand weedings had minimum density of *C. rotundus*, which was significantly lower than the other weed management practices in all other establishment systems of rice. Rice transplanting in puddled condition significantly reduced the total dry matter of weeds than other rice establishment systems. The highest weed dry matter was recorded in ZTR than in DSR. The maximum weed dry matter reduction was achieved under herbicides+two hand weedings (WC_3) in TPR followed by two hand weedings (WC_4) in wet seeding (WSR) and pre-emergence application of herbicide fb two hand weedings (WC_3) in zero till

Table 1. Interaction effect of rice establishment and weed managment on weed density and total dry matter of weeds at 56 days stage (Pooled for 2003-04)

Rice establishment	Weed density (No. m^{-2})																			
	Weed management																			
	WC_1	WC_2	WC_3	WC_4	Mean	WC_1	WC_2	WC_3	WC_4	Mean	WC_1	WC_2	WC_3	WC_4	Mean	WC_1	WC_2	WC_3	WC_4	Mean
	E. colona					*D. aegyptium*					*L. chinensis*					*E. indica*				
DSR	16.5	0.0	0.0	7.0	2.9	124.0	0.0	0.0	1.0	31.2	8.0	0.0	0.0	0.0	2.0	54	0.5	1.0	2.5	145
	(1.72)	(0.0)	(0.0)	(067)	(0.6)	(3.60)	(0.0)	(0.0)	(0.40)	(1.0)	(1.63)	(0.0)	(0.0)	(0.0)	(0.4)	(3.41)	(0.27)	(0.40)	(0.59)	(1.17)
WSR	13.5	1.5	0.0	2.5	2.18	14.0	7.25	2.50	1.05	8.56	6.5	1.5	0.75	2.7	2.8	30.75	3.75	0.0	3.75	9.0
	(1.71)	(0.34)	(0.0)	(0.57)	(0.65)	(1.9)	(1.2)	(0.88)	(1.79)	(1.4)	(1.6)	(0.67)	(0.34)	(0.89)	(0.88)	(2.92)	(1.02)	(0.0)	(0.62)	(1.18)
ZTR	6.5	0.5	0.0	3.0	1.25	22.7	0.25	0.0	6.75	7.43	0.27	0.0	0.0	0.0	0.68	59.75	0.0	0.0	3.75	1.58
	(1.42)	(0.17)	(0.0)	(0.48)	(0.52)	(2.99)	(0.17)	(0.0)	(1.32)	(1.12)	(0.93)	(0.0)	(0.0)	(0.0)	(0.23)	(3.92)	(0.0)	(0.0)	(0.69)	(1.15)
TPR	1.5	2.5	0.0	4.5	1.06	20.50	0.0	0.0	0.0	0.12	0.0	0.0	0.0	0.0	0.0	0.0	0.75	0.0	0.0	0.18
	(0.44)	(0.69)	(0.0)	(0.96)	(0.52)	(0.27)	(0.0)	(0.0)	(0.0)	(0.6)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.34)	(0.0)	(0.0)	(0.86)
Mean	4.75	0.56	0.0	2.12		40.31	1.87	0.62	4.56		4.3	4.3	0.37	0.18		36.12	1.25	0.31	1.87	
	(1.32)	(0.3)	(0.0)	(0.67)		(2.19)	(0.34)	(0.22)	(0.88)		(1.04)	(1.04)	(0.16)	(0.68)		(2.56)	(0.41)	(0.14)	(0.47)	

