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Effect of establishment method, fertility level and weed-management practices on aromatic rice *(Oryza sativa)*

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ABSTRACT

An experiment was conducted during rainy season of 2003 and 2004 at Agronomy Research Farm, Allahabad Agricultural Institute-Deemed University to assess the effect of establishment method, fertility level and weed-management practice on rice *(Orgza sativa* L.). The experiment was laid out in factorial randomized block design, comprising two establishment methods (direct wet seeding and transplanting); three levels of N, P_2O_5 and K_2O, viz. 80 : 40 : 40; 100 : 50 : 50 and 120 : 60 : 60 kg/ha; and four weed-management practices, viz. anilofos @ 0.4 kg a i/ha, butachor @ 1.5 kg a i/ha, two hand-weedings (at 30 and 60 DAS) and a weedy check. These 24 treatments, were replicated thrice. Transplanting method recorded higher grain yield than direct seeding. The yield increased with the increase in fertility level and reached maximum with 120 : 60 : 60 kg/ha N, P_2O_5 and K_2O/ha. Two hand-weedings registered higher grain and straw yields with respect to weed-management practices. Amongst all the interactions, the maximum grain yield was observed in direct seeded and transplanted plots treated with two hand-weedings and higher fertilizer dose of 120 : 60 : 60 kg/ha N, P_2O_5 and K_2O, and were at par. However, higher net profit and benefit: cost ratio (BCR) were observed in transplanted plots treated with 120 : 60 : 60 kg/ha N, P_2O_5 and K_2O and anilofos @ 0.4 kg ai/ha. The maximum weed-control efficiency was observed in transplanted rice, low fertility and anilofos @ 0.4 kg ai/ha treatments. The maximum weed index was observed in weedy check plots.

Key words : Direct-seed rice, Transplanted rice, Fertility level, Weed management

Rice *(Oryza sativa* L.) is the principal food for Indian people, being grown in 44.6 million ha, with a production of 87 million tonnes (Anonymous, 2005). There is enormous variability in rice yield, ranging from 948 kg/ha in Madhya Pradesh to 3,545 kg/ha in Punjab. India has 7.1 million ha rice under direct seeding (Moorthy and Saha, 2002). Attempts to introduce direct-seeding of rice in puddled soil to the farmer often fail owing to non-competitiveness of direct-seeded rice to weeds. Weed menance is 50-60% more in wet-seeded rice than in transplanted rice. Manual weeding becomes difficult because of possible damage to rice plants, problem in differentiating grassy weeds, labour scarcity, time consumed and relatively less effectiveness. Chemical control using herbicide mixture will control more weed species, and proper nutrient management will suppress them through crop-canopy management. The objective of this expeiment was to evaluate the performance of transplanted rice and wet direct-seeded rice under different fertility levels and weed-management practices and to develop optimum combination of establishment methods, fertility levels and weed-management practices.

MATERIALS AND METHODS

An experiment was conducted during rainy *(kharif)* season of 2003-04. The soil was sandy clay-loam, 0.60% in organic carbon, low in available nitrogen, medium in P_2O_5 (50 kg/ha) and potassium (235 kg/ha), and neutral in reaction (pH 7.5), with electrical conductivity (EC) 0.28 mmhos/cm. It was laid out in factorial randomized block design, comprising two establishment methods, viz. direct seeding of sprouted seeds in puddled soil and transplanting; three levels of N, P_2O, and K_2O, viz. 80 : 40 : 40 :, 100 : 50 : 50 and 120 : 60 : 60 kg/ha; and four weed management practices, viz. anilofos (Pre) @ 0.4 kg ai/ha, butachlor (Pre) @ 1.5 kg ai/ha, two hand-weedings (30 and 60 DAS) and a weedy check. The combinations of all the treatments were replicated thrice. For transplanting and seeding in direct-seeded plots, the nursery was raised on 25 June 2003 and 29 June 2004. As per the treatment,

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the entire quantity of phosphorus as single supephosphate and potassium as muriate of porash and half the dose of nitrogen as urea were applied basal; the rest nitrogen was applied in two equal splits through urea. Fifteen irrigations were given throughout the crop duration and in each irrigation 10 cm water was given. Both direct-seeded and transplanted plants matured on the same date, and were harvested on 7 November 2003 and 13 November 2004 respectively. The observations on the population count and dry weight of weeds were recorded. Weed data were transformed $\sqrt{x+0.5}$ before statistical analysis. Nirogen, phosphorus and potassium contents of weeds, grain and straw of rice were estimated by standard methods. Their uptake was estimated by multiplying the dry mater (oven dry) accumulated at maturity in weeds, grain and straw yields of rice by their respective percentages. Total uptake of rice was calculated by adding the uptake of grain and straw. The yield parameters and yields were recorded and economics was worked out.