Rice establishment	Weed density (No. m^{-2})																			
	Weed management																			
	WC_1	WC_2	WC_3	WC_4	Mean	WC_1	WC_2	WC_3	WC_4	Mean	WC_1	WC_2	WC_3	WC_4	Mean	WC_1	WC_2	WC_3	WC_4	Mean
	A. sessilis					*C. acutangulus*					*C. rotundus*					Total weed dry matter (g m^{-2})				
DSR	0.25	4.50	3.75	6.25	3.68	6.25	1.0	0.0	0.5	1.93	61.25	29.75	22.5	48.5	40.5	16.88	0.79	0.36	1.23	4.81
	(0.17)	(1.12)	(0.69)	(0.81)	(0.70)	(0.16)	(0.51)	(0.0)	(0.27)	(0.60)	(3.99)	(3.36)	(2.53)	(2.71)	(3.43)	(2.77)	(0.57)	(0.30)	(0.74)	(1.10)
WSR	12	0.0	0.0	8.25	5.06	1.25	0.0	0.0	0.0	0.31	44.5	62.7	28.25	37.0	43.12	11.8	1.52	0.43	2.33	4.03
	(2.1)	(0.0)	(0.0)	(1.77)	(0.98)	(0.69)	(0.0)	(0.0)	(0.0)	(0.17)	(2.92)	(3.37)	(2.70)	(3.55)	(3.13)	(2.36)	(0.90)	(0.35)	(0.10)	(1.17)
ZTR	4.25	3.5	0.0	7.0	3.68	10.25	1.0	0.0	1.0	3.06	83.75	70.75	27.5	91.5	68.37	15.9	1.47	0.29	3.58	5.32
	(1.29)	(1.02)	(0.0)	(1.88)	(1.05)	(2.3)	(0.40)	(0.0)	(0.51)	(3.06)	(4.22)	(4.18)	(3.30)	(4.40)	(4.02)	(2.76)	(0.89)	(0.25)	(1.45)	(1.34)
TPR	0.5	1.25	0.0	0.25	0.5	1.50	0.0	0.0	0.0	0.37	20.5	21.25	0.0	24.5	16.56	1.90	0.94	0.0	1.00	0.98
	(0.2)	(0.44)	(0.0)	(0.17)	(0.22)	(0.48)	(0.0)	(0.0)	(0.0)	(0.12	(3.00)	(2.82)	(0.0)	(3.17)	(2.22)	(0.85)	(0.65)	(0.0)	(0.73)	(0.56)
Mean	4.25	2.31	0.93	0.54		4.81	0.50	0.0	0.37		52.5	46.12	19.56	50.37		11.6	0.11	0.27	2.08	3.79
	(0.98)	(0.64)	(0.1)	(1.16)		(1.28)	(0.23)	(0.0)	(0.19)		(3.52)	(3.42)	(2.13)	(3.68)		(1.04)	(0.75)	(0.22)		(0.10)

LSD (P=0.05) :	*E. colona*	*D. aegyptium*	*L. chinensis*	*E. indica*	*A. sessilis*	*C. acutangulus*	*C. rotundus*	Total weed dry matter (g m^{-2})
Rice establishment	0.74	0.62	0.67	0.54	0.7	0.28	0.28	0.32
Weed management	0.53	0.74	0.41	0.60	0.52	0.40	0.40	0.28
Weed management at same level of rice establishment	1.06	1.40	0.82	1.21	1.05	0.81	0.81	0.56
Rice establishment at same level of weed management	1.18	1.36	0.98	1.18	1.19	0.76	0.76	0.58

WC_1 – Weedy check. WC_2 – Pre-em. application of herbicide fb one hand weeding at 30 DAS/DAT. WC_3 – Pre-em. application of herbicide fb two hand weedings at 30 & 60 DAS/DAT. WC_4 – Only two hand weedings at 30 & 60 DAS/DAT. DSR – Direct seeded rice. WSR – Wet seeded rice. ZTR – Zero tillage rice. TPR – Transplanted rice.

Table 2. Effect of rice establishment and weed management on yield and yield attributes (Pooled for 2003-04)

Rice establishment	1000-grain weight (g)					No. of panicles m^{-2}					No. of grains $panicle^{-1}$					Grain yield (kg ha^{-1})				
	Weed management																			
	WC_1	WC_2	WC_3	WC_4	Mean	WC_1	WC_2	WC_3	WC_4	Mean	WC_1	WC_2	WC_3	WC_4	Mean	WC_1	WC_2	WC_3	WC_4	Mean
DSR	27.4	27.6	29.2	29.4	28.4	134.7	188.5	252.7	264.0	210.0	82.7	95.0	119.2	88.2	96.3	1447	3618	3614	3138	2663
WSR	28.8	28.5	28.9	28.4	28.7	157.2	223.2	251.2	261.7	223.3	112.0	111.5	103.0	113.2	109.2	2655	3896	3926	4222	3675
ZTR	28.8	28.5	29.0	28.6	28.7	133.5	231.0	242.0	240.7	211.8	79.7	94.0	125.0	86.5	96.3	1400	3207	3688	2939	2789
TPR	29.3	29.2	29.3	27.2	28.7	226.2	221.0	228.0	198.7	218.5	125.5	131.7	120.5	133.5	127.8	3876	4224	4623	4496	43.4
Mean	28.6	28.5	29.1	28.4	28.6	162.9	215.9	243.5	241.3	215.9	100.0	108.0	116.9	105.3	107.5	2344	3736	3929	3708	
Rice establishment					0.96					38.06					20.34					127.94
Weed management					0.80					35.85					13.90					92.97
Weed management at same level of rice establishment					1.61					71.71					27.81					185.94
Rice establishment at same level of weed management					1.69					72.76					31.48					205.39

(ZTR) rice crop (Table 1).

Effect on Crop

All the rice establishments were statistically at par among themselves with respect to number of panicles and 1000-grain weight, however, TPR produced higher number of grains per panicle followed by WSR and significantly higher than the ZTR and DSR. This might be due to less competition with weeds in TPR than in direct seeding in conventional tillage (DSR) or without tillage (ZTR) which suppressed the weed flush at puddling. Weed management practices did not bring significant increase in 1000-grain weight over weedy (WC_1). Whereas more number of panicles m^{-2} and grains per panicle were recorded with application of herbicide supplemented with two hand weedings (WC_3) which was closely followed by application of herbicide supplemented with one hand weeding (WC_2) or only two hand weedings (WC_4) and significantly higher than the weedy check (WC_1). Application of herbicide supplemented with two hand weedings (WC_3) in transplanted (TPR) and direct seeded (DSR) and two hand weedings (WC_4) in DSR were equally effective in producing 1000-grain weight and significantly superior over weedy (WC_1) in DSR and TPR and application of herbicide followed by one hand weeding (WC_1) in DSR system (Table 2). The highest number of panicles was produced by application of herbicide followed by two hand weedings (WC_3) and only two hand weedings (WC_4) in DSR and WSR system. Significantly lower number of panicles was obtained in weedy check (WC_1) in all the establishments except TPR.

Rice establishment and weed management both significantly affected grain yield of rice. The highest grain yield (4304 kg ha^{-1}) was obtained by transplanting (TPR) than wet seeding (WSR), zero till (ZTR) and direct seeded rice (DSR). The mean grain yield over the weed management practices was significantly higher in treated plots than in weedy check (WC_1). Herbicides supplemented with two hand weedings at 30 and 60 DAS (WC_3) gave significantly higher yield of rice (3929 kg ha^{-1}) than the pre-emergence application of herbicide and one hand weeding (WC_2) and only two hand weedings (WC_4). The main reason for higher yield in transplanted and wet seeding was better control of weeds. The reductions in yield were 40.3% in weedy check.

Interaction effects between the rice establishment and weed management treatments with respect to grain yield were significant (Table 2). The highest yield (4626 kg ha^{-1}) was achieved by application of herbicide supplemented with two hand weedings in transplanted rice (TPR) which was significantly higher than the other treatments and at par with application of herbicide supplemented with one hand weeding (WC_2) and two hand weedings (WC_4) in transplanted rice. Among the direct seeding of rice the higher yield (4222 kg ha^{-1}) was recorded under wet seeding (WSR) with two hand weedings (WC_4) which was at par with rice established as transplanting and application of pre-emergence herbicide followed by one hand weeding. Similar results were also reported by Singh *et al.* (2003). Rice yield was recorded significantly lower in DSR where only hand weeding was done because of early competition of weeds.

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