RESULTS AND DISCUSSION

Effect on growth and yield attributes

Establishment methods, fertility levels and weed management practices had significant effect on growth and yield attributes, viz. plant height, dry weight/hill, effective tillers/hill, grains/panicle and test weight, during both he years (Table 1). The transplanted plants had more growth and yield attributes than direct-seeded plants. The growth and yield attributes increased with the increase in fertility level and were more in the plots receiving 120 : 60 : 60 kg/ha N : P_2O_5 : K_2O. This might be due to greater availability of nutrients, resulting in increased biomass. Amongst weed-management practices, two hand-weeded plots were found significantly superior, which registered more growth and yield attributes, followed by anilofos @ 0.4 kg ai/ha during both the years. The pre-emergence application of anilofos and buachlor did not control all the weeds and might have caused phytotoxicity to the emerg-

Table 1. Growth, yield attributes and yield of rice as affected by establishment method, fertility level and weed-management practice

Treatment	Plant height (cm)		Effective tillers/m²		Grains/ panicle		Test weight (g)		Grain yield (q/ha)		Straw yield (q/ha)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Establishment method												
Direct seeded	97.1	94.5	12.1	11.1	131	129	19.85	19.56	29.22	27.83	46.80	45.50
Transplanted	99.8	97.1	13.5	11.9	140	138	20.42	19.95	32.52	31.05	53.57	50.05
CD (P=0.05)	0.6	0.6	0.2	0.3	1	4	0.29	0.30	0.46	0.59	3.86	1.14
Fertility level (N : P_2O_5 : K_2O kg/ha)												
80 : 40 : 50	92.2	89.5	11.7	10.1	122	120	19.42	19.13	25.00	23.83	43.66	39.62
100 : 50 : 50	97.0	94.5	12.7	11.1	132	129	19.92	19.55	29.16	27.62	46.91	45.33
120 : 60 : 60	106.1	103.4	14.6	13.2	135	152	21.00	20.58	38.45	36.87	60.58	58.37
CD (P=0.05)	0.7	0.7	0.3	0.4	1	5	0.35	0.37	0.56	0.72	4.73	1.39
Weed-management practice												
Anilofos @ 0.4 kg a i/ha	101.4	98.8	13.7	12.3	145	141	20.68	20.23	35.66	33.88	56.55	54.72
Butachlor @ 1.5 kg a i/ha	98.2	95.5	12.7	10.9	134	131	20.06	19.68	30.22	28.77	47.72	46.05
Two HW (30, 60 DAS)	112.3	109.8	15.2	14.0	163	160	21.57	21.26	43.66	41.66	68.27	66.38
Weedy check	81.7	79.0	10.5	8.7	101	102	18.23	17.85	13.94	13.44	29.00	23.94
CD (P=0.05)	0.8	0.9	0.3	0.4	1	5	0.41	0.43	0.65	0.83	5.47	1.61

HW = Hand-weeding

Table 2. Grain yield as affected by interaction among establishment methods, fertility levels and weed-management practices

Tratment	Direct seeding						Transplanting					
	$N_{80}P_{40}K_{40}$		$N_{100}P_{50}K_{50}$		$N_{120}P_{60}K_{60}$		$N_{80}P_{40}K_{40}$		$N_{100}P_{50}K_{50}$		$N_{120}P_{60}K_{60}$	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Weed-management practice												
Anilofos @ 0.4 kg ai/ha	24.33	22.66	31.33	29.66	47.10	45.00	23.00	29.00	33.00	30.83	48.33	46.33
Butachlor @ 1.5 kg ai/ha	23.00	21.66	25.00	23.33	38.33	36.33	26.66	26.33	38.33	27.66	40.00	38.00
Two HW (30 60 DAS)	35.00	33.00	43.33	41.00	51.33	50.83	36.66	34.66	44.00	42.00	51.66	49.00
Weedy check	9.33	9.00	10.66	10.33	12.00	11.66	15.00	14.33	17.66	17.35	19.00	18.33
CD (P=0.05)	1.60	2.04										

ing seedling, leading to lesser yield attributes compared with two hand-weedings. Govindra *et al.* (2004) observed similar findings. Due to stiff competition from weeds the growth and yield attributes were recorded least in the weedy check plots.

Effect on yield

Establishment methods, fertility levels and weed-management practices significantly influenced the grain yield during both the years. Transplanting method outyielded direct seeding by recording higher grain yield of 39.42 q/ha in 2003 and of 31.05 q/ha in 2004, giving 11.3 and 11.7% more yield respectively. The yield increased linearly with corresponding increase in fertility level and higher yield was observed in plots treated 120 : 60 : 60 kg/ha N : P_2O_5 : K_2O. The nutrient uptake by plants increased with increase in fertilizer dose (Table 4), which significantly improved the growth and yield attributes and ultimately led to greater assimilation of photosynthates. Amongst weed-management practices, two hand-weeding registered significantly higher yield, followed by anilifos. The herbicides provided incomplete weed control when used alone, which was reflected in lower seed yields than two hand-weedings, but both the herbicides decreased the uptake of NPK by weeds, as also reported by Rana *et al.* (2000). Anilofos gave higher yield than butachlor, reflecting its superiority in terms of weed control and low crop phytotoxicity. The grain yield was significantly influenced by interaction among establishment methods, fertility levels and weed management practices (Table 2). The maximum grain yield was observed in direct-seeded and transplanted plots receiving two hand-weedings and higher fertilizer dose, but were at par. These results are in conformity with the findings of Singh *et al.* (2005). Similar yield was observed in direct-seeded and transplanted plots treated with high fertilizer dose and anilofos.

Effect on weeds

Dominant weed flora among grasses were: *Echinochloa colonum, E. cruss-galli, Digitaria sanguinalis, Ammania baccifera* and *Commelina benghalensis* among broad-leaf weeds; and *Cyperus rotundus* and *Cyperus difformis* among sedges. The population and dry weight of weeds were significantly influenced by establishment methods, fertility levels and weed-management practices during both the years (Table 3). The intensity and dry weight of weeds were more under direct seeding in establishment methods; under higher fertility in fertility levels; and under weedy check in weed-management practices, as

Table 3. Effect of weed intensity, dry weight of weeds, weed-control efficiency and weed index as affected by establishment methods, fertility level and weed-management practice

Treatment	Monocot weeds at 60 DAS/0.25 m^2		Dicot weeds at 60 DAS/0.5 m^2		Dry weight of weeds at 60 DAS/0.25m^2		WC (%)		Weed index (%)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Establishment method										
Direct seeded	2.89 (8.79)	3.03 (9.36)	3.44 (12.44)	3.49 (12.7)	2.61 (7.0)	2.71 (7.4)	29.0	37.1	33.1	31.7
Transplanted	2.56 (6.81)	2.73 (7.38)	3.13 (10.33)	3.19 (10.6)	2.39 (5.65)	2.44 (6.04)	50.7	48.7	25.5	24.3
CD (P=0.05)	0.047	0.79	0.04	0.036	0.06	0.03				
Fertility level (N: P_2O_5 : K_2O kg/ha)										
80 : 40 40	2.65 (7.32)	2.79 (7.82)	3.17 (10.5)	3.22 (10.8)	2.45 (5.9)	2.49 (6.20)	48.6	47.4	42.7	42.8
100 : 50 : 50	2.72 (7.75)	2.84 (8.27)	3.29 (11.3)	3.34 (11.7)	2.48 (6.31)	2.58 (6.72)	45.0	42.9	33.2	33.7
120 : 60 : 60	2.80 (8.33)	3.02 (9.02)	3.40 (12.1)	3.46 (12.5)	2.57 (6.7)	2.65 (7.24)	41.1	38.5	11.9	11.5
CD (P=0.05)	0.057	0.09	0.05	0.04	0.08	0.04				
Weed-management practice										
Anilofos @ 0.4 kg ai/ha	2.73 (7.03)	2.81 (7.17)	3.34 (10.7)	3.38 (10.9)	2.56 (5.8)	2.53 (6.15)	49.0	47.8	18.3	18.7
Butachlor @ 1.5 kg ai/ha	2.91 (8.04)	3.02 (8.61)	3.54 (12.1)	3.56 (12.2)	2.66 (6.6)	2.73 (7.09)	42.1	40.1	36.8	30.9
Two HW (30 60 DAS)	1.73 (1.41)	1.78 (2.75)	1.75 (2.61)	1.82 (2.86)	1.34 (1.3)	1.54 (1.89)	88.4	83.9		
Weedy check	3.89 (14.7)	3.92 (14.9)	4.52 (20.00)	4.60 (20.7)	3.45 (11.4)	3.51 (1.78)			68.1	67.7
CD (P=0.05)	0.066	0.11	0.069	0.05	0.09	0.04				

Transformed values ($Y=\sqrt{x+0.5}$; Figures within parentheses indicates the original values

Table 4. Nutrient uptake by rice (grain and straw) and weeds as affected by establishment method, fertility level and weed-management practice

Treatment	Nutrient upake (kg/ha) by											
	Rice (grain and sraw)						Weeds					
	N		P		K		N		P		K	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Establishment method												
Direct seeded	69.5	78.2	14.0	14.7	106.8	105.5	14.8	13.1	2.0	2.0	13.4	12.3
Transplanted	76.6	84.1	14.7	15.6	113.1	110.8	9.5	7.8	1.3	1.9	8.3	6.9
CD (P=0.05)	2.9	3.2	0.6	0.55	3.0	3.1	0.9	0.4	0.1	0.1	0.9	0.3
Fertility level (N : P_2O_5 : K_2O kg/ha)												
80 : 40 : 40	58.0	70.0	12.4	13.5	111.3	99.8	9.6	8.7	1.3	2.0	8.6	7.9
100 : 50 : 50	71.3	81.1	14.5	15.2	108.9	107.5	12.2	10.4	1.6	1.7	10.3	9.5
120 : 60 : 60	83.0	92.4	16.0	16.7	119.9	117.2	14.7	12.3	1.9	2.1	13.2	11.3
CD (P=0.05)	5.6	5.4	0.9	0.8	5.7	7.5	1.3	0.8	0.2	0.2	1.26	0.9
Weed-management practice												
Anilofos @ 0.4 kg a.i./ha	88.1	98.9	17.0	18.1	128.1	126.4	9.0	7.1	1.1	1.2	7.4	6.1
Butachlor @ 1.5 kg a.i./ha	83.9	93.3	16.5	17.2	126.3	120.6	9.3	6.2	1.6	0.7	8.2	5.6
Two HW (30, 60 DAS)	81.7	88.4	14.6	15.8	120.5	125.3	12.4	8.3	1.7	0.7	9.4	6.3
Weedy check	40.9	51.2	9.5	10.2	78.3	77.5	18.2	18.2	2.9	4.0	17.0	17.0
CD (P=0.05)	4.0	3.1	0.4	0.4	3.0	5.6	0.2	0.5	0.1	0.1	1.1	0.4

Table 5. Net income and benefit : cost ratio as affected by interaction among establishment methods, fertility level and weed-management practice in rice

Treatment	Direct seeding						Transplanting					
	$N_{80} : P_{40} : K_{40}$		$N_{100} : P_{50} : K_{50}$		$N_{120} : P_{60} : K_{60}$		$N_{80} : P_{40} : K_{40}$		$N_{100} : P_{50} : K_{50}$		$N_{120} : P_{60} : K_{60}$	
	Net income (Rs/ha)	BCR	Net income Rs/ha)	BCR	Net income (Rs/ha)	BCR	Net income (Rs/ha)	BCR	Net income (Rs/ha)	BCR	Net income (Rs/ha)	BCR
Weed-management practice												
Anilofos @ 0.4 kg ai/ha	2,128	1.09	8,576	1.37	23,102	1.97	9,695	1.47	11,177	1.51	25,493	2.12
Butachlor @ 1.5 kg ai/ha	855	1.03	1,849	1.08	14,506	1.61	6,381	1.31	6,606	1.30	17,353	1.76
Two HW (30 60 DAS)	9,138	1.35	15,667	1.59	23,224	1.82	11,701	1.47	17,917	1.69	23,983	1.88
Weedy check	16,305	0.46	11,225	0.49	10,876	0.53	4,127	0.79	3,485	0.83	3,097	0.86

weeds owing to their greater competitive ability than crop plants put forth higher biomass under weedy-check conditions. Two hand-weedings resulted in better control of weeds, which led to maximum weed-control efficiency. Anilofos registered greater weed-control efficiency than buachlor, as it was more effective in controlling the monocotyledon weeds, which mostly infest the rice crop (Vaishya and Tomar, 2000). The weed index was maximum in weedy check plots (68.1, 67.9%) and recorded least value in the plots treated with anilofos. Bindra *et al.* (2002) reported similar findings.

Effect on economics

In weedy check plots, the cost of cultivation was more than gross return, which resulted in loss (Table 5). The maximum net return was recorded in direct-seeded rice treated with 120 : 60 : 60 kg/ha N : P_2O_5 : K_2O and two hand-weeding treatments. However, higher net profit was observed in transplanted rice treated with 120 : 60 : 60 kg/ha N: P_2O_5 and K_2O with anilofos @ 0.4 ai/ha. Singh *et al.* (2002) reported increase in net profit with the application of anilofos.

It can be concluded that under existing agro-climatic conditions, direct sowing of sprouted rice in puddled soil can yield as high as transplanted rice by adopting 120 : 60: 60 kg/ha N: P_2O_5 : K_2O and two hand-weeding treatments. However, transplanted plots treated with 120 : 60: 60 kg/ha N: P_2O_5; K_2O and anilofos gave maximum net profit.

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